FOR FURTHER INFORMATION CONTACT: Caren Centorelli, Office of Rulemaking (ARM–1), Federal Aviation Administration, 800 Independence Avenue, SW., Washington, DC 20591. Tel. (202) 267–8199.

This notice is published pursuant to 14 CFR 11.85 and 11.91.

Issued in Washington, DC, on September 24, 2003.

Donald P. Byrne,

Assistant Chief Counsel for Regulations.

Petitions for Exemption

Docket No.: FAA–2003–15812.

Petitioner: Airbus.

Section of 14 CFR Affected: 14 CFR 25.562(b)(2).

Description of Relief Sought: Petitioner requests exemption from the floor warpage test requirements of 14 CFR 25.562(b)(2), which requires that ''where floor rails or floor fittings are used to attach the seating devices to the test fixture, the rails or fittings must be misaligned with respect to the adjacent set of rails or fittings by at least 10 degrees (i.e, out of parallel) with one rolled 10 degrees.'' The petitioner requests this relief for flightdeck seats on Model A380 aircraft.

[FR Doc. 03–25048 Filed 10–2–03; 8:45 am]

BILLING CODE 4910–13–P

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Aviation Rulemaking Advisory Committee Meeting on Transport Airplane and Engine Issues

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of public meeting.

SUMMARY: This notice announces a public meeting of the FAA's Aviation Rulemaking Advisory Committee (ARAC) to discuss transport airplane and engine (TAE) issues.

DATES: The meeting is scheduled for October 15–16, 2003, beginning at 9 a.m. on October 15. Arrange for oral presentations by October 10.

ADDRESSES: Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA.

FOR FURTHER INFORMATION CONTACT: Effie M. Upshaw, Office of Rulemaking, ARM–209, FAA, 800 Independence Avenue, SW., Washington, DC 20591, Telephone (202) 267–7626, FAX (202) 267–5075, or e-mail at *effie.upshaw@faa.gov.*

SUPPLEMENTARY INFORMATION: Pursuant to section 10(a)(2) of the Federal Advisory Committee Act (Pub. L. 92–463; 5 U.S.C. app. III), notice is given of an ARAC meeting to be held October 15–16, 2002, in Arlington, VA.

The agenda will include:

Wednesday, October 15

- Opening Remarks
- FAA Report
- European Aviation Safety Agency (EASA)/Joint Aviation Authorities (JAA) Report
- Transport Canada Report
- ARAC Tasking Priorities Discussion/Moratorium
- Avionics Harmonization Working Group (HWG) Report
- Ice Protection HWG Report
- Powerplant Installation HWG Report
- Human Factors HWG Report
- Mechanical Systems HWG Report and Approval
- Airworthiness Assurance Report and Approval
- Discussion of tasking on equipment, systems, and installations on transport category airplanes

Thursday, October 16

- General Structures HWG Report and Approval
- 2004 meeting schedule
- Written reports and statuses may be provided for the following HWGs—Engine, Electromagnetic Effects, Flight Test, Seat Test, Flight Control, Flight Guidance, System Design and Analysis, Electrical Systems, Loads and Dynamics, and Design for Security—and the Continued Airworthiness Working Group.

Three working groups will be seeking approval of reports/documents:

1. The Mechanical Systems HWG on ventilation and cabin pressurization;
2. The Airworthiness Assurance Working Group on widespread fatigue damage; and
3. The General Structures HWG on materials, birdstrike, and fatigue and damage tolerance.

Attendance is open to the public, but will be limited to the availability of meeting room space. Please confirm your attendance with the person listed in the **FOR FURTHER INFORMATION CONTACT** section no later than October 10. Please provide the following information: Full legal name, country of citizenship, and name of your industry association, or applicable affiliation. If you are attending as a public citizen, please indicate so.

The telephone number for participating in the teleconference will be available after October 6 by contacting the person listed in the **FOR FURTHER INFORMATION CONTACT** section or by going to the ARAC calendar at *http://www.faa.gov/avr/arm/araccal.htm.* Callers outside the Washington metropolitan area will be responsible for paying long distance charges.

The public must make arrangements by October 10 to present oral statements at the meeting. Written statements may be presented to the committee at any time by providing 25 copies to the Assistant Executive Director for Transport Airplane and Engine issues or by providing copies at the meeting. Copies of the documents to be presented to ARAC for decision or as recommendations to the FAA may be made available by contacting the person listed under the heading **FOR FURTHER INFORMATION CONTACT.**

If you are in need of assistance or require a reasonable accommodation for the meeting or meeting documents, please contact the person listed under the heading **FOR FURTHER INFORMATION CONTACT**. Sign and oral interpretation, as well as a listening device, can be made available if requested 10 calendar days before the meeting.

Issued in Washington, DC, on September 26, 2003.

Tony F. Fazio,

Director, Office of Rulemaking.

[FR Doc. 03–25051 Filed 10–2–03; 8:45 am]

BILLING CODE 4910–13–P

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

DEPARTMENT OF THE INTERIOR

National Park Service

Notice of Meeting of the National Parks Overflights Advisory Group

ACTION: Notice of meeting, correction.

SUMMARY: The National Park Service (NPS) and Federal Aviation Administration (FAA), in accordance with the National Parks Air Tour Management Act of 2000, announce the next meeting of the National Parks Overflights Advisory Group (NPOAG). The meeting will take place October 20, 2003, in Jackson Hole, Wyoming, not October 21 as previously announced. This notice informs the public of the changed date, location, and agenda for the meeting.

DATES: The NPOAG will meet October 20, 2003, at the Wort Hotel, 50 N. Glenwood Street, Jackson, Wyoming 83001 (telephone (307) 733–2190). The meeting will begin at 8 a.m. on Monday, October 20, 2003.

Aviation Rulemaking Advisory Committee (ARAC)
Transport Airplane and Engine (TAE) Issues

Meeting Minutes

DATE: October 15-16
TIME: 9:00 a.m.
LOCATION: Aerospace Industries Association
1000 Wilson Boulevard, Suite 1700
Arlington, VA 22209

Call to Order/Administrative Reporting

Craig Bolt, Assistant Chair, called the meeting to order. Mike Kaszycki, Assistant Executive Director, read the required statement for conducting the meeting, and attendees introduced themselves (see attached attendance sheet -- PDF). Mr. Bolt reviewed the agenda (handout 1 -- WORD) and then moved on to the Items of Interest since the last TAE meeting (handout 2 -- WORD), E-mail Update (handout 3 -- WORD), and Summary of Tasks in the Working Groups (handout 4 -- WORD). He then reviewed the Action Items from the June TAE meeting.

Item	Status
1	Completed
2	Completed --FAA New England Region indicated that new critical parts rule will have a new section number (currently under § 33.14) --Critical Parts rule will apply to critical static parts, such as diffuser cases --Static Parts rule has additional requirements, such as overpressurization
3	Completed
4	Discussion during PPHWG report
5	Discussion during PPHWG report
6	Completed
7	--FAA team (*Tiger Team)* appointed to resolve overlaps in several initiatives involving aging issues; the team is reviewing initiatives to resolve redundancies; hope to have official recommendation by month's end --Mr. Kaszycki said that there is a possibility that some tasking may come to TAE
8	Discussion during status report
9	Completed
10	Mr. Bolt to contact Thaddee Sulocki for confirmation that he provided Civil Aviation Authority (CAA) opinion on § 25.671

Mr. Bolt distributed the Open/Completed Tasking Charts (handout 5 -- PPT) asking that comments be forwarded to him.

FAA Report

Mr. Kaszycki provided an overview of the status report (handout 6 -- PPT). He indicated that three final rules had been issued (security considerations for large cargo operations, thermal acoustic insulation materials, and material strength properties and design properties). Twelve rulemakings are in headquarters for coordination and three taskings are under development (low fuel level warning, wheel well fire protection and tire burst, and 25.1309 (equipment, systems, and installations), phase 2). Four policy notices have been issued (no smoking placards and signs; AC 25-613 that accompanies the materials strength properties final rule; use of surrogate parts when evaluating seatbacks and seatback mounted accessories; and AC 39-8 addressing propulsion continued airworthiness). Three policies are out for comments. Twenty-six rules are being bundled into one notice of proposed rulemaking (NPRM). The bundle will include categories 1 and 3 harmonization projects that the Joint Aviation Authorities (JAA) have already adopted.

Discussion items included FAA prioritization lists; when industry gets notification of rulemakings/appropriate time for industry to get involved in rulemaking process; and industry's responsibility to taskings that it may not support but the FAA supports. Other discussion items included activities that will use other methods of resolution, rather than rulemaking; use of issue papers and special conditions; and rulemaking by policy.

Mr. Kaszycki indicated that, based on the prioritization efforts, the FAA plans to lift the moratorium. He said that the fuel tank vent protection tasking to the PPHWG would be formally detasked. Also, he asked for input from TAE on going forward with the tasking on the rotor burst (to define "minimize").

Parties at the Harmonization Management Team meeting agreed that the HMT prioritization process is good. HMT looked at how often prioritization process should take place. HMT decided to review list of rules every 2 years, and have ad hoc meetings to look at new emerging issues.

Mr. Kaszycki explained the purpose of the Tiger Team, which is reviewing rulemakings addressing Enhanced Airworthiness Program for Airplane Systems (EAPAS), Widespread Fatigue Damage, Corrosion Prevention, and Fuel Tank System Fault Tolerance Evaluations, and the Interim Aging Aircraft rule to determine where there are overlaps.

He also indicated that the templates in rulemaking documents are being reviewed; some material in the NPRM will not be repeated in the final rule, and economic analysis will be shortened.

JAA Report

Edmond Boullay indicated that the transition to EASA was progressing smoothly. Four directors will be appointed. All airworthiness directives (AD) from foreign manufacturers will be systematically incorporated into EASA system. Discussion included whether EASA would have the same effectivity for ADs as foreign manufacturers. The location of the EASA headquarters has not been finalized.

Transport Canada Civil Aviation (TCCA) Report

Maher Khouzam was unable to attend the meeting. When asked if he could provide any input, Keith Barnett indicated that he could not. However, he requested an update on the Changed Product Rule (CPR). Mr. Kaszycki indicated that CPR had been discussed at the annual FAA/TCCA conference held the previous week in Seattle. He indicated that the FAA has setup a Continuous Improvement Team (CIT) to deal with issues affecting the CPR as they arise. He indicated that the TCCA team thought things were going along well. Large-scale initiates should keep the CIT in place. New people will have to be trained as they come on board.

Executive Committee

Mr. Bolt indicated that the last meeting had been cancelled. The next meeting is scheduled for November 13. He indicated that Nick Sabatini had been invited to speak at the meeting.

Harmonization Team Meeting

No meeting has been held since the last TAE meeting. The next HMT meeting is scheduled for March 16-18, 2004 in Hoofddorp.

ARAC Tasking Priorities Discussion

Discussion items included the use of ARAC recommendations as a means of compliance, and missing taskings and recommendations on the ARAC web page. Participants were advised to contact Gerri Robinson of the FAA Office of Rulemaking on updates.

Human Factors Harmonization Working Group (HWG)

Kathy Abbott and Curt Graeber (by telephone) provided the status report (handout 7 -- PPT). Dr. Abbott provided an explanation and rationale for why the working group had chosen the alternative approach to address design characteristics that lead to or contribute to error, rather than address design-related error in revising the current § 25.771(a) and the related advisory material. She indicated that the JAA had tentatively agreed to the alternative approach.

Dr. Abbott indicated that the working group membership was stable even though only one JAA representative was participating with the working group. Dr. Graeber indicated that the commitment of the working group members was amazing

Discussion items included the affect the JAA interim policy would have on rulemaking; result of prototype testing to show compliance with the alternative approach; degree of misinterpretation; concern for future, potential errors; clarification of terms "intervene in a manner appropriate to the task" and "effects resulting from flightcrew actions" in rule language; need for thorough detailed explanation in preamble material in working group report of newly proposed rule § 25.1301 rule with existing rules; need for discussion about § 25.1309; and use of § 25.1309 quantitative data indirectly with § 25.1301 data. Extension of the report deadline to March and FAA commitments were also discussed.
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Ice Protection HWG

Jim Hoppins provided a status report (handout 8 -- PDF). Bob Park, Jeanne Mason, Gene Hill, Andrew Lewis-Smith, and Grant Maier also participated by telephone; Mr. Park also provided a status report (handout 9 – PPT). The following highlights were provided:

Task	Discussion/Action
1	--Working group to write a proposal to discuss TSO --Aircraft Certification to draft language and working

	group to review specification and make a recommendation to TAE
2	--Draft advisory circular about 90% complete, and ready to go to FAA technical writers --Appendix X about 95% complete --Meteorological Services of Canada to run values --Flight Test HWG considering impact of Appendix X --Combined Engine subgroup has been formed --Working group is comfortable with appendix but needs more information on mixed-phase conditions --Mr. Kaszycki expressed concern on working group need for more research on effects of mixed phase conditions --Working group advised to revise schedule to include subgroups
4	--Need to review advisory materials --Working group to write up a proposal to close out task and submit to TAE

Other discussion items included timing of economic analysis, technology roadmap and schedule, whether it is necessary to holdup airframe icing rule, and inclusion of engine aspects in rule.

Powerplant Installation HWG

Andrew Lewis-Smith, reporting by phone, provided the following highlights from the status report (handout 10 -- WORD):

Section	Discussion/Action
25.903(d)	--Project is on track; estimated completion date—November 30 --Working group needs input on whether rotorburst should go forward
25.1305	--Progress is good
25.975	--Working group needs direction on fuel vent fire protection and decision on whether it falls into moratorium --Mr. Kaszycki to check with FAA working group representative before making any decisions

Avionics HWG

Comments were represented to Clark Badie on draft regulatory language to § 25.1322 and accompanying advisory material. Discussion items included retrofit applicability and conflict with Changed Product Rule; applicability to other than part 121 operators; and inclusion of applicability to traffic alert and collision avoidance systems (TCAS) or terrain avoidance warning systems (TAWS). Other discussion items included process in the event consensus cannot be met; use of the terms "warning" or "caution" rather than "alerting"; use of the terms "should" and "must," and process for documenting dissenting opinions.

Mechanical Systems HWG

Pat Waters provided a status report (handout 11 -- PPT). After summarizing the working group report for § 25.831(g) (handout 12 -- WORD), TAE members unanimously approved forwarding the report to the FAA.

Mr. Waters then summarized the working group report for § 25.841(a)(2)(3) (handout 13 -- WORD). Discussion items included current work being done by FAA Transport Airplanes Directorate and Civil Aeromedical Institute (CAMI) to develop an interim policy; inability to certify newly developed aircraft under current policy; exemption process; and public perception on loss of life. Other discussion items included failure to properly include working group members' dissenting opinions in package and inclusion of engine failure in rule language. Members voted 7 to 2 in favor, with one abstention, to forward the report to the FAA. The Air Line Pilots Association and the Association of Flight Attendants opposed the motion, and the Regional Airline Association abstained.

Airworthiness Assurance Working Group

Amos Hoggard, reporting by telephone, provided a status report (handout14), and a summary of the Widespread Fatigue Damage (WFD) Bridging task reports presented for approval by TAE members. The reports addressed Multiple Elements Damage (handout 15 -- WORD), Non Destructive Inspections (handout 16 -- WORD), Mandatory Modifications, and WFD Training Syllabus. Discussion items included reason for accelerating rulemaking process; number of incident reports each year; relationship of WFD and the Aging Aircraft rules; and FAA Tiger Team efforts. Members voted unanimously to forward package to the FAA

Mr. Hoggard then summarized the working group's activity on and a description of a task addressing the Aging Airplane Safety interim final rule (AASIFR) (handout 14 -- WORD). Mr. Hoggard indicated the working group was developing the tasking on an ad hoc basis. Mr. Kaszycki indicated the Tiger Team is reviewing some of the issues. The FAA, however, could not support the development of the task; however, an FAA representative would participate in the working group. Mr. Hoggard indicated that the working group is concerned about the December 2003 effective date for the interim Aging Aircraft rule is December 2003, and the December 2007 compliance date. Member discussed whether ARAC could support the tasking.

Review of June Minutes

Members provided revisions to meeting minutes. Corrected copy of minutes will be sent to Mr. Bolt for distribution to members.

General Structures HWG

Andy Kasowski, reporting by telephone, provided a status report (handout 17 -- PPT), and summarized the working group reports (handouts 18 - WORD, 19 - WORD, 20 - WORD) presented to TAE for approval.

Section	Discussion/Action
§ 25.571	-- Discussion items included whether structural damage was in line with the Technical Oversight Group re Aging Aircraft position, "safe life" certification for engine mounts, establishing a limited life validity for

	the maintenance program, and establishing material for fail-safe structural damage capability --Unanimous approved with 1 abstention (Aerospace Industries Association of America (AIA)) to forward to FAA
§ 25.603	--Unanimous approval to forward to FAA
§ 26.631	--Working group unable to reach consensus because of FAA and JAA difference on bird weight limit and reduction in cutback speeds --Unanimous approval to forward to FAA with dissenting opinions --Assistant chair to draft transmittal letter with dissenting opinions
25.365(d) and AC 25-20	--Working group recommends removing task from working group and defer to MSHWG -Additional meetings needed to resolve issue on flight level; majority of working group members agree with flight level (FL) of 41,000 feet, but could compromise with an FL of 45,000 feet --Issue raised by members not in attendance at meeting indicate that they could not compromise with 45,000 feet --Working group was instructed to document dissenting opinion and submit report to TAE for November meeting

§ 25.1309 Phase II Task Discussion (handouts 21 – PPT, and 22 - WORD)

Linh Le, Chuck Huber, David Armstrong, Andrew Lewis-Smith, and Roger Sekijima participated by telephone. Task would address high priority items recommended in phase 1 and ICA issues with a 1 to 2 year timeframe for completing task. The goal is to revise AC addressing § 25.1309, § 25.1529, and appendix H25.4, and to prepare new AC materials. AC 25-19 may be revised by linking CMR to it. Recommendations from Certification Process Study (CPS) would be incorporated as appropriate. Two teams would be involved. Team 1A would identify safety critical process and information necessary to protect those features in operations. Team 1B would insure that FAA and industry provide data to identify accident precursor.

TAE members questioned timing of this task with the CPS recommendations. They also addressed need for communication with HFHWG to insure that there is no conflict in work being done to §§ 25.1302 and 25.1309. AIA indicated that the proposal should fully address where/what improvements are needed in §§ 25.1309 and 25.1529 and the need to make sure certification and maintenance communities understand and agree with tasking. AIA also questioned whether treatment of specific risk needed to be tasked and what safety benefits would result from such activity.

FAA expects formal tasking by next meeting, rulemaking project record by February 2004, and project kickoff by Spring 2004. Co-chairs need to be identified as soon as possible.

Presenters were told to address concerns, justification and rationale for tasking, safety benefits considering risk, and availability of resources at next TAE meeting.

Loads and Dynamics HWG

Larry Hanson and Todd Martin, reporting by telephone, provided a summary of the status report (handout 23 - PPT). Mr. Hanson indicated that the FAA Tech Center had completed fireproof testing. A preliminary review indicated Inconel 718 may be considered as "fireproof" for engine mounts but aluminum and titanium did not pass the test. Airbus and General Electric have proposed additional testing of larger diameter bars, which could potentially show better results for titanium; other group member do not support additional testing.

Discussion items included titanium vs. steel to show compliance, rather than requiring fire testing; acceptable means of compliance for titanium mounts; harmonization can be achieved through advisory circular since testing is only required when aircraft is brought into the United States.

The current plan for completion of the task is:

- No additional FAA Tech Center testing
- Remove "fireproof rating" table from AC. Replace with a paragraph noting Inconel 718 as fireproof material.
- Improve AC (paragraphs 7 – 9) with regard to acceptable means of compliance, using past compliance findings as a basis.
- Present revised AC for TAE issues group's approval

Flight Guidance HWG

John Ackland, reporting by telephone, indicated that the working group was conducting a phase 4 review. He indicated that the FAA had provided fairly significant changes to the working group document, and that for movement of language from the advisory material to the rule language will require a good deal of effort, especially in getting team members together. The NPA comment period closed in September, and the JAA received numerous comments. The FAA believes that its comments do not represent a significant change to the document. The working group will review comments at its next working group meeting.

Wrap-up

Action Items: Mr. Bolt reviewed the Action Items, and indicated that the list would be sent to members electronically.

Next Meeting: February 10-11, The Boeing Company, Arlington, Virginia.

Public Notification

The *Federal Register* published an announcement notice of this meeting on October 3, 2003 (handout 24 - PDF).

Approval

I certify the minutes are accurate.

s/sCraig R Bolt

TAEIG Action Items – October 15/16, 2003

1. Dionne Krebs to provide reference to most recent regulatory agenda that was published in Federal Register. – Done

2. TAEIG members should review ARAC website to be sure appropriate recommendations are on website. Gerri Robinson – Office of Rulemaking, should be contacted for corrections.

3. Mike Kaszycki to review acceptability of moving HFWG report from February 2004 to March 2004. – Done and agreed

4. PPIHWG sub group that is supporting IPHWG is to look at moving completion date of work to late '04 instead of June '05.

5. FAA to review course of action for 25.1309 phase II considering feedback provided at TAEIG meeting.

6. GE to review with GSHWG concerns on damage tolerance of engine mounts.

Carryover from October 2002 Meeting

1. Effie Upshaw to check status of EHWG recommendation on airport bird control.

AVIATION RULEMAKING ADVISORY COMMITTEE
ON
TRANSPORT AIRPLANE AND ENINGE ISSUES
AT
AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA
Meeting Sign-In Sheet

October 15-16, 2003

Name	MEMBER	NONMEMBER	Organization/Affiliation	Telephone No.	Fax No.	E-Mail Address
Sarah Knife		✓	GE	513 243 2032	513 243 0164	sarah.knife@ae.ge.com
Keith BARNETT	✓		AIAC	514 855 7567	7301	keith.barnett@ nxtec. canada.com
WALTER DESROSIER	✓		GAMA	202 637 1379	202 842 4063	WDESROSIER@GAMA.AERO
CLAUDIO PASSOS SIMÃO		✓	CTA	55(12) 3941-4600	55(12) 3941-4766	CLAUDIO.PASSOS@IFI.CTA.BR
SEBASTIÃO G.M. CAVALI		✓	CTA	55(12) 3913-6131	55(12) 3941-4766	SEBASTIAO.CAVALI@IFI.CTA.BR
JIM WALLACE	✓		ALPA	703 628 6858		JIM.WALLACE@ALPA.ORG
JOE BRACKEN		✓	ALPA	703 689-4208	703 464-2104	Joe.Bracken@alpa.org
Ken Waters		✓	Boeing	425 342 2466	425-294-7434	kenneth.l.waters@boeing.com
Alicia K. Douglas		✓	FAA	202-267-9681	202-267-5075	alicia.k.douglas@faa.gov
Effie Upshaw			FAA	202 267 7626	202 267 5075	effie.upshaw@faa.gov
Kathy Abbot		✓	FAA	202 267 7192	503 213 6495	kathy.abbott@faa.gov

AVIATION RULEMAKING ADVISORY COMMITTEE
ON
TRANSPORT AIRPLANE AND ENINGE ISSUES
AT
AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA
Meeting Sign-In Sheet

October 15-16, 2003

Name	MEMBER	NONMEMBER	Organization/Affiliation	Telephone No.	Fax No.	E-Mail Address
MIKE KASZYCKI			FAA - TRANSPORT AIRPLANE DIR.	425-227-2137	x 1320	mike.kaszycki@faa.gov
Dionne Krebs			FAA - TAD	425-227-2250	x 1100	dionne.krebs@faa.gov
MIKE ROMANOWSKI	✓		AIA	703-358-1082	x 1182	romanowski@aia-aerospace.org
TOM PETERS	✓		EMBRAER	55-12-3927-3543	x 1184	TOM.PETERS@EMBRAER.COM.BR
DOUG LANE	✓		BOEING	425.237.6825	x 9941	douglas.m.lane@boeing.com
Rolf Greiner	✓		Airbus	+49407437-3392	-3383	Rolf.Greiner@airbus.com
Christopher Witkowski	✓		AFA	202-712-9743	-9792	cwitkowski@afanet.org
Dinkar Mokadam		✓	AFA	202-712-9799	-9792	dmokadam@afanet.org
EDMOND BOULLAY	✓		JAA	2029446054	6058	eboullay.jaarep@erols.com
DAVID LOTTERER	✓		RAA	202 367-1252	-2252	dlotterer@smithbucklin.com
Brenda Courtney		✓	FAA	202-267-3327	-75025	brenda.courtney@faa.gov

Transport Airplane and Engine Issues Group Meeting
Aerospace Industries Association
1000 Wilson Blvd, Suite 1700
Arlington, VA 22209

DRESS: BUSINESS CASUAL

Wednesday, October 15, 2003 - ***Call in Number: 866-809-4014 Access code: 3581082***

9:00	Call to Order, Reading of the Procedures Statement, Review of Agenda, Meeting Logistics, Review of Action Items, Items of Interest	C. Bolt/M. Kaszycki
9:30	FAA Report	M. Kaszycki
9:45	EASA / JAA Report • JAA transition to EASA	T. Sulocki
10:15	-- ***BREAK*** --	C. Bolt
10:30	Transport Canada Report	M. Khouzam
	Excom Report	No report / No meeting
	Harmonization Management Team Report	No Report / No Meeting
10:45	ARAC Tasking Priorities Discussion / Moratorium	FAA / TAEIG
11:00	Avionics HWG • TAEIG comments on draft 25.1322 and AC 25.11	C. Badie
11:30	-- ***LUNCH*** --	
12:30	Ice Protection HWG Report • Include discussion of EHWG / FTHWG / PPIHWG support	J. Hoppins (J. McRoberts, Bob Park, A. Lewis-Smith)
1:00	Powerplant Installation HWG	A. Lewis-Smith
1:30	Human Factors HWG Report	K. Abbott
2:00	-- ***BREAK*** --	
2:15	Mechanical Systems HWG Report • Vote on 25.831(g) and 25.841(a)(2,3) packages	P. Waters
3:00	Airworthiness Assurance HWG • Vote on WFD Bridging Task	A. Hoggard
3:45	25.1309 Phase II Task Discussion	FAA / TAEIG
4:00	-- ***ADJOURN*** --	

Transport Airplane and Engine Issues Group Meeting
Aerospace Industries Association
1000 Wilson Blvd, Suite 1700
Arlington, VA 22209
(Continued)

Thursday, October 16, 2003 - *Call in Number: 866-809-4014 Access code: 3581082*

9:00	Call to Order/Review of Minutes from previous meeting	C. Bolt/M. Kaszycki
9:30	General Structures HWG Report • Vote on 25.603 (Materials), 25.631 (Birdstrike) packages and 25.571 (Fatigue and Damage Tolerance)	A. Kasowski
10:30	-- ***BREAK*** --	
10:45	• Engine HWG • Continued Airworthiness WG Status • Electromagnetic Effects HWG • Flight Test HWG • Seat Test HWG • Flight Control HWG • Flight Guidance HWG • System Design and Analysis • Electrical Systems HWG • Loads and Dynamics HWG • Design for Security	Written or verbal reports as required
11:15	Review Action Items / 2004 Meeting Schedule	C. Bolt
11:30	-- ***ADJOURN*** --	

Items of Interest Since June 2003 Meeting

1. TAEIG letter to FAA, Design for Security/Ease of Search, July 22, 2003.

2. TAEIG letter to FAA, Airworthiness Assurance – Multiple Complex STC's, September 18, 2003.

3. TAEIG letter to FAA, General Structures HWG, September 19, 2003.

4. Final Rule, Revised Requirement for Material Strength Properties and Design Values for Transport Airplanes, 25.613, August 5, 2003.

5. Published, AC39-8, Continued Airworthiness Assessments of Powerplants and APU Installations on Transport Category Airplanes, September 2003.

E-MAIL UPDATE SINCE JUNE 2003 MEETING

6/9/03	Canadian Transportation Safety Board Letter
6/9/03	Updated e-mail list since February's meeting
6/10/03	TAEIG Tasking Charts
6/10/03	AVHWG Status Report
6/10/03	REVISED AGENDA FOR NEXT WEEKS MEETING
6/16/03	HF HWG Report
6/16/03	Correction to DFS Presentation
6/16/03	MSHWG Report to TAEIG, June, 2003
6/16/03	IPHWG Report to TAEIG
6/16/03	FW: GSHWG TAEIG Report June 2003
6/16/03	FAA Acceptance letter - IPHWG recommendation package
6/16/03	April 11, 2003 Letter from the FAA
6/16/03	FTHWG TAEIG Report
6/16/03	FTWHG SoW
6/20/03	TAEIG Action Item/ AAWG Report
6/23/03	TAEIG: FAA presentation from June meeting
6/23/03	TAEIG - June PPHIWG Report
7/15/03	TAEIG Working Group Meeting Location Approval Form
7/15/03	TAEIG Meeting schedule
7/17/03	TAEIG – June 16/17, 2003 Action Items
7/31/03	TAEIG: New GACO tasks and withdrawals
7/31/03	TAEIG: Feb '03 meeting minutes

8/5/03	TAEIG: Final 25.831(g) WG Report from MSHWG
8/5/03	TAEIG: GSHWG Submittal - 25.571 Damage Tolerance and Fatigue Evaluation of Structure
8/18/03	TAEIG: Final 25.841(a) WG Report from MSHWG
8/18/03	TAEIG: 25.841(A) wg Report, Dissenting Positions
8/20/03	TAEIG: GSHWG Submittal - 25.603 Materials
8/20/03	TAEIG: GSHWG Submittal - 25.631 Birdstrike
8/22/03	TAEIG: AAWG Reports 1 of 3
8/22/03	TAEIG:AAWG Reports 2 of 3 email
8/22/03	FW: TAEIG: AAWG Reports 3 of 3 emails
9/10/03	TAEIG- Next Meeting info
9/10/03	TAEIG: AVHWG Draft Rule 25.1322 and AC/AMJ
9/10/03	ARAC tasking
9/10/03	TAEIG:PPIHWG Proposed work statement to support IPHWG SLD task
9/16/03	TAEIG: Project Status Reports
9/16/03	Draft Agenda for October 15th and 16th ARAC Meeting

FAA comments on Working Group Tasking Charts:

<u>Working Groups Under TAEIG – Open Taskings</u>

AAWG: Ok

ASHWG: Ok

FTHWG: Ok

GSHWG: 25.683 was already submitted to the FAA (9/19/03)

HFHWG: Ok

IPHWG:
- Should 25X1420 be added to the list of regulations on the left side of the chart? That will be the proposed SLD requirement number.

MSHWG: Ok

PPIHWG: Ok

<u>Working Groups Under TAEIG – Completed Taskings</u>

AAWG:
- Our specialist indicated that the AC 91-56 is only a draft AC. So, maybe this should be moved back to the left side of the chart.

ASHWG: Ok

BSHWG: Ok

Cargo Class B & Comp. HWG: Ok

CAAWG: Ok

DFSHWG:
- Should we remove ease of search from the left hand side? It is contained within the ICAO Annex 8 work which is already listed on the left. Or is there some reason to single it out?
- On the right side we could add "ICAO Annex 8 – Flight Deck Doors" if we want to reference the fact that the FAA has issued rulemaking for that portion of the tasking.

DVHWG:

ESHWG:
- Add 25.1353(e) to the left side of the chart

EEHWG: Ok

EHWG: Ok

FCHWG: Ok

FGHWG: Ok

FTHWG:

- The following rules were harmonized outside of ARAC (FTHWG was not involved), so if appropriate, add a note to that effect or please remove them: 25.109(a), 25.113, 25.103, 25.121, 25.125, 25.207)
- 25.1501, 25.1583(k) and 25X1591 should be moved to the left side of the chart, they are all connected with contaminated runway requirements. We agreed to hold those rules until the related operating rules are published (AFS action).
- The rightmost column on the left side of the chart (25.1527 – 25X1516) should be on the right side of the chart (Amdt 25-105, 6/26/01)

GSHWG: Ok

HTHWG: Ok

LDHWG:

- 25.34(b) should be deleted as it is really 25.341(b) which is addressed in the rulemaking (25.341) already listed on the right side
- 25.775(b)(d) should be removed because it is part of the GSHWG list
- 25.335 should be removed from the left side since 25.335(b)(2) is already on the right side (AC published 9/29/00 – no rule change)
- 25.493(d) should be moved to the right side (Amdt. 25-97, 5/27/98)
- 25.723(a) should be moved to the right side (Amdt. 25-103, 6/15/01; related AC published 5/25/01)
- AC 25.491-1 should be moved to the right side (AC published 10/20/00 – no rule change)
- The rules listed in the leftmost column on the left side of the MSHWG should be moved to the right side of LDHWG: 25.351(a)(1), 25.427, 25.473, 25.479, 25.483, AC 25.629-1A (note that 25.371 is already under the left side of LDHWG and 25.493 is already represented by 25.493 under LDHWG (which was moved to the right side of the LDHWG)).

MSHWG: Ok (as long as the changes identified under LDHWG are made)

PPIHWG:

- 25.905 should be moved to the right side of the chart as the AC was published 11/3/00
- 25.945(b)(5) should be added to the left side of the chart
- 25.973 should be 25.973(d)
- 25.1305(a)(7), (d)(2)(1) should read 25.1305(a)(7), (d)(2)(i)
- APP I should read APP I (25.904)

STHWG: Ok

SDAHWG: Ok

Working Groups Under TAEIG - Open Taskings

Transport Airplane and Engine Issues Group

Legend:

Presently Tasked: | **To be Tasked:**

FAA Part 21, 25, 33, 35
JAR 21, 25, E, P, Subpart J

Airworthiness Assurance Harmonization Working Group
A. Carter - Delta
K. Gopinath - Boeing

WFD Bridging

Avionics Systems Harmonization Working Group
C. Badie - Honeywell

25.1322
AC 25-11

Flight Test Harmonization Working Group
F. Iannarelli - Aerospatiale
R. Park- Boeing

25.1001
25.177
25.207
Min.Maneuver Speeds

General Structures Harmonization Working Group
A. Kasowski - Cessna

- 25.571
- 25.631
- 25.365(d)

25.775(b)
25.683
25.603

Human Factors Harmonization Working Group
R. Curtis Graeber - Boeing
D. Ronceray - Airbus

25.HF

Ice Protection Harmonization Working Group
J. Hoppins - Cessna
C. Laburthe - Airbus

- 25.1419
- 25.773(b)(1)(ii)
- 25.1323(e)
- 25.1325(b)

Mechanical Systems Harmonization Working Group
K. (Pat) Waters - Boeing
H. Asshauer - Airbus

25.831
25.841

Powerplant Installation Harmonization Working Group
F.A. Lewis -Smith - Boeing
J. Nanche - Airbus

25.975
25.903(d)

Rev. Sept. 2003

- *Indicates SRD items.*

Working Groups Under TAEIG - Completed Taskings

Transport Airplane and Engine Issues Group

Legend: FAA Actions Pending | FAA Actions Completed

FAA Part 21, 25, 33, 35
JAR 21, 25, E, P, Subpart J

Airworthiness Assurance Harmonization Working Group
A. Carter - Delta
K. Gopinath - Boeing

Repairs
WFD Report
WFD
Complex STC

AC 91-56

Avionics Systems Harmonization Working Group
C. Badie - Honeywell

- 25.703(a)&(b)
- 25.1333(b)

25.1423
25.1331
25X1328

Brake Systems Harmonization Working Group
R. Amberg - Boeing

- 25.735

25.731

Cargo Class B & Comp. Harmonization Working Group
D. Klippert(Retired) - Boeing

25.857(b)

Continued Airworthiness Assessments Working Group
S. Knife - GE

AC 39-8

Design for Security Harmonization Working Group
M. Allen- Boeing

ICAO Annex 8 Ease of Search

Direct View Harmonization Working Group
D. Klippert- Boeing

Flight Attendant Direct View AC

Electrical Systems Harmonization Working Group
B. Overhuls - Boeing
R. Bewsey - JAA

- 25.1351(b), (c)(d)

25.1353(a), (c)(5),(c)(6), (d)
25.1355(c)
25.1357
25X1360(a)(b)
25X1362

- 25.1431(d)
- 25X.899

25.869(a)
25.1309
25.1310

- 25.1363

Electromagnetic Effects Harmonization Working Group
O. Spiller - Airbus
J. Cross - Raytheon

- 25.581
- 25.1316
- 25.1317

Engine Harmonization Working Group
J. McRoberts - Rolls-Royce
F. Fagegaltier - JAA

33.27
FAR 35/JAR-P
Bird Phase II
Critical Parts

- 33.17

33.28

- 33.75
- 33.64
- APU
- OEI Shafts

- 33.76

Flight Controls Harmonization Working Group
L. Schultz - Boeing
P. Traverse - Aerospatiale

- 25.671
- 25.671(c)/25.672

Flight Guidance Harmonization Working Group
J. Ackland - Boeing
J. Beale - BAE

- 25.1329
- 25.1335

Flight Test Harmonization Working Group
F. Iannarelli - Aerospatiale
R. Park- Boeing

25.101(c)(2)
25.107(e)
25.111(c)(4)

- 25.1419
- 25.147(c)

25.161(c)(2)(e)
25.175(d)
25.177(a)(b)
25.177(c)

- 25.253(a)(3)
- 25.253(a)(5)

25.1527
25.1583(c)(f)
25.1585
25.1587
25x1516

25.109(a)
25.113
25.143(c)&(f)
25.149
25.201
25.203
25.145(c)
25.1501

25.1583(k)
25X1591

25.103
25.121
25.125
25.207
25.1323(c)

General Structures Harmonization Working Group
A. Kasowski - Cessna

AC25.775(d)

- 25.1529
- Appendix H Part 25

25.307(a)
25.603
25.621
25.683
25.783
25.963(e)(g)

AC25. 571
25.613

• Indicates SRD items.

Rev. Sept. 2003

Legend:

FAA Actions Pending | FAA Actions Completed

Working Groups Under TAEIG - Completed Taskings (continued)

FAA Part 21, 25, 33, 35
JAR 21, 25, E, P, Subpart J

Transport Airplane and Engine Issues Group

Hydraulic Test Harmonization Working Group

J. Draxler - Boeing

25.1435

Loads & Dynamics Harmonization Working Group

L. Hanson - Gulfstream

25.34(b)
25.1517
25.721
25.775(b)(d)
• 25.963(d)
25.994
25.471/ 25.519
25.865

25.301
25.302
25.305
25.331(c)
25.331(c)(1)
25.335
• 25.361/362
25.371
25.415
25.493(d)
25.723(a)
AC25.491-1

25.335(b)(2)
25.341
25.345
25.561
25.629

Mechanical Systems Harmonization Working Group

K. (Pat) Waters - Boeing
H. Asshauer - Airbus

25.351(a)(1)
25.371
25.427
25.473
25.479
25.483
25.493
AC25.629-1A

25X.1436
• 25.1438
25.1453
• 25.677(b)
• 25.729
• 25.773(b)(2)(b)(4)
• 25.1439
25.851(b)

Powerplant Installation Harmonization Working Group

F.A. Lewis-Smith - Boeing
J. Nanche - Airbus

• 25.901(c)(d)
25.903(d)(1)
25.903(e)
• 25.905
• 25.933(a)(1)
25.934
25.943/25 x1315
25.1091
• 25.1187/25.863
• 25.1193(e)
Notice 84-17A
25.973
25.1181(b)
25.1305(a)(7), d)(2)(1)

• 25.1093 (b)(1)(ii)
25.1141
25.1189(a)
25.1155
FAR 1 APP I

AC20-128A Phase I
• 25.929
25.1103
• 25.1183(c)

Seat Testing Harmonization Working Group

J.P. Deneuville - JAA/ DGAC

• 25.562
• 25.785(b)(c)&(e)

AC25.562-1A

Systems Design & Analysis Harmonization Working Group

D. Armstrong - Bombardier
J. Heckmann - Airbus

25.1301
• 25.1309
• 25.1310

• Indicates SRD items.

Rev. Sept. 2003

October 2003 TAEIG Meeting

Topics

- Rulemaking Project Status
- Non-Rulemaking Project Status
- Update on Rulemaking Prioritization
- Update on HWG Moratorium
- Update on HMT Ad Hoc Rulemaking Prioritization Team
- Other Items of Interest

October 2003 TAEIG Meeting

Rulemaking Project Status:

- Final Rules (FR) issued since June 2003:
  - Security Considerations for Large Cargo Airplanes
    (Amdt. 121-287 and 129-37, issued 7/11/03)
  - Thermal Acoustic Insulation
    (Amdt. 25-111, etc., issued 7/14/03)
  - Material Strength Properties and Design Values *
    (Amdt. 25-112, issued 7/25/03)

* Fast Track Project

October 2003 TAEIG Meeting

Rulemaking Project Status: *continued*

- 12 FRs in Headquarters coordination for issuance
- 1 FR in the Transport Airplane Directorate (TAD) for coordination
- 3 Notices of Proposed Rulemaking (NPRM) in Headquarters coordination for issuance
- 3 NPRMs in Headquarters for regulatory evaluation development
- 3 New Taskings under development

October 2003 TAEIG Meeting

Non-Rulemaking Project Status:

- Policy/Advisory Material Status (since June 2003):
  - 3 Final Policy Notices were issued:
    - No Smoking Placards and Signs (7/7/03)
    - Advisory Circular 25.613-1, Material Strength Properties and Design Values (8/6/03)
    - Use of Surrogate Parts When Evaluating Seatbacks and Seatback Mounted Accessories for Compliance with 25.562(c)(5) and 25.785(b)(d) (10/2/03)
  - 3 Notices of Policy were issued for comment:
    - Use of Surrogate Parts When Evaluating Seatbacks and Seatback Mounted Accessories for Compliance with 25.562(c)(5) and 25.785(b)(d) (6/26/03)
    - Conducting Component Level Tests to Demonstrate Compliance with 25.785(b)(d) (7/22/03)
    - Side Facing Seats on Transport Category Airplanes (9/8/03)

October 2003 TAEIG Meeting

Update on Rulemaking Prioritization

- Rulemaking projects are now being worked in accordance with:
  - AVRMT Rulemaking Priorities List
  - Joint FAA/JAA/TCCA Rulemaking Priorities List
- TAD is drafting an FYI Rulemaking Project Record for the bundled enveloping NPRM.
- The FAA will send a letter to ARAC to identify those ARAC taskings that will not receive FAA rulemaking resources.
  - The FAA is identifying appropriate ways to use the results of the ARAC recommendations:
    - Policy, Equivalent Safety Finding/Exemptions, Special Conditions, acceptable means of compliance, etc.

October 2003 TAEIG Meeting

Update on HWG Moratorium:

- May 2003: FAA issued a letter to TAEIG to place a moratorium on low priority ARAC HWG activities until prioritization is completed and implemented
  - The moratorium affects the active taskings for the Powerplant Installations HWG and General Structures HWG
- Based on the prioritization activity, the FAA will remove the moratorium:
  - Of the 5 active GSHWG taskings, all but one of the recommendations have been completed by the HWG.
  - The FAA requests that the GSHWG submit their outstanding report for a vote at the next TAEIG meeting.
  - FAA will formally de-task the PPIHWG 25.975 Fuel Tank Vent Fire Protection.
  - FAA requests TAEIG input on the PPIHWG 25.903(d) Rotorburst task.
- A letter will be sent to TAEIG to remove the moratorium.

October 2003 TAEIG Meeting

Status of the HMT Ad Hoc Rulemaking Prioritization Team:

- During the June TAEIG meeting the following actions were identified as open:
  - Determine an appropriate cycle for updating the Joint FAA/JAA/TCCA Rulemaking List
  - Develop a process to address and prioritize “pop-up” rulemaking activities
- A draft final report is being reviewed by the HMT ad hoc team
  - The team will finalize the report via telecon in late October
  - The report and recommendations will be presented to the HMT at the November 2003 meeting

October 2003 TAEIG Meeting

Other Items of Interest:

- Aging Airplane Tiger Team Activities:
  - FAA team is currently reviewing the aging airplane related initiatives to determine ways to minimize impact on industry
  - Once the team reports their recommendations, the FAA will determine and implement an appropriate strategy for aging airplane rulemaking
  - Related rulemaking projects are on hold pending the results of this activity
- Rulemaking Document Revisions:
  - Revisions to FR templates to shorten document length:
    - some of the background material in the NPRM will no longer be repeated in the final rules: for example information on ARAC, Fast Track, etc.
    - regulatory evaluation summaries, rather than more detailed discussions of the economic analysis will be included

Human Factors HWG

Curt Graeber & Kathy Abbott

Report to the TAEIG

October 15, 2003

Washington, DC

HF HWG Progress

- Draft rule
  - HWG believes that current rules (e.g., 25-771(a), 25-1301(a)) are not sufficient as regulatory basis
  - Issues were identified with error-based rule
  - HWG decided to explore an alternative approach to address the issues
  - In comparing the error-based rule versus alternative, latter seems more viable, JAR/14 CFR 25.1301(e)
  - JAA tentatively agrees that alternative draft addresses HF Interim Policy
- Now reviewing 13th draft of proposed AC/ACJ 25-HF
  - Establishing ties to existing rules
  - Refining clarity of methods of compliance
  - Focusing on usability by industry and regulators
- Organization feedback on Draft 13 and rule draft being gathered

Two Approaches to Rule Language

- Error-based: the objective is to explicitly address design-related error
- Alternative: addresses design characteristics that lead to or contribute to error

Rule Summary: Objective-based Error Concept

Installed systems (individually and in combination with other systems) must:

- Avoid design-induced error
- Make errors detectable and reversible, or effects are mitigated by the system design
- Effects must be apparent to the flight crew

Rule Draft: Error Based Approach

JAR/14 CFR Part 25.1302 (DRAFT of August 26, 2003):

A. Installed systems and equipment and associated procedures used by the flight crew to operate the airplane in normal and non-normal conditions must be shown, individually and in combination with other installed systems, to be designed to:

   i. Avoid misleading or confusing design characteristics of flight deck indications, annunciations, displays, controls, and system logic that induce flight crew errors, and

   ii. Enable the flight crew to manage errors (resulting from interaction with the installed systems) that can be reasonably expected in service from proficient and properly trained flight crews by providing means to:

      a. Enable the flight crew to detect and reverse errors, or to recover from the adverse effects of errors, or

      b. Ensure that effects on the airplane functions or capabilities are evident to the flight crew and continued safe flight and landing is possible, or

      c. Preclude flight crew errors or their effects (e.g., switch guards, interlocks, confirmation actions, or system logic that prevents an error from having an effect).

Pros: Error-Based Approach

- Explicitly addresses the deficiency related to design-related error and tasking of this group – makes it easier to explain rationale for the rule
- Objective and logic of rule are explicitly included
- Allows multiple ways of achieving compliance and corresponding safety objective
- Some boundaries for scope of rule are addressed explicitly
- Simplifies 25.1309(c) by removing second sentence related to flight crew error after a failure
- Apparent broad coverage

Cons: Error-Based Approach

- Could be interpreted as open-ended
- Could be interpreted as involving a great deal of subjective opinion – AC/J tries to address this
- Apparent broad coverage
- Boundaries must be explicitly described
- Ties to AC/J & coverage of some topics (automation, integration, pilots characteristics) are not clear
- MoCs not completely clear
- Some applicants may attempt to use analysis as primary MoC which may not result in better design

Alternative Rule Approach - Concept

- Focus on characteristics that lead to error
  - Information, controls and system logic required for flight crew tasks must be provided in accessible, usable, unambiguous form
  - Must address integration with other systems

Alternative Rule Approach

JAR/§ 25.1301 Function and Installation (Draft of Oct. 10, 2003)

Each item of installed equipment must-

(e) If intended for the flight crew's use from the normally seated position in the flight deck, be of a kind and design such that the flight crew can safely perform their tasks associated with the intended function of this and other such equipment in normal and non-normal conditions.

(1) Flight deck controls and information must be sufficient to accomplish these flight crew tasks.

(2) Installed equipment behavior that is operationally relevant to the flight crew tasks must be:

i. Predictable and understandable for a proficient and properly trained flight crew, and

ii. Designed to enable the flight crew to intervene in a manner appropriate to the task.

Alternative Rule Approach

JAR/§ 25.1301 Function and Installation

(3) The information in (e)(1) must:

i. Be presented in an unambiguous form, at a suitable resolution/precision,

ii. Be accessible and usable by the pilots in a manner consistent with the urgency, frequency, and duration of their tasks, and

iii. Be sufficient to provide awareness to the flight crew of the effects resulting from flight crew actions on the aircraft or systems.

(4) The design of the equipment must enable the flight crew to manage errors resulting from flight crew interaction with the installed equipment and that can be reasonably expected in service from proficient and properly trained flight crews.

Pros – Alternative Approach

- Addresses design characteristics that lead to error rather than error itself (potentially allowing for more focused discussions between the applicant and authority)
- Narrows the focus to certain aspects of design characteristics, allowing more focused discussions
- Explicit ties to the flight crew tasks
- Potentially easier to tie to methods of compliance
- Allows a more direct regulatory basis for sections such as integration & automation

Cons – Alternative Approach

- Rule language not as mature as error-based rule
- Tie to AC/J structure is not clear at this point
- The list of characteristics may not be complete, thus leaving "holes" that the error-based rule would cover
- Being based on design characteristics may not result in applicant taking a more structured and thorough approach to the design process

("ERROR RULE")
JAR/14 CFR Part 25.1302

A. Installed systems and equipment and associated procedures used by the flight crew to operate the airplane in normal and non-normal conditions must be shown, individually and in combination with other installed systems, to be designed to:

i Avoid misleading or confusing design characteristics of flight deck indications, annunciations, displays, controls, and system logic that induce flight crew errors, and

ii Enable the flight crew to manage errors (resulting from interaction with the installed systems) that can be reasonably expected in service from proficient and properly trained flight crews by providing means to:

a Enable the flight crew to detect and reverse errors, or to recover from the adverse effects of errors, or

b Ensure that effects on the airplane functions or capabilities are evident to the flight crew and continued safe flight and landing is possible, or

c Preclude flight crew errors or their effects (e.g., switch guards, interlocks, confirmation actions, or system logic that prevents an error from having an effect).

B. Subparagraph A assumes a proficient and properly trained flight crew and does not require consideration of acts of violence, willful negligence, or non-compliance with established or published procedures, disregard of alerts or displayed information, or errors in judgment or airmanship, that are not contributed to by the design.

Note: This is assuming that 25.1309(c), second sentence will be deleted.

("ALTERNATIVE RULE")

JAR/§ 25.1301 Function and Installation

Each item of installed equipment must-

(e) If intended for the flight crew's use from the normally seated position in the flight deck, be of a kind and design such that the flight crew can safely perform **their tasks associated with the intended function** of this and other such equipment in normal and non-normal conditions.

1 Flight deck controls and information must be sufficient to accomplish the flight crew tasks.

2 Installed equipment behavior that is operationally relevant to the flight crew tasks must be:

i Predictable and understandable for a proficient and properly trained flight crew, and

ii Designed to enable the flight crew to intervene in a manner appropriate to the task.

3 The information in (e)(1) must:

i Be presented in an unambiguous form, at a suitable resolution/precision,

ii Be accessible and usable by the flight crew in a manner consistent with the urgency, frequency, and duration of their tasks, and

iii Be sufficient to provide awareness to the flight crew of the effects resulting from flight crew actions on the aircraft or systems.

4 The design of the equipment must enable the flight crew to manage errors resulting from flight crew interaction with the installed equipment and that can be reasonably expected in service from proficient and properly trained flight crews

HF HWG Issues

Participation:

- Only one JAA representative remaining.
- Membership is now stable and sufficient to accomplish the task.
- Commitment is high.

Scope:

- Schedule and scope remain ambitious
- Reviewing existing FAR/JARs and AC/ACJs related to flight crew error and performance to assess:
  - Adequacy of explaining the associated regulations and MOCs
  - Whether explanations exceed the airworthiness standards of the regulations
- Progress satisfactory, final report will be available February 2004.

Future Meetings

Next (and final) meeting:

- Dates: **Late** January 2004
- Location: European location

Ice Protection HWG Status

Presentation to ARAC TAEIG

October 15, 2003

"As a short-term project, consider the need for a regulation that requires installation of ice detectors, aerodynamic performance monitors, or another acceptable means to warn flight crews of ice accumulation on critical surfaces requiring crew action (regardless of whether the icing conditions are inside or outside of Appendix C of 14 CFR Part 25). Also consider the need for a Technical Standard Order for design and/or minimum performance specifications for an ice detector and aerodynamic performance monitors. Develop the appropriate regulation and applicable standards and advisory material if a consensus on the need for such devices is reached."

- ⇨ Proposed Part 121 rule submitted to TAEIG with FAA legal and economic analysis, September 2002
- ⇨ Proposed Part 25 certification rule "fast tracked" in Dec 2000, no further WG actions

Task 1 Ice Detector TSO

Proposed Operational and Certification rules address Task 1, except for TSO aspect

- "Also consider the need for a Technical Standard Order for design and/or minimum performance specifications for an ice detector and aerodynamic performance monitors. Develop the appropriate regulation and applicable standards and advisory material if a consensus on the need for such devices is reached."

IPHWG recommended working TSO after Task 2

- An inquiry has been made to AIR-120 as to whether TSO could be drafted based on existing SAE/EUROCAE specification and submitted to IPHWG for review and comment
- No change

"Review National Transportation Safety Board recommendations A-96-54, A-96-56, and A-96-58, and advances in ice protection state-of-the-art. In light of this review, define an icing environment that includes supercooled large droplets (SLD), and devise requirements to assess the ability of aircraft to safely operate either for the period of time to exit or to operate without restriction in SLD aloft, in SLD at or near the surface, and in mixed phase conditions if such conditions are determined to be more hazardous than the liquid phase icing environment containing supercooled water droplets. Consider the effects of icing requirement changes on 14 CFR part 25 and revise the regulations if necessary. In addition, consider the need for a regulation that requires installation of a means to discriminate between conditions within and outside the certification envelope."

- ⇨ Removed reference to Part 23 per FAA letter 2/12/02

Status Task 2

Concept approved at March '02 TAEIG Meeting

- ⇨ Proposed rule §25.1420 would require unrestricted operation or exit from SLD
- ⇨ Includes definition of Appendix X (SLD envelopes)

June & Sept IPHWG Meeting Status

- ⇨ Draft AC Materials (~95%)
  - Released to sub-groups for consideration in their efforts
- ⇨ Definition of Appendix X (~95%)
  - Released to sub-groups for consideration in their efforts
  - Meteorological Services of Canada to verify values based on current data (EOY 2003)
  - Data is still being added to database, but not expected to significantly alter current version.
- ⇨ Working group report for preamble considerations (~60%)

Status Task 2 (continued)

Issue of devising "requirements to assess the ability of aircraft to safely operate" requires consideration of more than airframe ice protection

- Letters sent out to FTHWG, PPIHWG & EHWG via TAEIG
- Joint HWG meeting held in 1/2003 to provide information on SLD
  - ⇨ Representatives/delegates from working groups attended

Issue resolution progressing

- FTHWG considering impact of Appendix X on 25.21(g) proposals
  - ⇨ Status to be provided by FTHWG
- Joint Engine and Engine Installation sub-group formed

Engine HWG's Support of IPHWG Task 2

Combined Engine & Engine Installations sub-group formed

- Have had several telecons and one meeting (Sept. 16-17)
- Findings from Sept. Meeting
  - ⇨ Have reasonable understanding of draft App. X and origins
  - ⇨ Reviewing service experience/icing events
  - ⇨ Service record indicates events in mixed-phase and SLD
  - ⇨ Mixed phase appears to be more of an issue than App. X for engine operation
  - ⇨ Concerns that App. X does not address convective conditions
  - ⇨ Need better knowledge of mixed-phase conditions
    - LWC, IWC and drop size
    - Coexistence of SLD and mixed-phase conditions
  - ⇨ Concerns over means of compliance for App. X
  - ⇨ Need more research on effects of mixed phase conditions on engine operations

Plan for Final Product

IPHWG to complete Task 2 systems aspects and environment definitions as much as possible with current information and moves on to other tasking

- ⇨ Release interim products to sub-groups to assist in tasking
- ⇨ Maintain coordination with other sub-groups as required
- ⇨ Start FAA preliminary technical writer and legal review of IPHWG products

When other working group products are received, a review & coordination period to consolidate the IPHWG/other sub-group products will likely be required

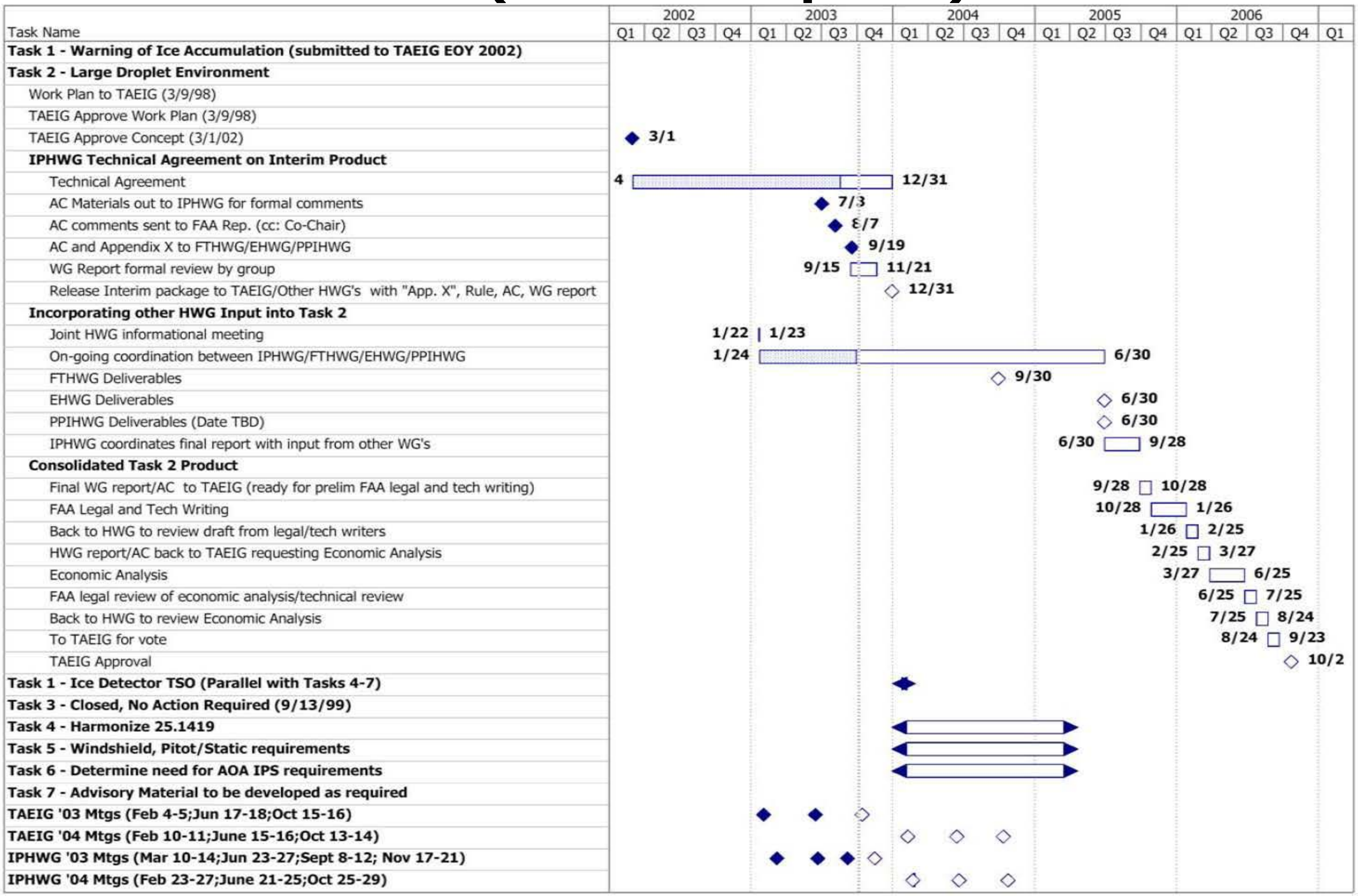
- ⇨ Telecons and/or meeting(s) as required
- ⇨ Other sub-group products are incorporated in IPHWG report as separate sections or appendices

Consolidated package submitted to TAEIG for approval and final FAA economic and legal review

Task 2 Major Issues

- Need for a "means to discriminate between conditions within and outside the certification envelope"
- Working Group Report

IPHWG Schedule (revised 3rd qtr '03)



WG Task Priorities & Schedule

Priorities

- Task 2 – Working Group Report
- TSO and Tasks 4-7 will not be addressed until technical agreement is reached on Task 2
- Task 4 could be considered complete, as AC 25.1419 was incorporated into a harmonized AC 25.1419/25.1420.

Schedule

- Moving to 3 meetings in 2004 (was 4/year last several years)
- Mtg 22 - Nov. 17-21, 2003 Madrid (INTA)
- Mtg 23 - Feb. 23-27, 2004 Ft. Lauderdale (Embraer)
- Mtg 24 - Jun. 21-25, 2004 Europe (TBD)
- Mtg 25 – Oct. 25-29, 2004 Montreal (TC)

Remaining Tasking (reference) IPHWG

Task 3 - "Propose changes to make FAR 23.1419 and 25.1419 the same"

- ⇨ Returned to FAA for further action (ref. FAA letter Sept 13, 1999)
- ⇨ No further IPHWG actions

Task 4 - "Harmonize 14 CFR 25.1419 and JAR 25.1419"

- ⇨ Revised per FAA letter of Nov. 10, 1999
- ⇨ Rule language harmonized, but advisory materials are not
- ⇨ Need to review advisory materials

Task 5 - "Consider the effects icing requirement changes may have on 14 CFR 25.773(b)(1)(ii), 25.1323(e), 25.1325(b) and JAR 25.773(b)(1)(ii), 25.1323(e), 25.1325(b). Revise and harmonize the regulations if necessary."

- ⇨ Revised per FAA letter of Nov. 10, 1999

Task 6 - "Consider the need for a regulation on ice protection of angle of attack probes"

Task 7 - "Develop or update advisory material pertinent to items 2 through 6 above."

FLIGHT TEST HWG STATUS

PRESENTATION TO ARAC TAEIG

October 15, 2003

Topics

- TAEIG Request of FTHWG
- Current Status
- FTHWG/IPHWG Coordination Issues
- Meeting Schedule

TAEIG Request of FTHWG

- The IPHWG through the TAEIG has requested coordination on this tasking relative to the flight test aspects of the proposed rulemaking. The specific aspects requiring coordination are the use of the proposed rules for § 25.21(g) relative to the unrestricted flight in SLD conditions. The present concept for unrestricted flight does not require identification or differentiation of the SLD environment from the current Appendix C icing environment. As such, it would appear appropriate to use the same set of airplane performance and handling characteristic standards as proposed under § 25.21(g) relative to Appendix C.
- The second part of the proposed IPHWG rulemaking would allow the optional certification in SLD conditions to be limited to the period required to identify and exit the conditions. The proposed performance and handling characteristic standard for this exit is the "safe return and landing" criterion commonly used in association with system failure conditions. This reduced handling criterion provides a standardized, widely accepted level of safety, yet provides greater certification flexibility for small-scale 14 CFR 25 aircraft.
- The specific action requested of the FTHWG is the consideration of the above-proposed performance and handling standards and to provide concurrence and/or comments.

Current Status

- The FTHWG met Oct. 7-9 in support of IPHWG Task 2.
  - » Tom Bond detailed the SLD Technology Roadmap.
  - » Draft Appendix X and AC 25.1419/1420 were reviewed.
  - » FAA and JAA discussed their SLD policy and actions.
  - » Several manufacturers presented their SLD experience.
  - » Changes to 25.21(g) including the validity of current exclusions for the SLD case were discussed.
  - » Subpart B rules needing changes for SLD were identified.
  - » Additional FTHWG/IPHWG coordination issues were identified, some requiring subgroup action to fully define.
  - » Propulsion representation facilitated this coordination.
- Details of FTHWG/IPHWG coord. issues to be provided.

FTHWG/IPHWG Coord. Issues

- FTHWG identified further consistency issues regarding relation between 25.1419, 25.1420, and 25.21(g).
- FTHWG to recommend adding mean vertical extent information to Appendix X.
- FTHWG is further reviewing the IPHWG draft AC and will have comments or questions regarding certain aspects (SLD scenarios, critical ice shape definitions, etc.) that affect the FTHWG rule and advisory material updates.
- FTHWG recommends that IPHWG coordinates with other WGs that may be affected by the SLD rule or advisory material (FGHWG re: autopilot, Structures re: flutter, etc.).

FTHWG Meeting Schedule

FTHWG-24	Feb. 3-5, 2004	Hoofddorp
FTHWG-25	May 4-6, 2004	USA
FTHWG-26	Sept. 28-30, 2004	Europe

TAEIG

October 15/16
2003
Arlington, VA.

Andrew Lewis-Smith

PPIHWG Report

To

15/16 October, 2003 Meeting

Of

TAEIG

Current Activities

PPIHWG met June 2003 in Brighton, UK

PPIHWG is now under a moratorium

- **25.903(d)---** **Engine Rotor Burst**
  Team progressing to document work to date----ECD November 30, 2003

- **25.1305---** **Powerplant Indications**
  (AIA/AECMA Activity)--Ongoing

  - **Ad hoc team working on SLD icing to support IPHWG.**

Current Activities (Cont.)

- **25.1305**

- **Good progress being made.**

- **Team will meet in Renton, October 21-23, 2003**

- **As this is an AIA sanctioned task, this team will continue during the PPIHWG moratorium.**

Future Activities

- **Due to the Moratorium on PPIHWG activities there are no further meetings planned.**

- **Task teams and PPIHWG will document and deliver to TAEIG the results of the work accomplished to date to enable the tasks to be restarted at a future date when the moratorium is lifted.**

Mechanical Systems Harmonization Working Group Report to TAEIG October, 2003

Kenneth (Pat) Waters, Co-Chair
Associate Technical Fellow
Environmental Control Systems
Boeing Commercial Airplane Group
425-342-2466
Kenneth.l.waters@Boeing.com

MSHWG Membership

AFFILIATIONS	VOTING MEMBERS	COMPANY
FAA	Steve Happenny	FAA
JAA	Laurent Fleury (NV) Patrick Louchez Cliff Barrow (NV)	DGAC - ESC DGAC – SFACT/N CAA - SRG
AECMA	Hartwig Asshauer (NV) Stefan Repp, Phd Amine Chabbi (NV)	Airbus Toulouse **(Co-Chair, Europe)** Airbus Germany Airbus Toulouse
AIA	Ken (Pat) Waters (NV) Mark Lord Chris Lomax (NV)	Boeing **(Co-Chair, US)** Boeing, Env. Control Systems Boeing, Env. Control Systems
Cessna	Roy Shelinbarger(NV)	Cessna
Honeywell	Stan Pollitt	Honeywell
Gulfstream	Mehdi Motlagh(NV)	Gulfstream
Fairchild Dornier	Ms. Anna Katysheva(NV)	Fairchild Donier GmBH
Embraer	Pedro Seiti Endo Acir Padilha Jr. (NV)	Embraer Embraer
Bombardier	Keith Ayre	Bombardier
UK Assoc. of Aviation Medical Examiners	Dr. Michael Bagshaw (NV)	British Airways
ATA	Charlie Bautz George Hallen (NV)	Air Transport Association Delta Air Lines
CAMI	Dr. Noal May	CAMI
academia	Dr. Stanley Mohler	Wright State University
ALPA	Bernie Sanders	Airlines Pilots Association
U.S. Air Force	Lt. Col.Thomas Morgan	Air Force Research Laboratory, Biodynamics & Protection Div.
TransportCanada	Jim Marko	Transport Canada
Association of Flight Attendants	Dinkar Mokadam	Assoc. of Flight Attendants

Status Summary

- Tasked in July 2001. WG Reports due July, 2003.
- Both the FAA and JAA have drafted differing interim policies for 25.841(a).
- Sixth meeting of MSHWG held week of June 23 in Florida
- Working Group reports complete and sent to TAEIG for approval.
- No further meetings or work scheduled.

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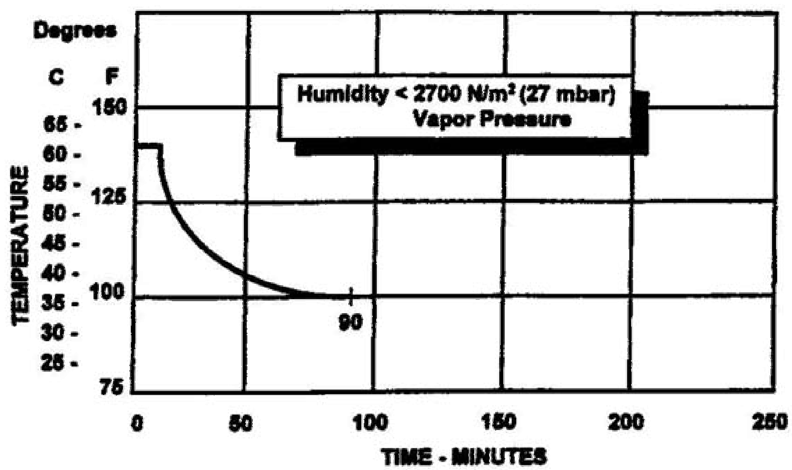
25.831(g)

Maximum Temperature/Humidity under Failure Conditions

Current 25.831(g) Rule

- **Sec. 25.831 (g)** The exposure time at any given temperature must not exceed the values shown in the following graph after any improbable failure condition.



TIME–TEMPERATURE RELATIONSHIP]

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Impact of Current 25.831(g)

- Very difficult to design to a single point humidity condition. Added weight, cost and maintenance burden would be substantial with no corresponding increase in safety.

- Meeting rule would require the addition of one or more air conditioning systems and/or flight critical software.

25.831(g)
Proposed Rule

The airplane design must accommodate any environmental control system failure condition not shown to be extremely improbable, such that:

(a) Flight deck and cabin environmental conditions shall not adversely affect crew performance that results in a hazardous condition.

(b) No occupant shall sustain permanent physiological harm.

25.831(g) Proposed AC Material

- For applicable failure events prior to final descent, an acceptable means of compliance (MOC) is considered to be a 1 deg C rise, not to exceed 38 deg C body core temperature. A 38.5 deg C body core temperature limit is acceptable, only for final approach and landing, during any time period not to exceed 20 minutes. 38.5 deg C body core temperature shall not be exceeded or sustained for any amount of time.

- The body core temperature analysis must be conducted using a comprehensive, rationale, heat balance analysis.

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25.831(g) Proposed AC Material

- Flight profiles shall consider the longest potential exposure times, including the critical diversion point with respect to temperature/humidity. The direction of flight and solar orientation should be considered in determining the time-dependent solar load into the airframe. For compliance purposes an emergency descent at maximum rate of descent speed can be assumed.

- Residual heat from equipment exposed to the flight deck or cabin will be included in the evaluation.

25.831(g) Proposed AC Material

- The condition shall be assumed to take place under the maximum solar load conditions taking into account geographical and calendar considerations for the environment the aircraft was designed to operate in. A recognized source such as MIL-HDBK-310 provides guidance for determining hot day extremes.

- The maximum occupancy shall be the basis of calculating the aircraft heat load.

25.831(g)

- Working Group Report is complete and was submitted to TAEIG for approval in July, 2003.
- All committee members attending Florida meeting voted in favor of the report except for one abstention (AFA). There were no dissenting opinions.
- TAEIG requested to approve Working Group Report.

25.841(a)(2,3)

Rapid Depressurization

Current 25.841(a)(2,3) Rule

(2) The airplane must be designed so that occupants will not be exposed to a cabin pressure altitude that exceeds the following after decompression from any failure condition not shown to be extremely improbable:

- (i) Twenty-five thousand (25,000) feet for more than 2 minutes; or
- (ii) Forty thousand (40,000) feet for any duration.

(3) Fuselage structure, engine and system failures are to be considered in evaluating the cabin decompression.

Impact of Current 25.841(a)

- No large subsonic airplane with wing mounted engines in service today can meet the current rule without a substantial decrease in certified airplane altitude. For airplanes with rear-mounted engines, pressure shell cannot be in burst zone.

- Altitude decrease invokes economic and operating penalties with no corresponding increase in safety. New airplane designs cannot compete with existing airplanes certified under rules prior to Amendment 25-87.

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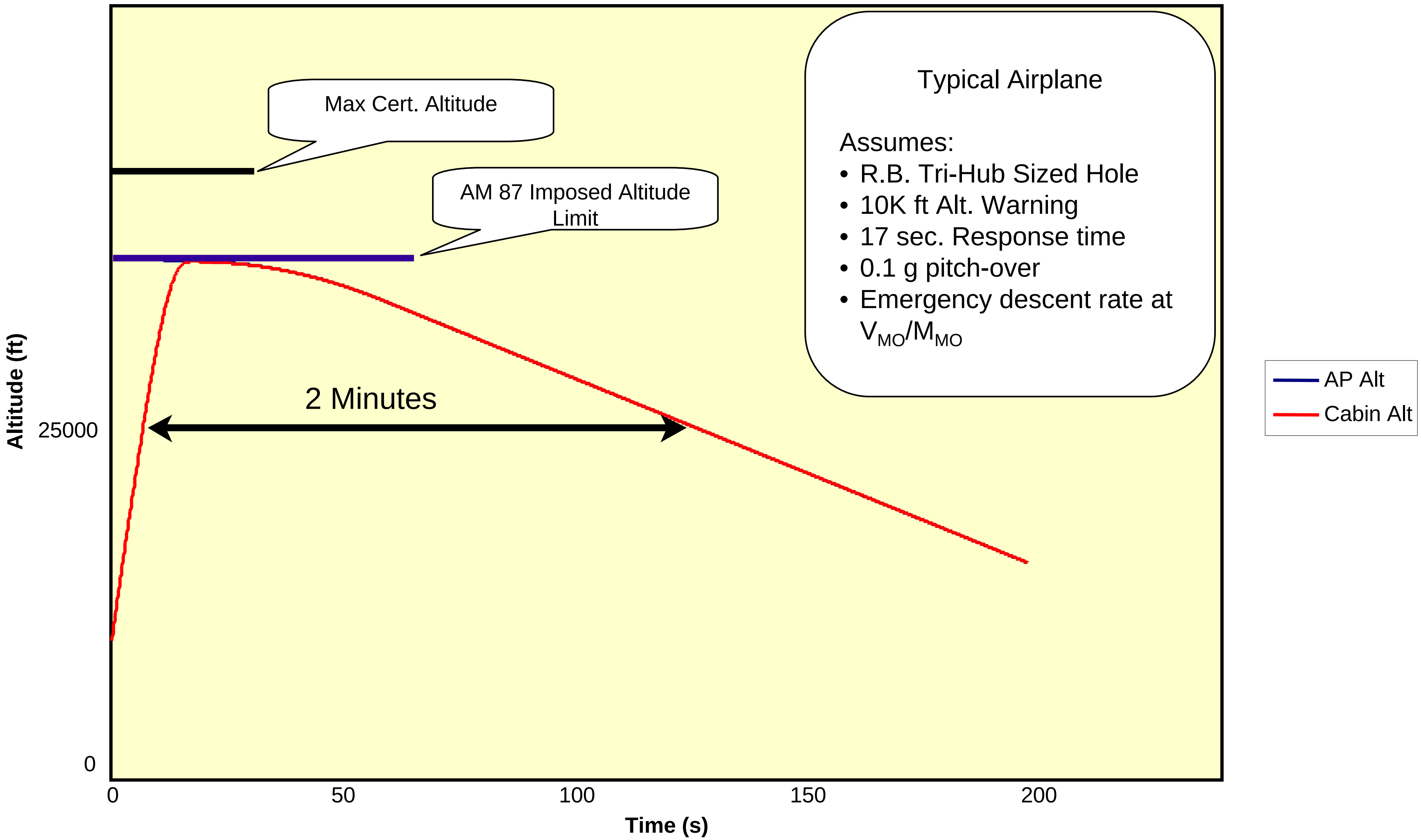
Typical AM 87 Imposed Altitude Limits

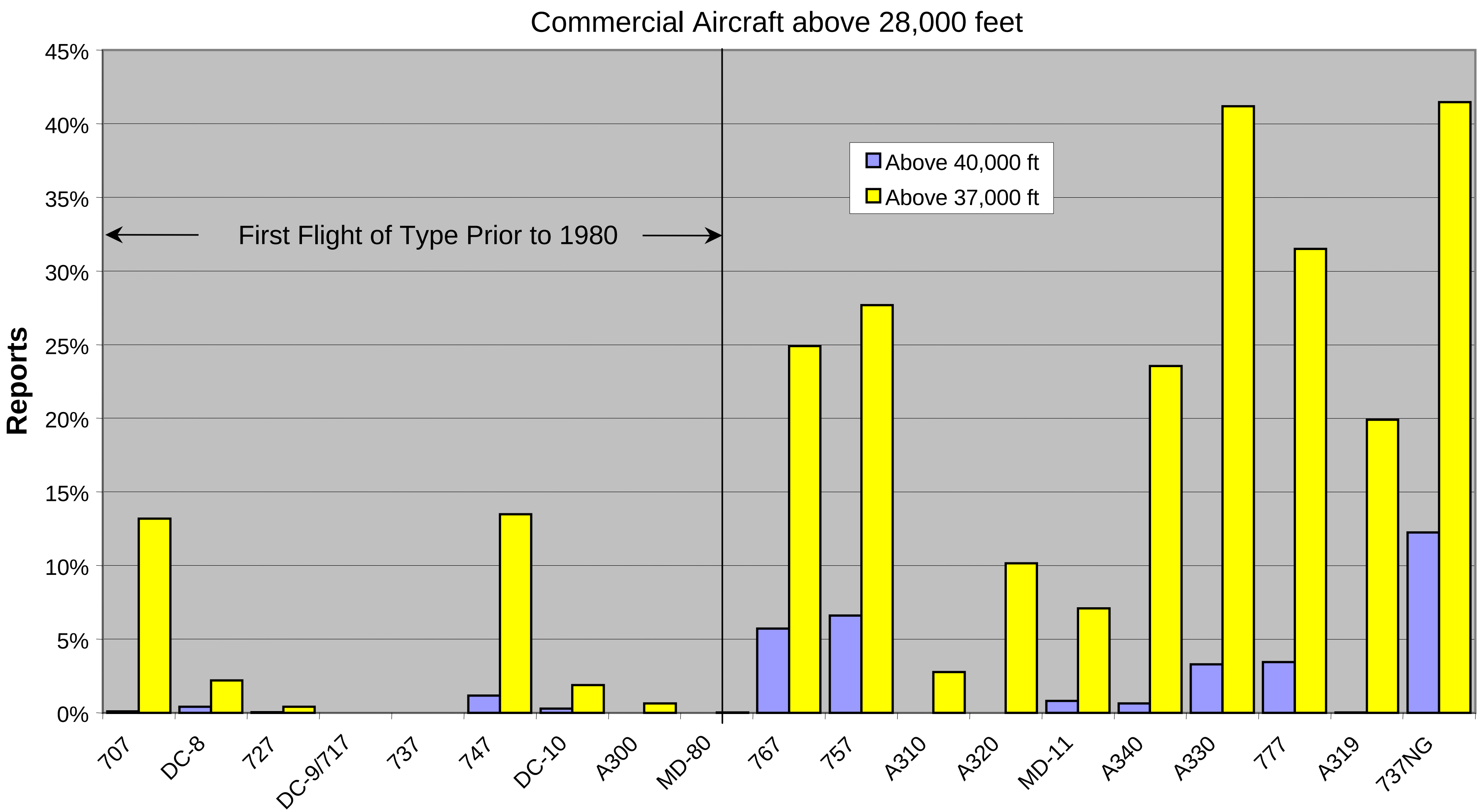


AM 87 Limits New Generation Airplanes To Substantially Less Efficient Altitudes

BOEING

Altitude Reports By Airplane Model

FAA's Enhanced Traffic Management System (ETMS) Reports for U.S.



- Data represents reports from one week in Sept. 2000
- Based on position reports every 3 minutes.

Newer Airplanes Fly at Higher Altitudes

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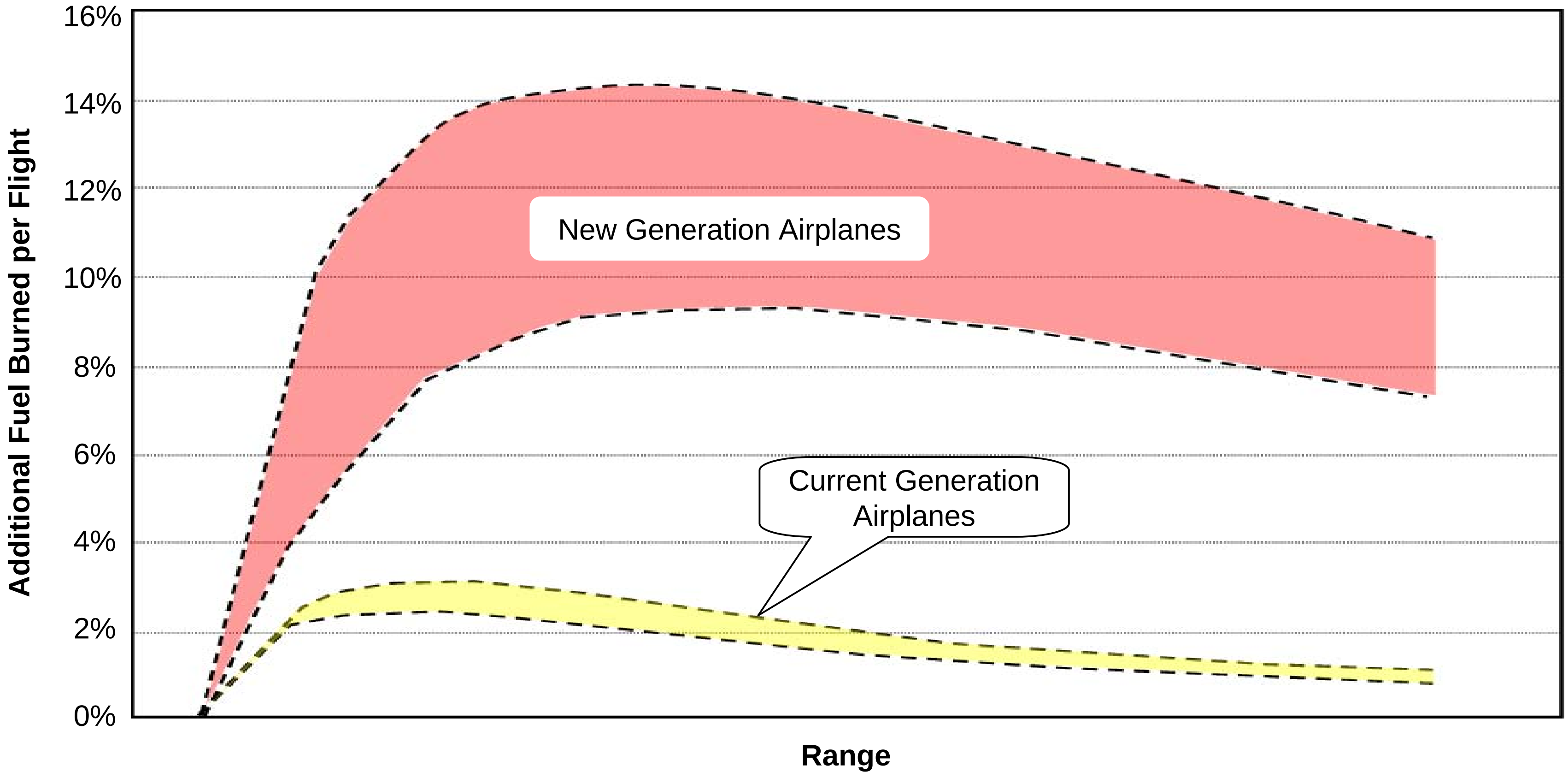
Additional Fuel Burned Due to AM 87 Imposed Altitude Limits



AM 87 Significantly Diminishes Fuel Efficiency of New Generation Airplanes

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AM 87 Imposed Economic Penalty

- **$1 B to $6 B Net Present Value (NPV) (in 2001 Dollars) on a Typical Fleet of New Generation Airplanes for the First 14 Years of Operation.**

AM 87 Would Preclude Development Of New Generation Airplanes

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Estimated Effect of AM 87 on U.S. Economy

- Revenue Lost* –
  - $90 B – $170 B Total
  - $7 B – $ 13 B Annually

* Per Family of New Generation Airplanes Not Built

U.S. Aerospace Jobs Lost Per Airplane Family

41,000 – 75,000

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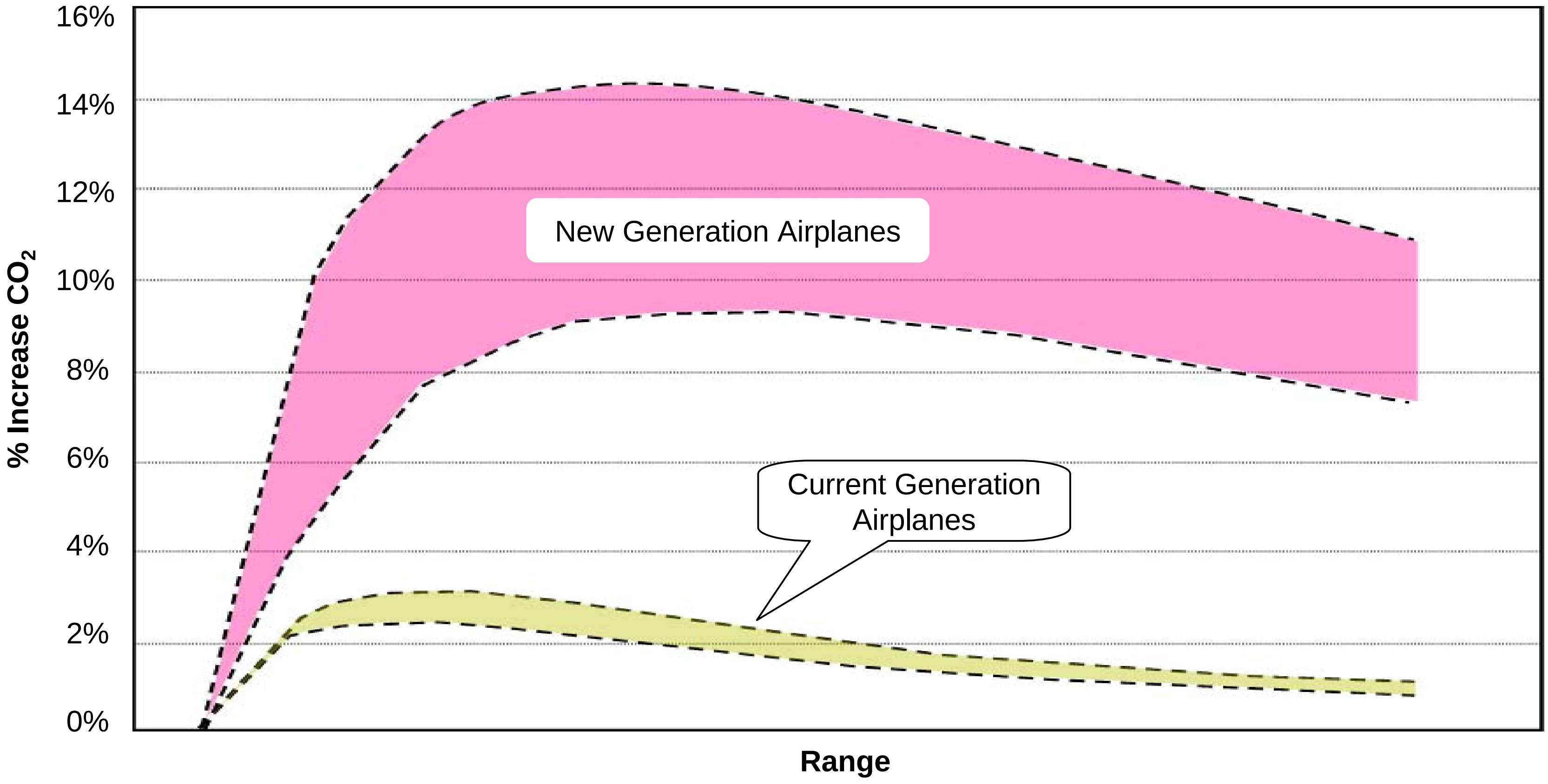
Increased CO_2 Emissions Under AM 87 Imposed Altitude Limits



AM 87 Has A Potential Negative Effect On The Environment

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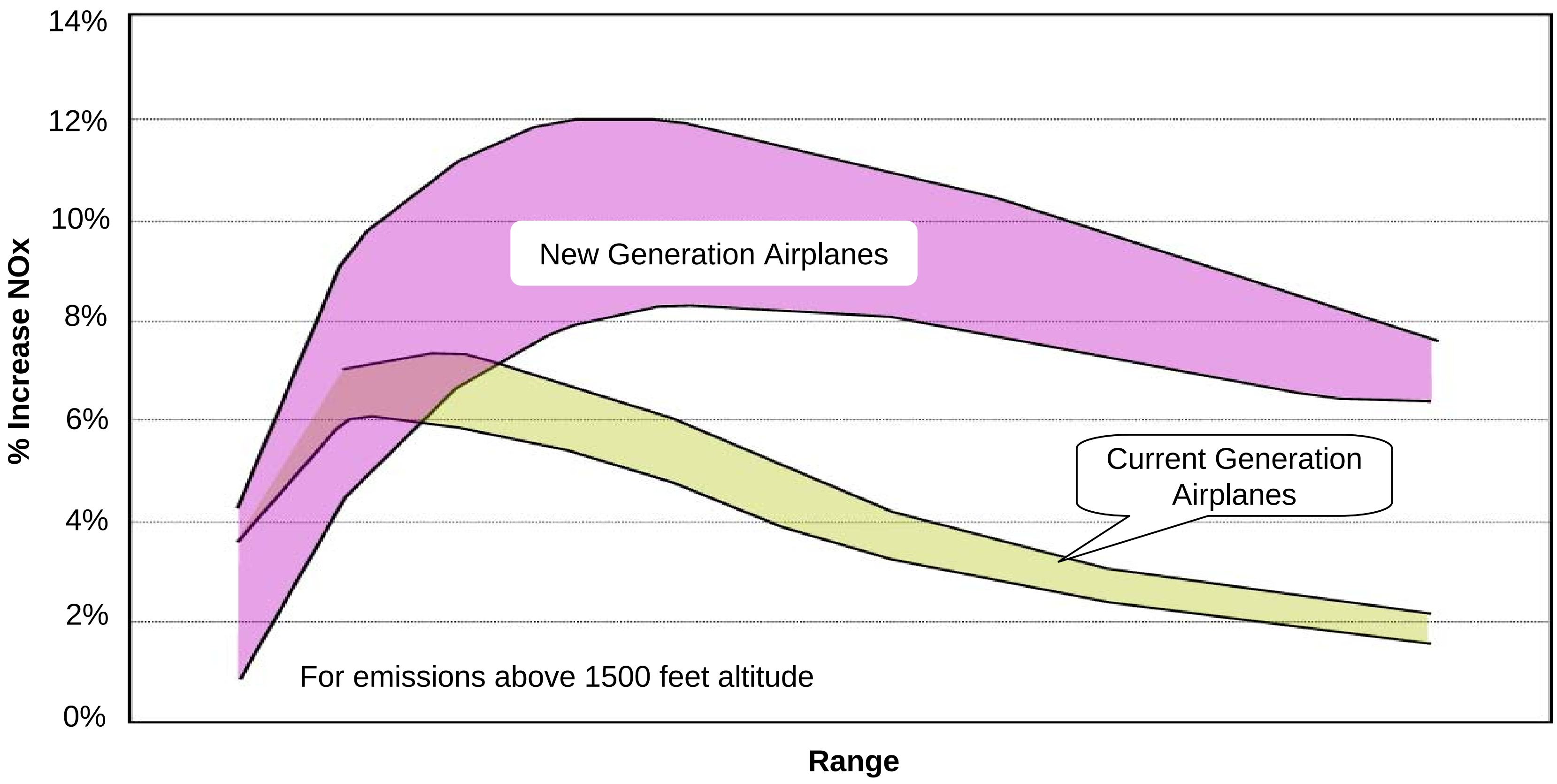
Increased NOx Emissions Under AM 87 Imposed Altitude Limits



AM 87 Has A Potential Negative Effect On The Environment

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Potential Effect of FAR 25.841(a) AM 87 on Air Traffic Environment

- US Domestic
  - Approximately 16% of traffic currently operates above FL 370
- North Atlantic
  - Approximately 21% above FL370
- North and Central Pacific
  - Approximately 12% of traffic above FL370 in all Oakland's oceanic airspace
  - Approximately 9% of traffic above FL370 in Anchorage's oceanic airspace

Note: Data are not long-term statistics; simply a quick look at representative numbers.
Based on ATM Center reports for one day in Aug. 2002.

10% to 20% of Today's Fleet Operates Above FL 370
New Generation Airplanes Fly Higher

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FAR 25.841(a) AM 87 Effect on Flight Safety

- AM 87 may have an unintended negative effect on the cost of flight safety
  - Limiting operation of new generation airplanes to lower altitudes will result in higher traffic density and lead to greater collision risk if not otherwise mitigated.
  - In order to maintain an acceptable level of safety, additional costs will be imposed on the aviation system:
    - **Larger separation minima may be required, resulting in lower capacity, more delay and less growth potential.**
    - **Use of even lower, less economical altitudes required.**
    - **More sectors, controllers and communications frequencies required.**
    - **More automation tools required.**
    - **Improvements in Flow Management required.**
    - **Earlier implementation of ground system enhancements required.**

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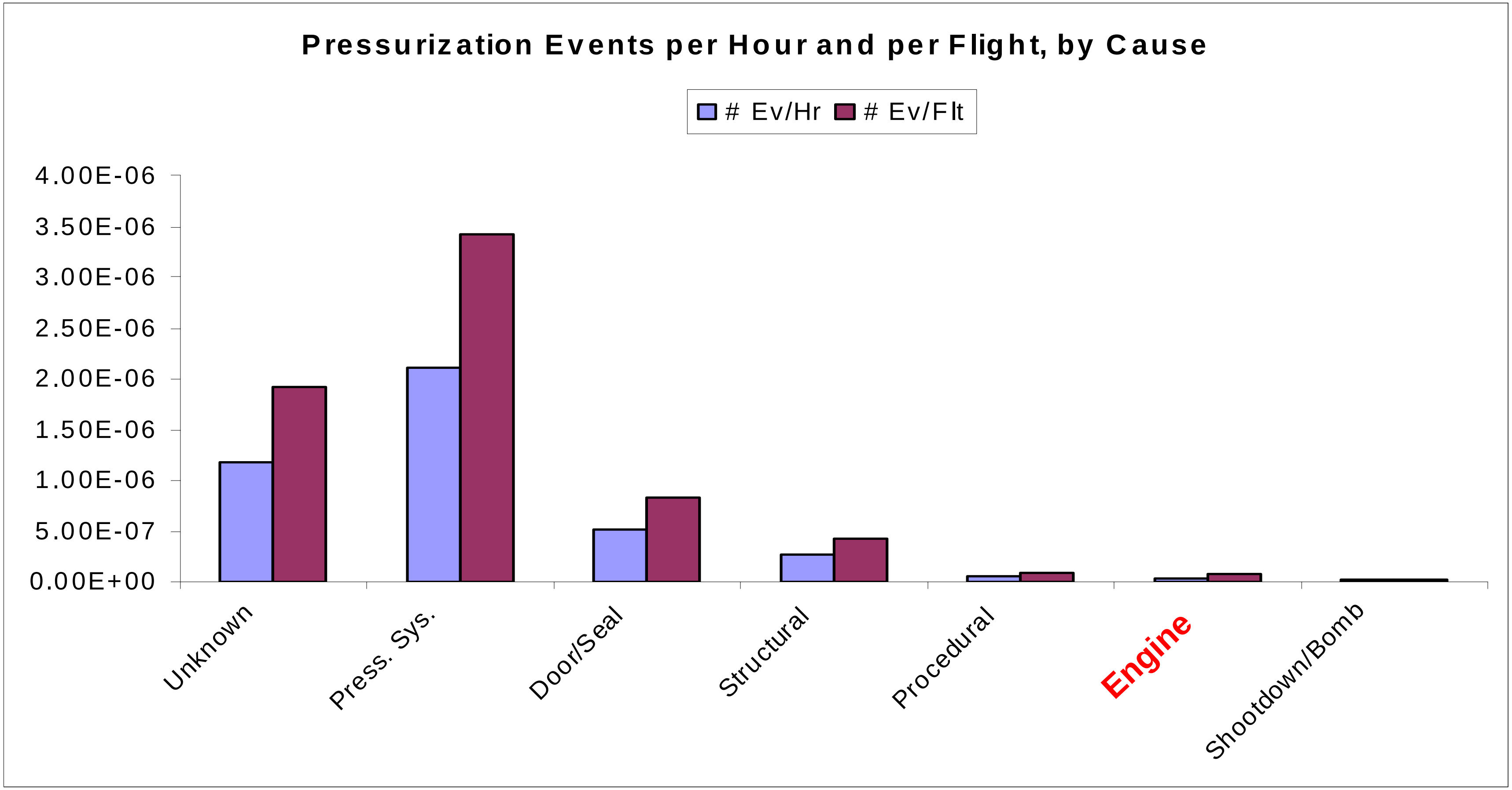
25.841(a)(2,3)
Safety

- Relative to other causes, decompression is not a significant accident contributor, and there is no compelling safety justification for FAR 25.841(a)(2,3) AM 87 for today’s fleet.

- New rule needs to reflect proper balance between risk and safety management.

- New rule should provide an acceptable level of safety without precluding flight at higher cruise altitudes.

Decompression Events by Cause



Sources: Boeing Airplane Safety Engineering (ASE) and Safety Information System (SIS), National Transportation Safety Board (NTSB)

Engine Events Are Rare Contributors To Decompression Events

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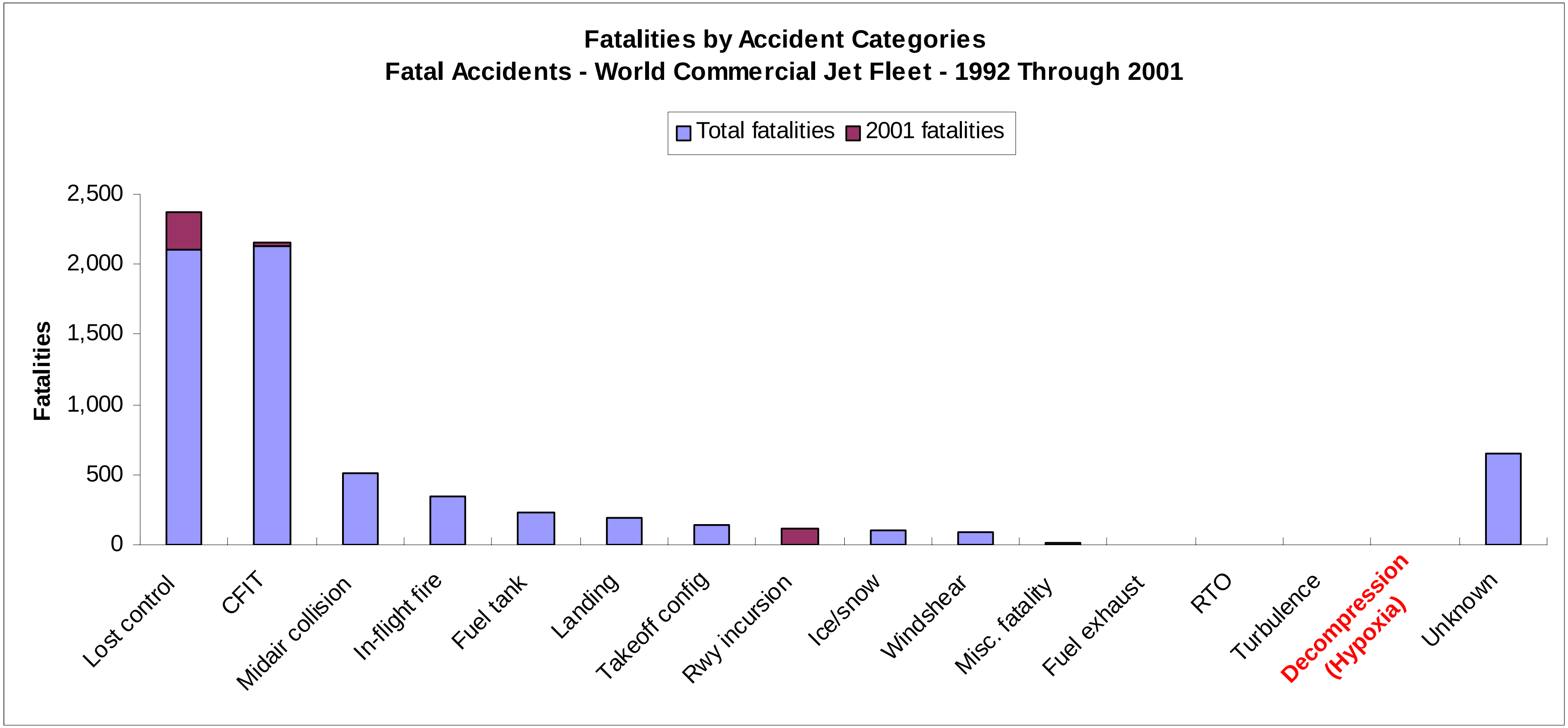
Fatal Accidents by Category



Sources: Boeing Airplane Safety Engineering (ASE) and Safety Information System (SIS), National Transportation Safety Board (NTSB)

Of 7,171 Fatalities For The Period Of 1992 – 2001, No Hypoxia Related Fatalities Were Due To In-flight Decompression Events.

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25.841(a)(2,3)
Proposed Rule

The airplane must be designed and operated such that after a decompression event, the occupants will not be exposed to transient or steady state cabin pressure altitudes that:

- **Result in fatalities or permanent physiological harm to any crewmembers, or more than a small number of passengers, following any engine failure that does not result in a catastrophic loss of the airplane;**
- **Result in permanent physiological harm to any occupants following certain structural failure events;**
- **Result in permanent physiological harm to any occupants following system failure conditions not shown to be extremely improbable.**

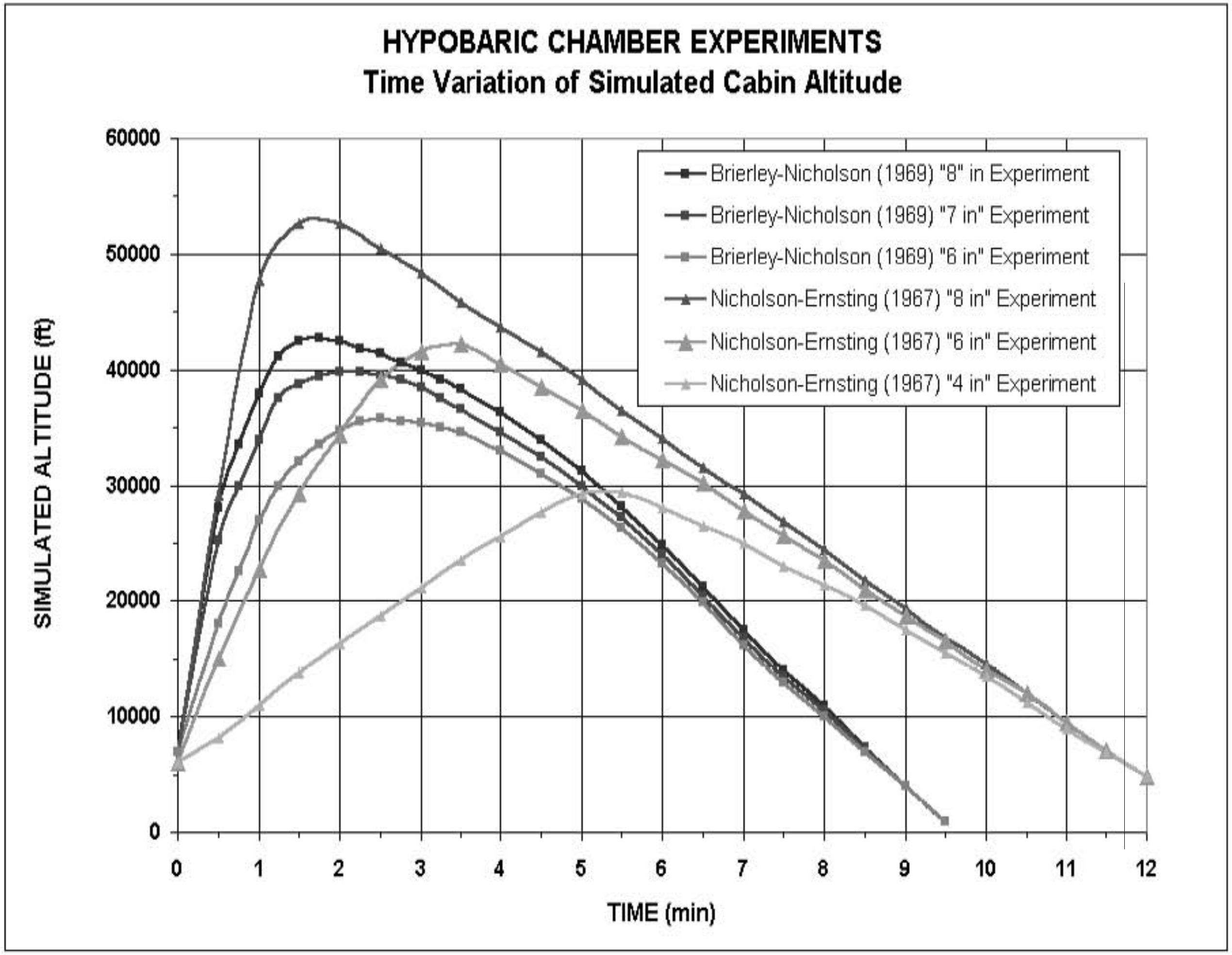
25.841(a) Proposed AC Material

- For system and structural failures, the airplane must be designed so that occupants will not be exposed to a cabin pressure altitude that exceeds the following after decompression:
  - (i) Twenty-five thousand (25,000) feet for more than 2 minutes; or
  - (ii) Forty thousand (40,000) feet for any duration.
- In the event of an uncontained engine failure, only loss of system capability associated with the failed engine, but not associated with the debris, must be considered.
- A means of compliance to the requirements of 25.841(a) may be demonstrated through the use of the Depressurization Exposure Integral (DEI) method.
- Engine failure debris model may be used to determine threat.
- Cabin altitude cannot exceed maximum performance capability of the flight deck crew oxygen system.

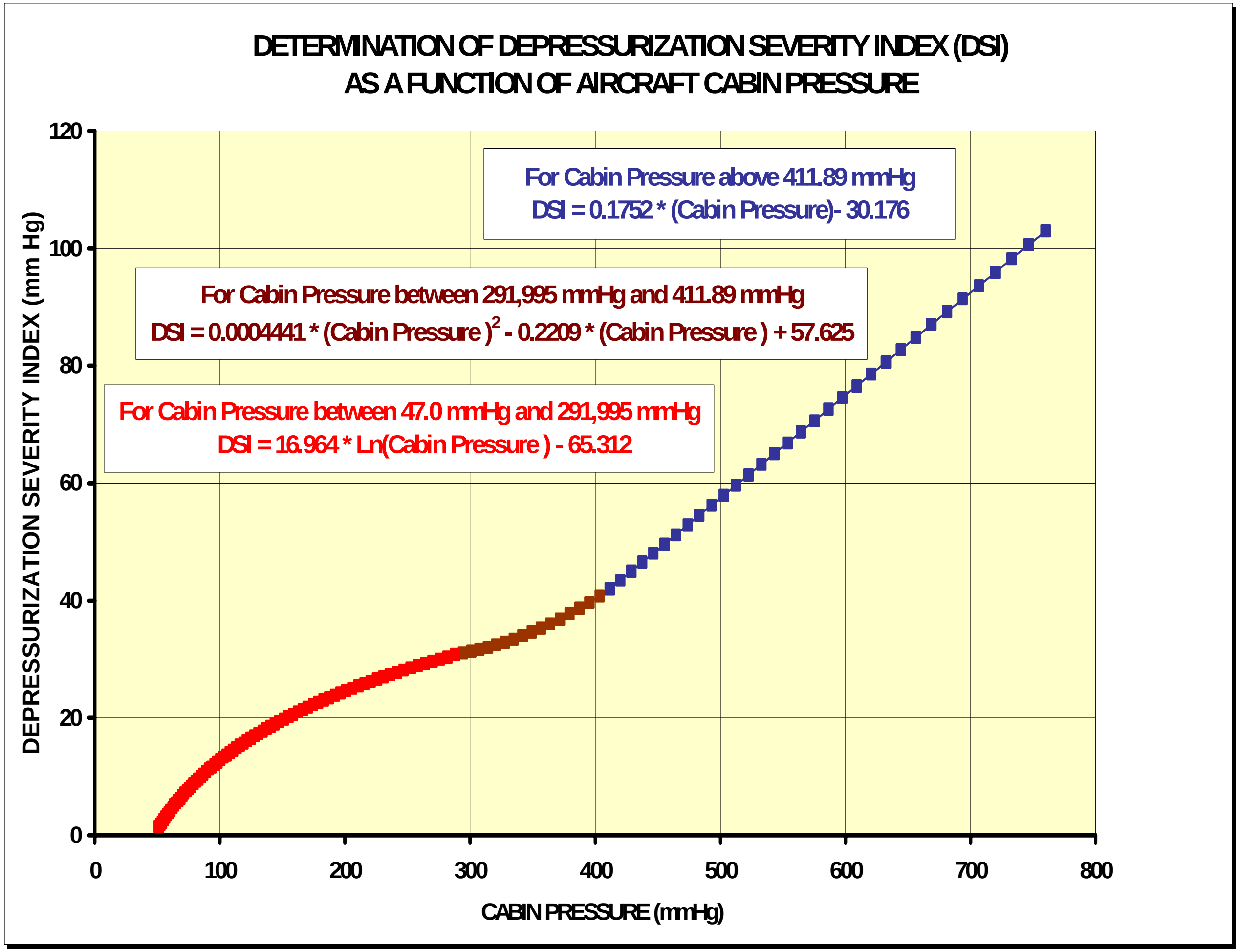
Depressurization Exposure Integral (DEI) method

- Physiological criterion based on the severity of oxygen deprivation and time of exposure.
- Oxygen deprivation measured by alveolar partial pressure (pAO2), which is simply lung pressure.
- Relationship between pAO2 and cabin altitude tabulated by DeHart to 25K, and then linear extrapolated to 61K.

Depressurization Exposure Integral (DEI) method



Depressurization Exposure Integral (DEI) method



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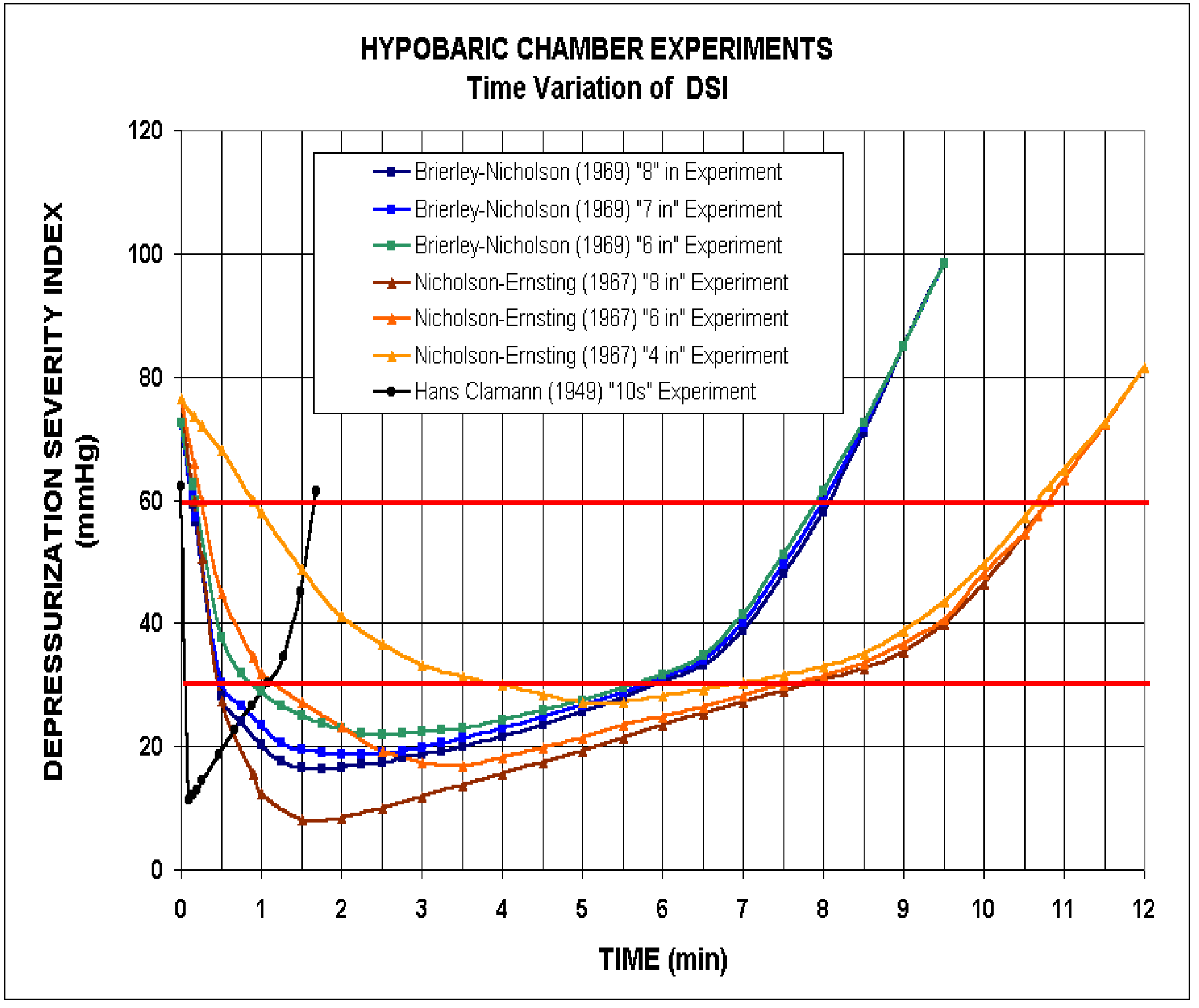
Depressurization Exposure Integral (DEI) method



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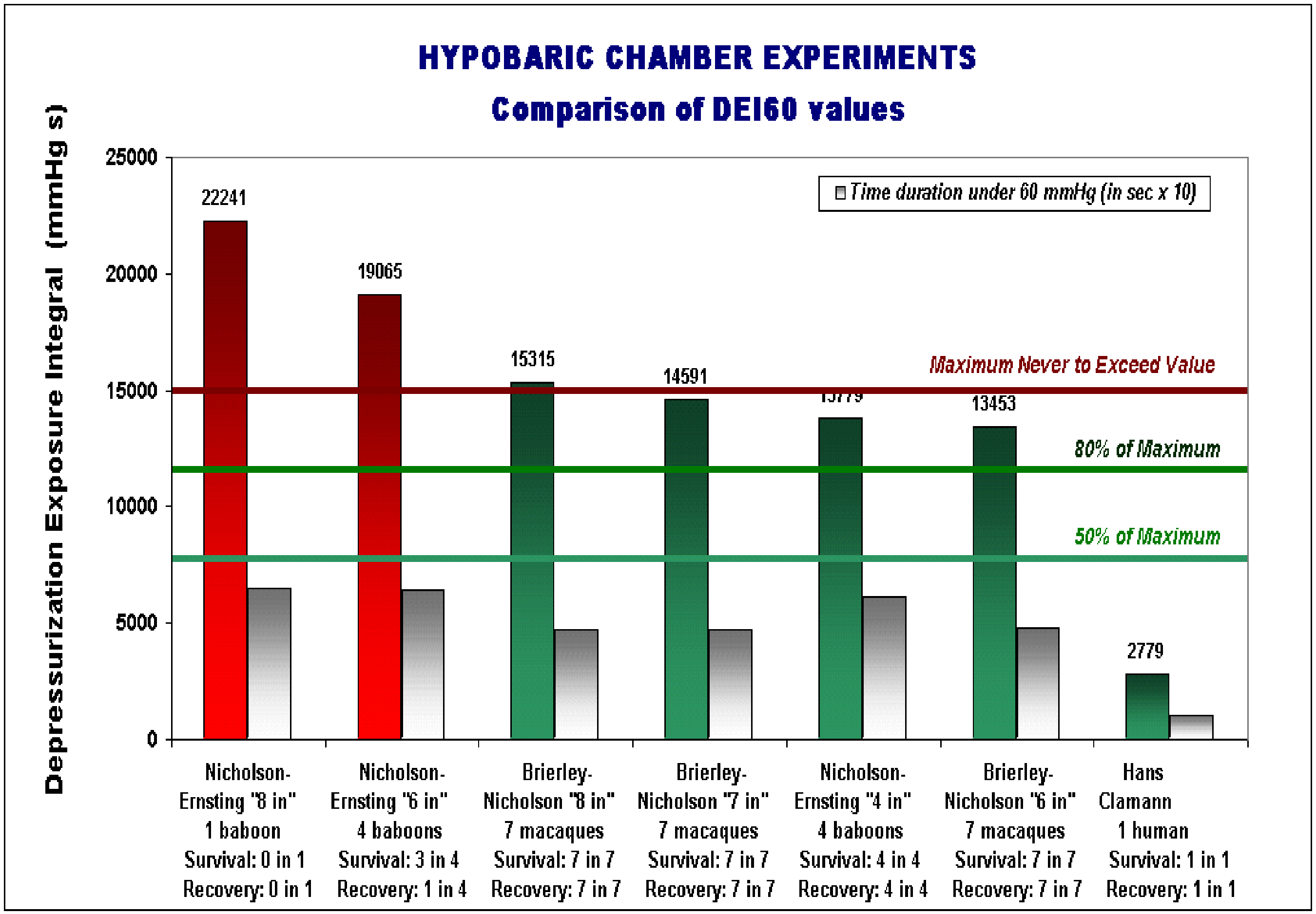
Depressurization Exposure Integral (DEI) method



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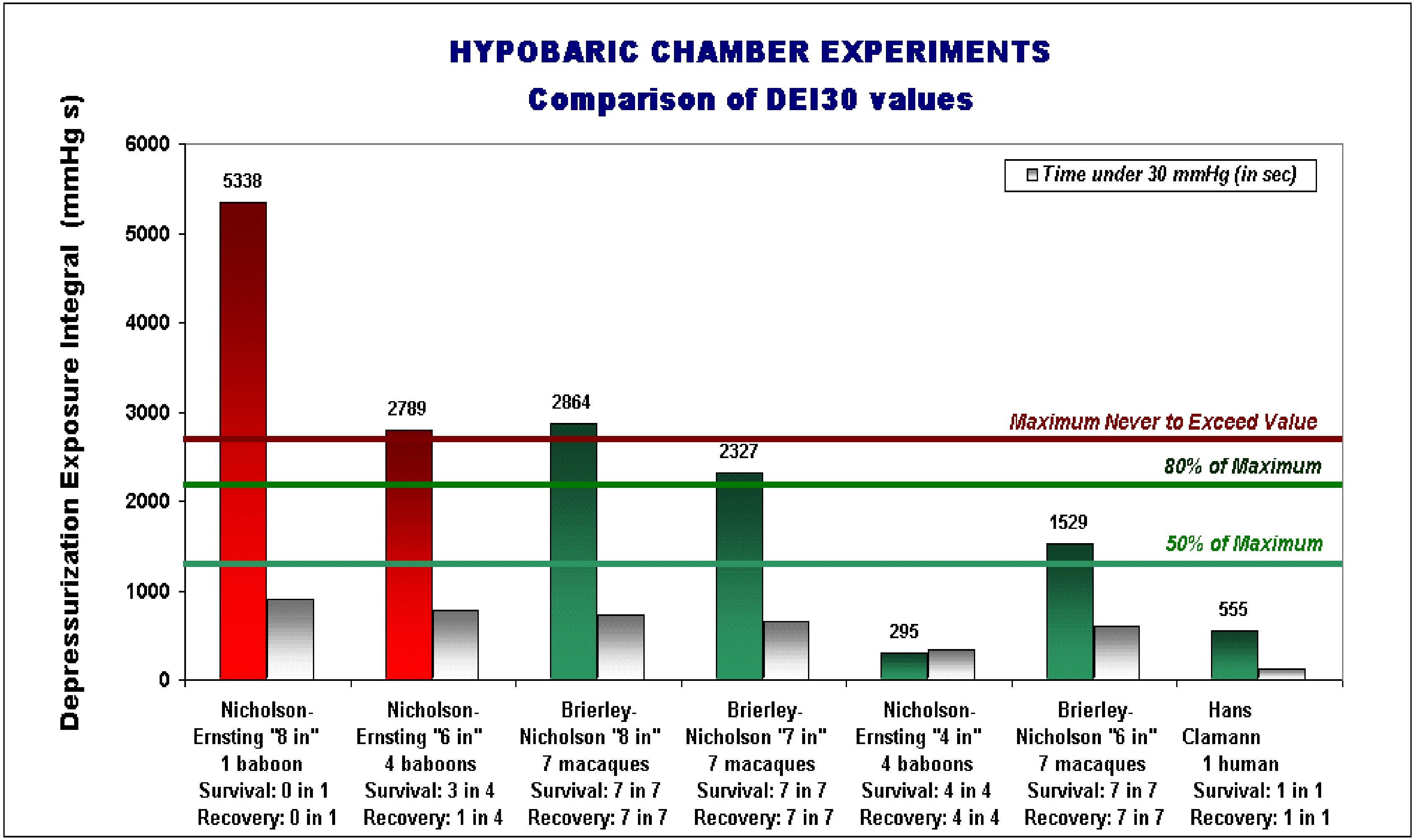
Depressurization Exposure Integral (DEI) method



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Dissenting Opinions

- AFA Major Concerns:
  - Allowing cabin altitudes to exceed 40,000 ft. in the absence of human tolerance data at high altitudes,
  - Proposed DEI method lacks supporting data and peer review to validate its use, and
  - Interim policy recommendation circumvents existing regulations and is not in public interest.

- CAMI Major Concerns:
  - Cannot support final report until proposed human/primate tests are conducted.
  - Cannot support new rule that permits the death of a small number of passengers from hypoxic exposure.

Response to Dissenting Opinions

- Current fleet has been operating safely above 40,000 ft. for many years.
- Proposed DEI method, due to paucity of data, contains sufficiently conservative acceptance criteria for use until validated by additional experimental data obtained through an appropriate research program.
- Interim policy recommendation is in public interest as it would allow A380 and 7E7 development.
- Harmonized 25.1309, proposed by SDAHWG, allows serious or fatal injury to a relatively small number of occupants other than the flight crew for hazardous events.

25.841(a)(2,3)

- Working Group Report is complete and was submitted to TAEIG for approval in August, 2003 along with two dissenting opinions (AFA, CAMI)

- 80% of team attending Florida meeting voted in favor of the report.

- Current rule precludes development of A380 and 7E7. Need for new rule is <u>very urgent</u>.

- TAEIG requested to approve Working Group Report.

Mechanical Systems Harmonization Working Group (MSHWG) Final Report on

FAR/JAR 25.831(g)

July 24, 2003

Draft 25.831(g) Working Group Report

Harmonization (Category 3) and New Projects

1 - What is underlying safety issue to be addressed by the FAR/JAR? [Explain the underlying safety rationale for the requirement. Why should the requirement exist? What prompted this rulemaking activity (e.g., new technology, service history, etc.)?]

The intent of the specific § 25.831(g) is to ensure that in the event of ventilation system failure the temperature and humidity within the airplane shall not exceed values that are hazardous to the occupants.

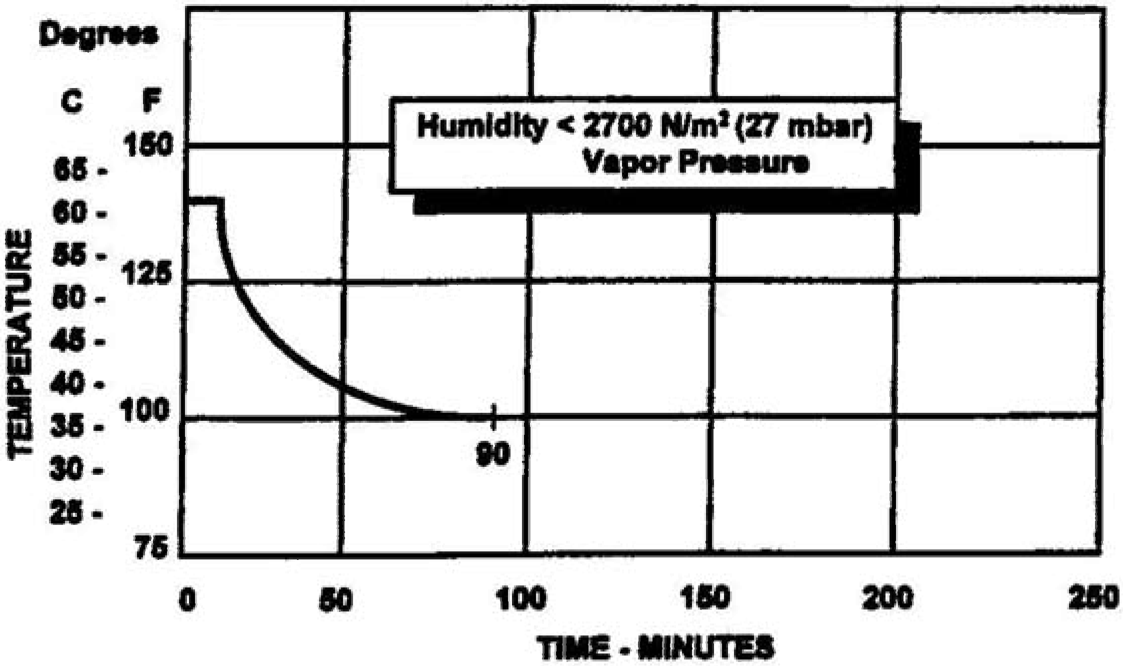
As noted in the preamble to Amendment 25-87, during the Supersonic Transport (SST) review in the 1960s, it was noted that certain pressurization system failures, whether considered alone or in combination with the use of hot ram air for emergency pressurization, could lead to cabin temperatures exceeding human tolerance. The FAA therefore concluded that any failure or combination of failures that could lead to temperature exposures that would cause undue discomfort must be shown to be improbable. Minor corrective actions (e.g., selection of alternate equipment or procedures) would be allowed if necessary for probable failures. The FAA also concluded that any failure or combination of failures that could lead to intolerable temperature exposures must be extremely improbable. Major corrective actions (e.g., emergency descent, configuration changes) would be allowed for an improbable failure condition. Temperature limits were incorporated into the special conditions imposed on executive transport airplanes when approved for high altitude operation. The SST and executive transport special conditions contained two graphs that explained the requirements for the probable and improbable cases. In formulating this amendment, the FAA has determined that the public interest is served by adopting the time-temperature limits associated with improbable failure conditions, and they were adopted in FAR 25.831(g). This amendment does not allow the time of exposure at any given temperature to exceed the values given in the associated graph.

Amendment 25-87 incorporated a time-temperature relationship containing a single-point humidity requirement. Manufacturers have found this difficult or impossible to comply with under the assumption of loss of all conditioned airflow for flight following failure, including descent and landing. It should be noted that no mention of the 27 mBar limit appears in Amendment 25-87. It has been speculated that the fixed humidity level of 27 mBar appears to be a reasonable limit for altitude conditions around 10,000 feet. Unfortunately this humidity level is often exceeded at lower altitudes at and near sea level for airport ambient conditions. Thus, this requirement would prohibit the use of outside air to ventilate the aircraft during high humidity conditions above 27 mBar. It is this restriction to any fixed humidity limit that has created the need for rulemaking in this section of Part 25.

2 - What are the current FAR and JAR standards relative to this subject? [Reproduce the FAR and JAR rules text as indicated below.]

Current FAR text:

Sec. 25.831 (g) The exposure time at any given temperature must not exceed the values shown in the following graph after any improbable failure condition.



TIME–TEMPERATURE RELATIONSHIP]

Current JAR text:
There is no JAR 25.831(g) regulation.

2a – If no FAR or JAR standard exists, what means have been used to ensure this safety issue is addressed? [Reproduce text from issue papers, special conditions, policy, certification action items, etc., that have been used relative to this issue]

Historically, the FAA, JAA, and Transport Canada have issued special conditions for aircraft certificated for flight above 41000 feet. These special conditions have been used on a number of certification programs albeit with some inconsistency (i.e. some large transport category aircraft have been approved for flight above 41000 feet without the imposition of any similar special conditions). Subsequently, FAR Part 25 has been revised at amendment 87 to incorporate the special conditions to the rule that resulted in part to the formation of a new paragraph, 25.831(g). Transport Canada has since adopted and is applying the standards of amendment 87. The JAA do not currently have an equivalent rule in JAR 25 but continue to impose special conditions to address this issue. Nonetheless, the current standards contained in the JAA special conditions provide an equivalent level of safety to FAR 25 at amendment 87 with respect to § 25.831(g) at or above 15,000 feet.

3 - What are the differences in the FAA and JAA standards or policy and what do these differences result in?: [Explain the differences in the standards or policy, and what these differences result in relative to (as applicable) design features/capability, safety margins, cost, stringency, etc.]

Historically, the FAA, JAA and Transport Canada have issued special conditions for aircraft certificated for flight above 41000 feet. These special conditions have been used on a number of certification programs albeit with some inconsistency (i.e. some large transport category aircraft have been approved for flight above 41000 feet with and without the application of any special conditions).

Subsequently, Part 25 has been revised at amendment 87 to incorporate the special conditions to the rule that resulted in part to the formation of a new paragraph, 25.831(g). Transport Canada has since adopted and is applying the standards of amendment 87. The JAA do not currently have an equivalent rule in JAR 25 but continue to impose special conditions to address this issue. Nonetheless, the current standards contained in the JAA special conditions are identical to FAR 25 at amendment 87 with respect to 25.831(g) at or above 15,000 feet. On this basis, there should exist no differences between regulatory authorities with respect to design requirements, safety margins or cost.

4 - What, if any, are the differences in the current means of compliance? [Provide a brief explanation of any differences in the current compliance criteria or methodology (e.g., issue papers), including any differences in either criteria, methodology, or application that result in a difference in stringency between the standards.]

The Special Conditions and means of compliance have been similar for FAA, JAA, and Transport Canada application as applied to business jets. Issue papers for large transport aircraft have resulted in the manufacturers obtaining exceptions to FAR 25.831(g). Instead of showing compliance to FAR 25.831(g), the large transport manufacturers have been providing analysis for Equivalent Safety Findings under FAR/JAR 25.1309.

Transport Canada has adopted the FAR 25.831(g), including Amendment 25-87. The JAA has a generic Special Condition, see Reference (2), which retains the main intent of the previous Special Conditions. The main area of difference in terms of means of compliance between the FAA and JAA is application of the rule below 15,000 feet altitude. The JAA generic Special Condition is limited to at or above 15,000 feet, whereas the FAA rule is applied to all altitudes.

5 – What is the proposed action? [Describe the new proposed requirement, or the proposed change to the existing requirement, as applicable. Is the proposed action to introduce a new standard, or to take some other action? Explain what action is being proposed (not the regulatory text, but the underlying rationale) and why that direction was chosen for each proposed action.]

The proposed action is to harmonize on a new, performance-based standard for failure conditions not shown to be extremely improbable. The objective of this standard is to preserve a tolerable environment by limiting the metabolic and environmental heat loads to passengers and crew during exposures to a potential heat stress event. Compliance to this new regulation will require a combination of quantitative and qualitative means to demonstrate compliance. This is not unlike the requirements that exist in 14 CFR Part 25.671 or 25.1309.

6 - What should the harmonized standard be? [Insert the proposed text of the harmonized standard here]

While the task of this working group was limited to the working group report, the working group recommends that the regulatory authorities consider the following harmonized rule and preamble in promulgating a new regulation on § 25.831(g).

RULE

The airplane design must accommodate any environmental control system failure condition not shown to be extremely improbable, such that:

- **(a) Flight deck and cabin environmental conditions shall not adversely affect crew performance that results in a hazardous condition.**
- **(b) No occupant shall sustain permanent physiological harm.**

PREAMBLE

Note: The "… environmental control system failure condition not shown to be extremely improbable …" referenced in the above proposed rule (including loss of inflow) shall be referred to as the "event" hereafter.

It should be noted that the proposed rule is based on human performance. The intent of the rule is to provide flight deck and cabin environments that do not result in crew mental errors or physical exhaustion that prevent the crew from successfully completing their assigned tasks – continued safe flight and landing. This includes the cabin crew being able to initiate and direct a cabin evacuation. Analysis showing the flight deck and cabin crew performance is not degraded is an acceptable means of demonstrating compliance.

Further, while it is recognized there is a lack of data for infants and frail passengers, the cabin environment resulting from an event shall be conservatively specified such that no permanent physiological harm shall be incurred by any occupant. Provided it can be shown that the passenger cabin remains a safe environment for the cabin crew, it is assumed to be an acceptable limit for sedentary passengers since it is acceptable for cabin crew members working at higher metabolic rates in the same environment. The environmental and physiological performance limits used for demonstrating compliance must originate from recognized and cognizant authorities as accepted by the regulatory authority reviewing the compliance finding.

While the rule is supposed to be based on human performance, the reviewers of the reference material should note that all the presented data relates human performance to time-temperature-humidity exposure. The MSHWG notes that none of the data links human performance with these parameters in combination with a low flight deck/cabin ambient pressure characteristic of operating altitudes to which the occupants are not acclimated. Consequently with the paucity of data available in conjunction with low flight deck/cabin ambient pressure the selection of the limiting cabin environmental conditions should be conservative until new data shows otherwise.

The proposed rule utilizes the phrase "…failure conditions not shown to be extremely improbable …" The intent of this being included in the rule is to address such events and the resulting operation of the aircraft. Unrelated failures not tied to the event need not be considered; for example, cargo fire or failure of the in-flight entertainment system. Aircraft systems required for safe flight and landing must be evaluated for continued operation during the event environment under the applicable FAR/JAR(s) (e.g. FAR/JAR 25.1309).

The entire flight profile of the aircraft during the event is to be considered. This includes cruise and transient conditions during descent, approach, landing and rollout to a stop on the runway. Taxi is not included in compliance considerations since the aircraft is on the ground and can be evacuated, or flight deck windows and cabin doors opened for ventilation. The intent of having to consider the condition from initiation of the event to the termination of the landing roll is to make sure the entire event is accounted for until it is safe to depart the airplane.

The words "… shall not adversely affect crew performance …" have been chosen to indicate the crew can be expected to reliably perform their published and/or trained duties to complete a safe flight and landing. This has been measured in the past by a person's ability to track and perform their tasks. The event should not result in expecting the crew to perform tasks beyond the procedures defined by the manufacturer, or required by existing regulations.

The phrase "No occupant shall sustain permanent physiological harm" is intended to mean that the occupants who may have required some form of assistance, once treated, shall be expected to return to their normal activities.

In showing compliance to the proposed rule, the applicant should consider the consequential airplane and system effects of the event. Operational provisions, which provide for, or mitigate the resulting environmental effects to airplane occupants, may be considered. If the manufacturer provides an approved procedure(s) for the event, the flight deck and cabin crew may configure the aircraft to moderate temperature and/or humidity extremes on the flight deck and in the cabin. This may include turning off non-critical electrical equipment and opening the flight deck door, or opening the flight deck window(s).

Thermal comfort and lower (cold stress) temperatures are outside the scope of this rule.

7 – How does this proposed standard address the underlying safety issue (identified under #1)? [Explain how the proposed standard ensures that the underlying safety issue is taken care of.]

The current regulation limits the humidity to an absolute moisture content - approximately 120 grains of moisture per pound of air (27 mBar). If this moisture content limit is applied at saturation (RH=100%), the corresponding air temperature limit is 72 Deg F (22 Deg C) dry-bulb temperature. These temperature/humidity limits are unrealistic when applied to tropical latitudes following a failure event during low altitude flight, descent and landing. Furthermore, these limits are significantly less than those accepted by recognized cognizant authorities. For example, NIOSH, see reference (3), advises that 86 Deg F (30 Deg C) WBGT (equivalent to 86 deg F dry bulb temperature at saturation) is acceptable for continuous light work by unacclimated individuals (NIOSH "Occupational Exposure to Hot Environments;" p 90 dated 1986).

The proposed standard ensures the flight deck and cabin crew's ability to perform their assigned tasks and not compromise safe flight and landing of the aircraft. The proposed standard utilizes data as accepted by recognized cognizant authorities to ensure the crew is provided a safe working environment.

8 - Relative to the current FAR, does the proposed standard increase, decrease, or maintain the same level of safety? Explain. [Explain how each element of the proposed change to the standards affects the level of safety relative to the current FAR. It is possible that some portions of the proposal may reduce the level of safety even though the proposal as a whole may increase the level of safety.]

The new rule will propose a harmonized performance based regulation and an acceptable means of compliance to this standard.

The current regulation limits the humidity to an absolute moisture content - approximately 120 grains of moisture per pound of air (27 mBar). If this moisture content limit is applied at saturation (RH=100%), the corresponding air temperature limit is 72 Deg F (22 Deg C) dry-bulb temperature. These temperature/humidity limits are unrealistic when applied to tropical latitudes following a failure event during low altitude flight, descent and landing. Furthermore, these limits are significantly less than those accepted by recognized cognizant authorities. For example, NIOSH, see Reference (3), advises that 86 Deg F (30 Deg C) WBGT (equivalent to 86 deg F dry bulb temperature at saturation) is acceptable for continuous light work by unacclimated individuals (NIOSH "Occupational Exposure to Hot Environments;" p 90 dated 1986).

Therefore, relative to the current FAR 25.831(g), and considering the inapplicability of its humidity requirements, the proposed regulation does not reduce the current level of safety.

9 - Relative to current industry practice, does the proposed standard increase, decrease, or maintain the same level of safety? Explain. [Since industry practice may be different than what is required by the FAR (e.g., general industry practice may be more restrictive), explain how each element of the proposed change to the standards affects the level of safety relative to current industry practice. Explain whether current industry practice is in compliance with the proposed standard.]

Relative to current industry practice, the proposed standard maintains an equivalent level of safety. The proposed standard adheres to recognized industry and regulatory guidelines and preserves the crew's ability to perform their expected duties, as defined in Question 6 above, while maintaining an acceptable level of safety and health for all aircraft occupants during the event. The proposed standard recommends consideration of the effects on crew performance of all relevant heat sources and sinks, humidity levels, barometric pressures and contaminants. The proposed regulation requires a comprehensive, performance-based analysis, and therefore has greater credibility and scientific basis than the existing regulation, which is based on simplistic, independent limits of humidity and temperature.

10 - What other options have been considered and why were they not selected?: [Explain what other options were considered, and why they were not selected (e.g., cost/benefit, unacceptable decrease in the level of safety, lack of consensus, etc.) Include the pros and cons associated with each alternative.]

Among the proposed alternatives to a performance based regulation that have been discussed and eliminated are; basing the analysis on dry bulb temperature, omitting analysis of the approach and landing phase of the mission, skipping the ETOPS airport and flying a longer distance to a cooler airport, and limiting the environment the airplane flies in and is analyzed for. Each represents a compromise of the intent of the original rule. Dry bulb temperature analysis does not account for the effects of humidity that contribute to stress on the human physiology. Diverting to another airport could exceed the ETOPS range capability of the airplane. Omitting the approach and landing phase of the mission is not realistic in that eventually the airplane has to land. Each proposal potentially compromised the crew’s ability to perform their duties to complete a safe flight and landing as intended by the original regulation. Another option discussed is to recommend repealing FAR 25.831(g) for new Type Certificate aircraft, and then showing compliance under FAR 25.1309 as has been done in the past for Amended Type Certificate aircraft. Discussions between the FAA and the manufacturers came to the conclusion that a specific FAR was still needed to address the event as a result of industry experience. Consequently it was concluded that a rewriting of the FAR 25.831(g) regulation was necessary.

11 - Who would be affected by the proposed change? [Identify the parties that would be materially affected by the rule change – airplane manufacturers, airplane operators, etc.]

Airplane manufacturers and suppliers will benefit from the single well-defined harmonized ruling thereby reducing certification costs. The proposed change would affect the airplane manufacturers by having a regulation that defines a reasonable means for showing compliance. It would also establish a consistent rule as applied to all manufacturers. There is a potential design savings for the manufacturer by not having to design the aircraft systems to accommodate the fixed humidity limit of 27 mbar. Added standby equipment would have to be incorporated to the aircraft to condition the air drawn into the airplane to an acceptable humidity level under the 27 mbar limit during an event in hot and humid conditions. This equipment would be an operational weight penalty to the airlines that do not operate in such hot and humid conditions when industry data has shown it is not necessary for providing working conditions conducive for the crew to complete safe flight and landing operation of the aircraft.

12 - To ensure harmonization, what current advisory material (e.g., ACJ, AMJ, AC, policy letters) needs to be included in the rule text or preamble? [Does any existing advisory material include substantive requirements that should be contained in the regulation? This may occur because the regulation itself is vague, or if the advisory material is interpreted as providing the only acceptable means of compliance.]

The relevant advisory material is AC 25-20, which does not contain any additional information that needs to be included in the rule text or preamble. Issues significant in showing compliance to the proposed rule are identified in the response provided for Question 6, above.

13 - Is existing FAA advisory material adequate? If not, what advisory material should be adopted? [Indicate whether the existing advisory material (if any) is adequate. If the current advisory material is not adequate, indicate whether the existing material should be revised, or new material provided. Also, either insert the text of the proposed advisory material here, or summarize the information it will contain, and indicate what form it will be in (e.g., Advisory Circular, policy, Order, etc.)]

The existing FAA advisory material is not considered adequate. AC 25-20 contains guidance material for pressurized compartment loads (§ 25.365(d)), ventilation (§ 25.831), pressurized cabins (§ 25.841) and equipment standards for oxygen dispensing units (§ 25.1447), that were introduced at Amendment 25-87. However, only those portions of AC 25-20 that provide guidance to 25.831(g) are addressed in this report.

The working group recommends the FAA consider the following material in promulgating new regulatory material.

Portions of existing Advisory Circular AC 25-20 should be retained. Some sections should be modified slightly while others require major rewrite. The group recommends the following changes:

Portions of AC 25-20 that need minor modification are:
Section 3 Background section should be modified to add the information on the new standard and information gained with respect to Amendment 25-87 regulation.
Section 7 Failure Conditions needs to reflect the proposed modification of the standard.
Section 12 Glossary needs to reflect the new standard and definitions of terms.

Portions of AC 25-20 that will need a complete rewrite:
Section 5, Ventilation, sub-part (f) needs to reflect the proposed modification of the new standard and explain the acceptable means of compliance.

As the existing FAA advisory material is not considered adequate, the following material is recommended for inclusion in the advisory material.

A transient heat stress analysis can be used as a means of compliance. For applicable failure events prior to final descent, an acceptable means of compliance (MOC) is considered to be a 1 deg C rise, not to exceed 38 deg C body core temperature see page 2 of Reference 3. As discussed in the report this is a conservative criteria for exposure of unacclimatized people working for long periods of time in a hot environment. It is acknowledged that occupants will be able to receive appropriate medical treatment immediately after landing. Therefore, a 38.5 deg C body core temperature limit is acceptable, only for final approach and landing, during any time period not to exceed 20 minutes. 38.5 deg C body core temperature shall not be exceeded or sustained for any amount of time.

Following the event, a safe cabin environment still must be maintained. Therefore, consideration, based upon available data, shall be given to the additional effects of elevated levels of air contaminants and cabin pressure altitude.

In showing compliance to the proposed rule, the applicant should consider the consequential airplane and system effects of the event. Operational provisions, which provide for, or mitigate the resulting environmental effects to airplane occupants, may be considered. If the manufacturer provides an approved procedure(s) for the event, the flight deck and cabin crew may configure the aircraft to moderate temperature and/or humidity extremes on the flight deck and in the cabin. This may include turning off non-critical electrical equipment and opening the flight deck door, or opening the flight deck window(s).

Due to the unique design of each type of aircraft, the mission profile resulting from an event must take into consideration the flight profile that results from the event. This includes longer cruise times that result from having to operate at lower altitudes and slower speeds. Such flight profiles shall consider the longest potential exposure times, including the critical diversion point with respect to temperature/humidity.

Residual heat from equipment exposed to the flight deck or cabin will be included in the evaluation. For example the residual heat from electronic equipment that has been shut down and activated chemical oxygen systems will be included in the compartment heat load considerations.

The condition shall be assumed to take place under the maximum solar load conditions taking into account geographical and calendar considerations for the environment the aircraft was designed to operate in. A recognized source such as MIL-HDBK-310 provides guidance for determining hot day extremes. The direction of flight and solar orientation should be considered in determining the time-dependent solar load into the airframe. For compliance purposes an emergency descent at maximum rate of descent speed can be assumed.

The solar load must be included in the respective cabin/flight deck heat load calculations based on aircraft heat transfer properties. This includes solar heat through the skin and windows of the aircraft. If so equipped, window shades or other equipment may be utilized to reduce window solar load. But the calculated heat transfer through the shade (or equipment) must be considered as a general compartment heat load much as is done for the skin of the airplane.

The use of fans (i.e. recirculation, or lav/galley, etc.), if available to distribute the heat loads throughout the aircraft shall be taken into consideration when assessing aircraft compartment temperatures and occupant convective cooling.

The maximum occupancy shall be the basis of calculating the aircraft heat load.

Occupants of the aircraft will be assumed to be able to shed layers of clothing down to a level equivalent to “light summer clothing” in an attempt to remain comfortable.

14 - How does the proposed standard compare to the current ICAO standard? [Indicate whether the proposed standard complies with or does not comply with the applicable ICAO standards (if any)]

The proposed standard is in agreement with the intent of International Civil Aviation Organization (ICAO) Annex 8 "Airworthiness of Aircraft" requirements, Reference (1), as there are no specific ICAO requirements defining cabin environmental limits following a failure.

15 - Does the proposed standard affect other HWG's? [Indicate whether the proposed standard should be reviewed by other harmonization working groups and why.]

The proposed standard and the proposed means of compliance are independent of any Harmonization Working Group ARAC activities currently tasked. In addition, the FAA has completed all steps prior to officially tasking the Cabin Environment ARAC HWG. The MSHWG is aware that this tasking is currently on hold pending the results of an industry research activity.

16 - What is the cost impact of complying with the proposed standard [Please provide information that will assist in estimating the change in cost (either positive or negative) of the proposed rule. For example, if new tests or designs are required, what is known with respect to the testing or engineering costs? If new equipment is required, what can be reported relative to purchase, installation, and maintenance costs? In contrast, if the proposed rule relieves industry of testing or other costs, please provide any known estimate of costs.]

All manufacturers agree that adopting the new standard will result in significantly reduced costs. Although quantitative assessments are not available, the following cost reduction measures can be identified:

- Airplane manufacturers and suppliers will benefit from the single well-defined harmonized ruling thereby reducing certification costs.
- There is a potential design savings for the manufacturer by not having to design the aircraft systems to accommodate the fixed humidity limit of 27 mbar. Added standby equipment would have to be incorporated to the aircraft to condition the air drawn into the airplane to an acceptable humidity level under the 27 mbar limit during an event in hot and humid conditions.
- There is a potential operating cost savings for the airlines by not having the additional standby equipment (as a result of weight reduction, and reduced maintenance costs).

17. - If advisory or interpretive material is to be submitted, document the advisory or interpretive guidelines. If disagreement exists, document the disagreement.

The proposed advisory material (i.e., Advisory Circular) and issue that should be included in the AC appear in the response to question 13. Below are the guidelines that were used in developing the proposed advisory material and rule. Where disagreements exist, the proposed rules, preamble, and advisory material take precedence.

1. Environmental Conditions

1.1 Occupant Exposure Scenario

a. Failure conditions that are not shown to be extremely improbable and that lead to elevated temperatures and/or humidity (excluding fires) in the aircraft shall not permanently harm the occupants nor impair the crew's ability to conduct safe flight and landing.

b. Thermal comfort, lower (cold stress) temperatures, and rates of recompression or re-pressurization after decompression (FAR 25.841(a)(1) and (2)) are outside the scope of this activity on FAR 25.831(g).

c. In a single flight, it is not necessary to consider all combinations of possible effects and environmental conditions. Acceptable failure analyses, such as is described in AC 25.1309-1A or later revision, and AMJ 25.1309 could be used.

d. Consideration should be given to the post failure mission profile such that the conservative condition (e.g., short descent followed by longer "cruise" time) at warmer temperatures and higher humidity are evaluated for occupant exposures.

e. It is understood that for compliance purposes, operating requirements and conditions may vary with different types of airplanes.

1.2 Flight Deck Crew Performance

a. Such an event, as described in a. of 1.1 above, shall not affect the flight deck crew's performance such that continued safe flight, landing and egress from the airplane are adversely affected.

b. The criterion for flight deck crew performance assumes that the flight deck crew is not at rest following a failure of conditioned pack air. Performance deterioration of the flight deck crew will be evaluated during exposures to rising, peak, lowering, and sustained high temperature/humidity conditions. Additional performance deterioration of the flight deck crew due to the combined effects of elevated levels of air contaminants and flight deck pressure altitude will also be evaluated.

1.3 Cabin Crew Performance

a. Such an event, as described in a. of 1.1 above, shall not adversely affect the cabin crew's ability to ensure that continued passenger safety and egress from the airplane are maintained.

b. The criterion for cabin crew performance assumes that the cabin crew is not at rest following a failure of conditioned pack air. Performance deterioration of the cabin crew will also be evaluated during exposures to rising, peak, lowering, and sustained high temperature/humidity conditions. Additional performance deterioration of the cabin crew due to the combined effects of elevated levels of air contaminants and cabin pressure altitude will be evaluated.

1.4 Passenger Heat Stress Tolerance

a. Such an event, as described in a. of 1.1 above, shall not cause permanent physiological harm to the passengers. For most passengers such events shall not prevent safe egress from the airplane. However, due to health conditions, some passengers may be at increased risk, and may experience symptoms consistent with heat exhaustion. These individuals may require assistance to safely egress from the airplane and/or medical attention after landing.

b. The criterion for passenger's heat stress tolerance is based on the assumption that they are at rest. Following such an event, as described in a. of 1.1 above, passenger exposures will be evaluated during rising, peak, lowering, and sustained high temperature and humidity conditions. Additional deterioration of passenger health due to the combined effects of elevated levels of air contaminants and cabin pressure altitude will also be evaluated.

2. Physiological Basis for Standard

The objective of this standard is to preserve a tolerable environment by limiting the metabolic and environmental heat loads to passengers and crew during exposures to a potential heat stress event.

2.1 Requirements

a. As recommended by cognizant authorities, the requirements of this standard for the crewmembers will be physiologically based for unacclimatized workers performing emergency duties in high temperature/humidity environments. Additional performance deterioration of the flight deck and cabin crew due to the combined effects of air contaminants and pressure altitude inside the airplane will also be evaluated.

b. As recommended by cognizant authorities, the requirements of this standard for the passengers will be physiologically based for unacclimatized individuals at rest in high temperature/humidity environments. Additional deterioration of passenger health due to the combined effects of air contaminants and cabin pressure altitude will also be evaluated.

c. The overall heat load will be evaluated over maximum and averaged times to limit potential increases in core or deep body temperatures and ensure crew performance in continued safe flight, landing and egress from the airplane.

d. The cumulative physical effects of exposures to a time-variable heat load profile should at no time adversely affect crew performance, as specified in 3.1 and 3.2 above. Consideration of the cumulative physical effects should be given to their different exposures.

2.2 Heat Load Assessment

a. The metabolic heat load will be estimated considering basal metabolism and pertinent heat/moisture generating activities, such as a seated/mentally active flight deck crew performing both light handwork and leg/footwork, a standing/mentally active cabin crew performing light walking and handwork, and seated/sedentary passengers.

b. Environmental heat loads will be evaluated with due consideration to all parameters affecting the overall heat/moisture transfer between occupants and their respective flight deck and cabin environments, including convection, radiation, conduction and evaporation.

c. Requirements for maximum exposure times and heat loads should consider different physiological thresholds for the flight deck crew, the cabin crew, and the passengers based on their respective roles in supporting continued safe flight, landing and egress from the airplane.

Dehydration due to lack of fluid replenishment is only a factor when considering long term exposures (i.e. on the order of a day or so) thus it should not be a matter of concern for 25.831(g). Medical experts on the MSHWG commented that the duration of exposure in an airplane would not be long enough for dehydration to become a serious health consideration or compromise a person's ability to function. Thus the consensus was that fluid intake during the event, and subsequent flight, approach and landing is not an issue.

18. - -Does the HWG wish to answer any supplementary questions specific to this project? [If the HWG can think of customized questions or concerns relevant to this project, please present the questions and the HWG answers and comments here.]

A supplementary question to be answered regards the relevance of the Packs Off Takeoff operating procedure. The MSHWG considered the material, “Airplane Operation with Air Conditioning Packs-Off” Revision to Memorandum of June 28, 1999, “same subject", September 3, 1999 policy memo. The MSHWG tasking was determined not to be affected based on the memorandums' focus related to "Normal" operations only. This Packs Off Takeoff issue is related to FAR 25.831(a) Ventilation Rate and is for what is considered a normal operational procedure to improve the aircraft performance on hot days or short runways. In contrast, this MSHWG was tasked with the non-normal Loss of Inflow event of 25.831(g). Therefore the referenced memorandums are not applicable.

19. – Does the HWG want to review the draft NPRM at "Phase 4" prior to publication in the Federal Register?

A Notice is required for the proposed FAR change and the Mechanical Systems Harmonization Working Group should review any draft Notice of Proposed Rulemaking prior to publication in the Federal Register.

No Notice is required for the advisory material. However, it has been the policy of the Transport Airplane Directorate to provide a Notice of Availability of Proposed Advisory Circular (AC) and request for comments prior to issuing advisory material. Therefore, the MSHWG would like to review any draft notice prior to publication in the Federal Register.

20. – In light of the information provided in this report, does the HWG consider that the "Fast Track" process is appropriate for this rulemaking project, or is the project too complex or controversial for the Fast Track Process? Explain. [A negative answer to this question will prompt the FAA to pull the project out of the Fast Track process and forward the issues to the FAA's Rulemaking Management Council for consideration as a "significant" project.]

Harmonization of these regulatory issues is beyond the "Better Plan" for Harmonization tasks that are being handled under the Fast Track ARAC process. This issue has been identified as a Category 3 task, and therefore, should not be a "fast track" process, but instead should follow a normal NPRM process. This issue should be forwarded to the FAA's Rulemaking Management Council for establishment as a "significant" project. It should then be given highest priority to complete as quickly as possible. Failure to do so will increase the cost of the design and manufacture of new commercial airplanes by requiring the manufacturer to apply for an exemption to FAR 25.831(g) on new Type Certificate programs or an exception for Supplemental Type Certificate programs.

Attachment A - Reference List

1. International Civil Aviation Organization, Ninth Edition, July 2001.
2. "Aircraft Standards for Subsonic Transport Aeroplanes to be Operated above an Altitude of 41 000 ft", Generic Special Condition, developed by Panel 08 CSP, JAA/ System D&F Steering group, October 15, 2002.
3. "Criteria for a Recommended Standard; Occupational Exposure to Hot Environments Revised Criteria 1986," National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 86-113, April 1986

Attachment B - Bibliography

1. "2003 Threshold Limit Values and Biological Exposure Indices," ACGIH Worldwide, Section Thermal Stress, pp. 170-178.
2. "Aircraft Standards for Subsonic Transport Aeroplanes to be Operated above an Altitude of 41 000 ft," Generic Special Condition, developed by Panel 08 CSP, JAA/ System D&F Steering group, October 15, 2002.
3. ASHRAE Handbook: Fundamentals, Chapter 8, Society of Heating Refrigerating and Air Conditioning Engineers Inc, 1989 & 1997. (Human Body model for perspiration coverage of the skin.)
4. ASHRAE Handbook: Applications, Chapter 40, American Society of Heating Refrigerating and Air Conditioning Engineers Inc, 1991. (Outdoor CO2 concentration levels).
5. ASHRAE Handbook: Applications, Chapter 41, American Society of Heating Refrigerating and Air Conditioning Engineers Inc, 1995. (Modeling and Control of Contaminants Generated by Metabolic functions).
6. "Combined Effects of Altitude and High Temperature on Complex Performance," FAA-AM-71-17, April 1971.
7. Report AM 69-10, "Complex Performance During Exposure to High Temperatures," DOT, FAA, Office of Aviation Medicine, June 1969.
8. "Criteria for a Recommended Standard; Occupational Exposure to Hot Environments Revised Criteria 1986," National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 86-113, April 1986
9. "Determining Lines of Equal Comfort," F. C. Houghten, and C. P. Yagloglou, Transactions of American Society of Heat-Ventilation Engineers, No. 655, January 1923.
10. "Global Climatic Data for Developing Military Products," MIL-HDBK-310, June 1997
11. International Civil Aviation Organization, Ninth Edition, July 2001.

12. AMRL-TR-102, “A Review of the Effects of High Ambient Temperature on Mental Performance,” J. Wing, Aerospace Medical Research Laboratories Aerospace Medical Division, Air Force Systems Command Wright-Patterson Air Force Base, Ohio, September 1965.
13. Amendment 25-87, “Standards for Approval for High Altitude Operation of Subsonic Transport Airplanes”
14. “Task Categorization and the Limits of Human Performance in Extreme Heat,” P. A. Hancock; Aviation, Space and Environmental Medicine: August 1982.
15. “Human Cardioaccelerative Responses to Hypoxia in Combination with Heat,” H. B. Hale, Aerospace Medicine: April, 1960.

Attachment C - Associated Regulatory and Advisory Material

1. Airworthiness Standards

The pertinent sections from FAA 14 CFR 25, 2001, and JAA JAR-25, 2000 related to the certification of today’s aircraft are as follows:

<u>A. Airworthiness Standards, Transport Category Airplanes</u>

FAR 25.831(g)	Ventilation
FAR/JAR 25.831(b)(1&2)	Ventilation
FAR/JAR 25.832(a)(1&2)	Ozone
FAR/JAR 25.1309(b)(1), (b)(2)	Equipment, Systems & Installations

2. Operating Requirements: Domestic, Flag, and Supplemental Operations

U.S. Operators

FAR 121.557	Emergencies: Domestic & Flag Operations

<u>Canadian operators,</u>

Operational Standards-Airline Operations
Operational Standards-Private Operator Passenger Transportation
604.40 Protective Equipment

<u>European operators</u>

JAR-OPS 1.760 First aid oxygen

Airworthiness Standards and References

The pertinent FAA major category, Title 14, 2001, constituting the certification of today's aircraft are as follows:

FAR 25.1309 & ACs Equipment, systems, and installations

Attachment D - Definitions

Body Core Temperature - Temperature of the tissues and organs of the body, also called deep body temperature.

Critical diversion point w.r.t Temperature/Humidity – Point within flight profile in which loss of conditioned airflow failure results in severe environmental exposure related to combined effects of temperature and humidity.

Dry Bulb Temperature – Temperature of air as measured with a bare thermometer exposed to the air protected from any radiation effects.

Final Approach – Flight phase immediately preceding landing.

Heat Stress – The sum of the environmental and metabolic heat load on an individual.

Permanent Physiological Harm – Physical or mental damage (death, injury, or illness) to an organism’s healthy or normal functioning that continues or endures without fundamental or marked change.

Time-dependent Solar Load – Solar generated heat load based on applicable window area and solar flux as a function of altitude, time, and solar orientation.

Wet Bulb Globe Temperature (WBGT) – Index developed as a basis for environmental heat-stress monitoring that combines the effects of humidity, air movement, radiation, and air temperature.

Mechanical Systems Harmonization Working Group (MSHWG)
Final Report on

FAR 25.841(a)(2,3)

August, 2003

ARAC 25.841(a) WG Report

1 - What is underlying safety issue addressed by the FAR/JAR? [Explain the underlying safety rationale for the requirement. Why does the requirement exist?]

FAR/JAR 25.841(a) contains the requirements that the design and operation of an airplane meet specific performance requirements following failure conditions that can result in a sudden loss of cabin pressure. FAR 25.841(a) intends that the occupants be afforded protection by limiting the exposure to the environment following cabin decompression.

2 - What are the current FAR and JAR standards? [Reproduce the FAR and JAR rules text as indicated below.]

Current FAR text:

Amendment 25-87 established new requirements in 14 CFR Part 25.841 (a) intended to upgrade the airplane and equipment airworthiness standards for subsonic transport airplanes operated above 40,000 feet. These were based in part on special conditions that had been used on type certification of executive business airplanes for many years. Specifically, Amendment 25-87 created three requirements in Part 25.841(a)(2) and (a)(3) governing the cockpit/cabin environment:

> *(2) The airplane must be designed so that occupants will not be exposed to a cabin pressure altitude that exceeds the following after decompression from any failure condition not shown to be extremely improbable:*
> *(i) Twenty-five thousand (25,000) feet for more than 2 minutes; or*
> *(ii) Forty thousand (40,000) feet for any duration.*

(3) Fuselage structure, engine and system failures are to be considered in evaluating the cabin decompression.

The intent of these regulations is to ensure occupant survivability in the event of decompression through establishment of minimum design standards. They require that the occupants be afforded protection by limiting the exposure to the environment following cabin decompression and by stating that this environment will not result in fatalities or permanent physiological harm to any occupant.

Current JAR text:

There is no applicable JAA regulation.

2a – If no FAR or JAR standard exists, what means have been used to ensure this safety issue is addressed? [Reproduce text from issue papers, special conditions, policy, certification action items, etc., that have been used relative to this issue]

While FAR 25.841 (a)(2) and (3), Amendment 25-87 does exist, as mentioned several places, no new wing-mounted engine airplane program has been certified by the FAA to these requirements. FAA currently has several new airplane certification programs underway. Of these, one manufacturer (rear-mounted engine) has said that they will meet the Amendment 25-87 requirements; one (wing-mounted engine) has petitioned for exemption, FAA has not heard from the others.

As the FAR change per Amendment 25-87 became effective in July of 1996, there have been no new wing-mounted engine airplanes certified to this level (although several are currently pending). However, the underlying safety issue has been addressed via special conditions and effectively demonstrated via the associated means of compliance.

For certification with FAA as primary authority, standards were developed in the early 1950s to permit safe operation of early turbojet transport airplanes up to certain maximum operating altitudes - typically 41,000 or 43,000 feet. Subsequent to the type certification of the early turbojet transport airplanes, applicants requested approval to operate certain later airplanes at higher altitudes. These were in most cases small executive transport airplanes, and the requested altitudes ranged up to 51,000 feet.

The operation of these executive transport airplanes at altitudes above 40,000 feet usually involved a number of novel or unusual design features that were not addressed by the airworthiness requirements in the current regulations. In order to ensure a level of safety equivalent to that established by part 25 of the FAR, §§ 21.16 and 21.101 of part 21 require that additional standards be developed in the form of special conditions and that compliance with the special conditions be demonstrated.

The regulatory changes adopted by Amendment 25-87 were intended to codify and consolidate the different high-altitude criteria that have been applied to previously certificated subsonic transport airplanes certified under special conditions.

In the case of the JAA this safety issue is currently addressed through Certification Review Items (CRI), issued separately for each certificated aircraft type, which introduce a Special Condition (SC). The specific SC generally comprised requirements essentially similar to the FAA special conditions, which were the template for the current FAR regulation.

3 - What are the differences in the standards and what do these differences result in?: Explain the differences in the standards, and

what these differences result in relative to (as applicable) design features/capability, safety margins, cost, stringency, etc.]

The current rule has not been adopted by the JAA due to its difficulty of implementation for the large transport category aircraft. Consequently, the current status presents a potential for differing requirement by the FAA and the JAA, which could introduce significant differences in design features/capability, safety margin, costs, and stringency.

For executive transport airplanes, the FAA and JAA policies are similar in technical intent, and only differ in their formats. The fundamental problem is that, per FAA interpretation of the provisions of § 25.841 (a) (2) and (3), subsonic transport airplane designs incorporating wing-mounted engines must be evaluated for fuselage penetrations by engine rotor parts following an uncontained event.

Transport Canada and the Brazilian authority are other aviation authorities that have adopted these FAA requirements as conditions for the operation of airplanes at altitudes up to 51, 000 feet.

4 - What, if any, are the differences in the means of compliance? Provide a brief explanation of any differences in the compliance criteria or methodology, including any differences in criteria, methodology, or application that result in a difference in stringency between the standards.]

The differences now between FAR 25 Amendment 87 and the JAA generic Special Conditions (see Reference 1) proposal generally result in making the FAA rule more difficult to comply with. The primary difference regarding failure conditions to consider is that the FAA rule specifically includes engine failures and this in turn includes rotor burst. For aircraft with wing-mounted engines, where the pressurized fuselage is within the debris zone, a possible rapid or instantaneous depressurization to a high cabin altitude causes severe difficulty in demonstrating compliance.

5 – What is the proposed action? [Is the proposed action to harmonize on one of the two standards, a mixture of the two standards, propose a new standard, or to take some other action? Explain what action is being proposed (not the regulatory text, but the underlying rationale) and why that direction was chosen.]

The proposed action is to harmonize on a new, performance-based standard. Compliance to this new regulation will require a combination of quantitative and qualitative means to demonstrate compliance. This is not unlike the requirements that exist in 14 CFR Part 25.671 or 25.1309.

All passengers are at some level of risk for permanent physiological harm. Due to numerous factors, including age, pre-existing medical condition, etc., some passengers will face greater levels of risk than others. The current FAR/JAR 25.1309 categorizes this failure condition as hazardous and acknowledges the potential for incurring injuries and/or fatalities to the airplane occupants, especially those passengers with certain pre-existing medical impairments (i.e. unhealthy passengers), following this failure event as follows:

Harmonized 25.1309 (Reference 2) (Proposed by SDAHWG)

Serious or fatal injury to a relatively small number of the occupants other than the flight crew.

With the type of failure condition defined above, there exists uncertainty with respect to the level of risk to each passenger's survival associated with exposure to the cabin environment following decompression. To satisfy the harmonized FAR/JAR 25.1309 it is necessary to assess the degree of risk in order to minimize the potential for permanent physiological harm to the airplane's occupants. An analysis that defines the envelope of vulnerability of passengers for permanent physiological harm in a decompression and identifies the continuously available design features of the airplane (i.e., aircraft systems) and the operational features (e.g., crew training, Airplane Flight Manual (AFM) limitations, etc.) to enhance the survivability of those passengers at increased levels of risk, would be an acceptable approach towards determining compliance with the harmonized FAR/JAR 25.1309. Note that the measure of adequacy is the presence of aircraft features (e.g., design and operational) that are commensurate with the level of risk associated with the cruise flight altitude.

Healthy passengers will self resuscitate, i.e., regain consciousness without any direct action of the crew and/or other occupants. Passengers must recover sufficient cognitive function to exit the aircraft following emergency descent, safe flight and landing. Some assistance may be required for passengers with pre-existing impairments.

The intent of this new regulation is to afford realistic protection to the occupants while allowing design flexibility to the airplane industry. Therefore, in contrast to Amendment 25-87, the new proposed rule acknowledges the potential for loss of life or permanent physiological harm to a small number of passengers, who are not considered healthy, following the decompression event. It is assumed the flight deck and cabin crew are healthy, and follow appropriate procedures.

It is because of uncertainty in predicting uncontained engine failure (UEF), uncertainty in the potential severity of the cabin environment following decompression at high altitudes, and uncertainty in the response of the occupants to that environment that acceptable means of compliance to this rule will require both quantitative and qualitative means. The underlying rationale is a belief that the cabin pressure field and the duration of the event determine the severity of the exposure to decompression. This is predicated on observations made from flight physiological and medical experiments, conducted during 1939, 1967 and 1969 (References 3, 4, 5) on a human subject and non-human primates, which provide guidance as to the maximum exposure time an unprotected person (i.e., without supplemental oxygen and pressure garment) may be exposed to the rarefied environment without permanent physiological harm. Experimental data on a human subject and non-human primates have shown exposure times that have resulted in fatalities and/or permanent physiological harm or no resultant injuries. There is no corroborated data that establishes the maximum safe exposure time (i.e., the maximum amount of time an unprotected individual may remain in the rarefied environment without incurring any permanent physiological harm). Certain reports have provided some guidance on exposure times that resulted in impairment of mental performance or loss of useful consciousness without resulting in permanent physiological harm. However, these data are at lower altitudes than the maximum certified altitudes for existing commercial airplanes, and are not representative of the extreme environmental conditions that the cabin can be exposed to in the historically rare event of decompression at high altitude.

Research work on non-human primates and a human subject as reported in References 3, 4, and 5 form the basis for this methodology. It was observed and is hypothesized that when the decompression data are evaluated via the use of a Depressurization Exposure Integral (DEI) a trend emerges; the DEI method is described within the draft Advisory Circular in the response provided for Question 13. There appears to be a positive association between the value of the integral and the likelihood of fatalities or permanent physiological harm being sustained by the subjects. The DEI method may provide a quantitative means to estimate the oxygen deprivation and thus, the severity of the exposure.

It was recognized by the working group that an interim policy should be established until validation testing is complete. As additional data are needed to address uncertainties in this method, it is recommended that the FAA and other regulators sponsor additional, independent research. It is recommended that the DEI method be submitted as a concept for peer review and validation to include testing. The DEI method may be validated or modified as a result of peer review.

A properly designed decompression study including human and/or primate subjects would define parameters for an analytical method (such as the DEI method) that are protective of human health. Test conditions should be designed to ensure that there are no fatalities and that the possibility of permanent physiological harm to the test subjects is remote. The decompression study should test at the highest rates of descent first and move to the slower rates as shown in the following table (for illustrative purposes with exact altitudes to be determined by the sponsors and cognizant medical authorities):

Descent Rate	**Altitude**	**40,000 feet**	**43,000 feet**	**45,000 feet**	**51,000 feet**
15,000 ft/min		H & N-HP	H & N-HP	N-HP	N-HP
10,000 ft/min		H & N-HP	N-HP	N-HP	N-HP
8,000 ft/min		N-HP	N-HP	N-HP	

Where: H signifies human subjects and N-HP signifies non-human primates.

All subjects should breathe air at chamber conditions, without pre-breathing oxygen. Safety precautions must be taken to avoid fatalities and permanent physiological harm (i.e., oxygen masks must be available for use by the observer to ensure the safety of the subject). Initial conditions would be set at an 8,000-ft altitude, and final conditions should be established to 10,000 feet. (Note that the chamber ascent rate from initial altitude pressure condition to maximum altitude pressure given in the table should occur within about 20 seconds. This results in rates of chamber pressure altitude rise of 1600, 1750, 1850 and 2150 feet per second, respectively.) The 20 second criterion was based upon the following considerations. For the safety of the subjects, an explosive decompression (i.e. duration of less than a few seconds) should not be simulated. Decompressions longer than the crew reaction time, say 30 seconds, permit crew actions to lower the peak altitude. Much longer times to maximum altitude as observed in the Nicholson & Ernsting, April 1967 data (Reference 4) of about 1.75 min., 3 min., and 5 min., respectively, are not representative of either worst-case decompression or practical airplane response. . A time delay of 20 seconds to decompress from 8, 000-ft altitude to the max altitude is recommended. For comparison purposes, the Nicholson & Ernsting 1967 (Reference 4) data show a chamber rise of approx 390 ft/sec while Brierley & Nicholson 1969 (Reference 5) data was approximately 410 ft/sec. Finally, the H.G. Clamann 1939 per Blockely & Hannifan 1961(Reference 3) data was approximately 6600 ft/sec.

Measurements would be made to determine alveolar oxygen level and other relevant parameters as selected by a group of medical specialists. Non-invasive means (e.g. behavioral tests, computed tomography scans, magnetic resonance imaging scans, and positron emission tomography scans) could be employed to examine the subjects for signs of precursors to permanent physiological harm.

6 - What should the harmonized standard be? [Insert the proposed text of the harmonized standard here]

While the task of this working group was limited to the working group report, the working group recommends that the FAA and other regulatory authorities consider the following material in promulgating a new harmonized rule and preamble to replace 14 CFR Part 25.841(a)(2) and (a)(3).

RULE

Proposed text for the new harmonized 14 CFR Part 25.841(a)(2) and (a)(3) rule:

The airplane must be designed and operated such that after a decompression event, the occupants will not be exposed to transient or steady state cabin pressure altitudes that

- ***i. Result in fatalities or permanent physiological harm to any crewmembers, or more than a small number of passengers, following any engine failures that do not result in a catastrophic loss of the airplane;***
- ***ii. Result in permanent physiological harm to any occupants following certain structural failure events;***
- ***iii. Result in permanent physiological harm to any occupants following system failure conditions not shown to be extremely improbable.***

PREAMBLE

The working group recommends that the FAA and other regulatory authorities consider the following material for use in the preamble for a new regulation.

> The original 14 CFR Part 25.841(a) (2) and (3) per earlier amendments had the laudable goal of ensuring no fatalities or permanent physiological harm (brain damage) following a decompression event. However, there is an inherent risk associated with any decompression event over and above that caused by the initiating failure itself. All occupants are at some level of risk during a decompression event. Permanent physiological harm to some occupants may occur during the initial event (i.e., from impact of uncontained engine debris or from being ejected from the airplane). In addition, some cases of permanent physiological harm among unprotected occupants may occur during the airplane descent due to hypoxia. Some occupants may be at increased level of risk because of numerous factors (e.g., age, pre-existing medical conditions, etc.). Those occupants at increased level of risk may suffer permanent physiological harm as a result of exposure to hypoxic conditions during a sudden decompression and the resulting emergency descent, flight and landing.
>
> The current proposed harmonized FAR/JAR 25.1309 requirements allow fatalities or permanent physiological harm for failure conditions categorized as hazardous. It acknowledges the potential for incurring injuries and/or fatalities to the airplane occupants following this type of failure event.
>
> The intent of this new regulation is to afford realistic protection to the occupants while allowing design flexibility to the airplane industry. It should be noted that the “worst-case” decompression events have originated from uncontained engine failures, which are rare, and structural failure events that do not result in catastrophic loss of the airplane. The proposed regulation acknowledges the potential for permanent physiological harm to a small number of passengers, only for structural and engine-related failures. It is because of uncertainty in predicting uncontained engine failure, uncertainty in the potential severity of the cabin environment following decompression at high altitudes, and the uncertainty

in the response of the occupants to that environment that acceptable means of compliance to this rule will require both quantitative and qualitative means. This is not unlike the requirements that exist in 14 CFR Part 25.671 or 25.1309.

The FAA, foreign regulators and industry need reasonably accurate quantitative means to assess features incorporated into the design and operation of an airplane. The MSHWG believes that the DEI method as described within the draft Advisory Circular in the response provided for Question 13, provides the quantitative means to ensure that an airplane design, properly operated, meets the intent of Part 1 of the new regulation with respect to protecting human physiology following a rapid decompression. However, it should be noted that the medical community is in disagreement over whether there is sufficient theoretical basis for this approach due to the paucity of useful data. Portions of the medical community are divided, citing a concern over the use of a simplified analysis to determine the severity of the human response to the rarified atmosphere following decompression. In fact, this is a dynamic multi-factorial response to changes in, among other things, the oxygen saturation of the blood, tracheal, alveolar, arterial and end-tidal partial pressure of oxygen, carbon dioxide, water vapor, pH of the blood, arterial blood pressure, cerebral vascular resistance and the local cerebral blood flow. In the opinion of some medical experts, this is a time dependent, multi-variable, highly synergistic problem that is not amenable to simplistic methods of analysis. While we acknowledge these concerns, we believe that through the selection of sufficiently conservative acceptance criteria validated by additional experimental data obtained through an appropriate research program, this approach will permit a realistic numerical appraisal of the severity of the decompression environment.

It is further recommended that the following issues be addressed in the preamble of the regulation:

The application of probability of structural failure is contrary to the basic structural design approach, and therefore probability of structural failure should not be considered in establishing compliance to the subject rule. The regulations governing structures are intended to render structural failures extremely improbable by virtue of choice of design loads, margins of safety, testing, and required maintenance programs, even though a numerical value for extremely improbable is not always computed.

System failure conditions not shown to be extremely improbable and certain structural failures shall not result in fatalities or permanent physiological harm. Therefore, the airplane must be designed so that occupants will not be exposed to cabin pressure altitudes that exceed the following after decompression:
(i) Twenty-five thousand (25,000) feet for more than 2 minutes; or
(ii) Forty thousand (40,000) feet for any duration.

The MSHWG recommends consideration of the structural failures specified in the Amendment 25-87 preamble and AC 25-20 for consideration with the following corrections:

The wheel rim release does not occur in flight condition, based on the very stringent requirements applied to the wheel design and tests and historic data. Also the probability method for fatigue model presented by one manufacturer gives substantiation that wheel failure is extremely improbable, therefore wheel rim release need not be considered.

The tire burst in flight is not extremely improbable as demonstrated by historic data. The ground loads are not applicable in flight and for this condition tires are extremely robust; according to 25.729(f)(1) and historic data, the tire burst occurs in flight and as it is very difficult to demonstrate that tire cannot be burst in case of overheat, it is not possible to demonstrate that this event does not occur in high altitude flight. Therefore, the tire burst event must be considered in the depressurization analysis.

Pressure vessel openings resulting from uncontained engine failure, loss of antennas, or stall warning vanes, or any system failure conditions that are not shown to be extremely improbable must be considered. The effects of such damage while operating under maximum normal cabin pressure differential must be evaluated. It can be assumed that the aircraft is operated as designed. In the event of an uncontained engine failure, manufacturers may assume that other, unrelated system or structural failures do not occur at the same time; however, loss of system capability, linked to the loss of the one engine has to be considered.

The loss of a “typical skin panel” bound by a crack stopper pattern need not be considered. It is assumed that propagation of a crack from stringer to stringer, frame to frame leading to the total loss of a skin panel is prevented by scheduled maintenance programs, and therefore does not occur. Structural cracks will be addressed as per the existing Amendment 25-87 preamble, and repeated below:

The maximum pressure vessel opening resulting from an initially detectable crack propagating for a period encompassing four normal inspection intervals. Mid-panel cracks and cracks through skin-stringer and skin-frame combinations must be evaluated.

It is recommended that the flight deck crew be trained in initiating emergency descent following rapid decompression. It is recommended that flight deck crew flying aircraft certified to fly above 41,000 ft. altitude undergo initial and periodic training in the use of positive pressure breathing masks. In demonstrating compliance with proposed § 25.841, the first priority of the flight deck crew shall be to don oxygen masks. The flight deck crew would then presumably perform an emergency descent in accordance with an approved emergency procedure. In order to maximize occupant survivability following a rapid decompression, the flight deck crew shall descend the airplane at the maximum safe descent speed, which is Vmo/Mmo, assuming structural failure as defined by FAR/JAR 25.571. Any additional training components and flight manual revisions necessary for adoption of the Vmo/Mmo descent criterion shall be required.

In demonstrating compliance with proposed § 25.841, the manufacturers shall account for loss of system capability, based on the specific systems architecture of the aircraft (only the systems that may be lost following an engine failure, as would be done in a hazard analysis, etc.), following loss of an engine.

During rapid and/or explosive decompression at cruise altitudes, flight deck crew would be in a highly chaotic environment with various warning sounds and vision may be severely limited due to fog, etc., in the flight deck air. Similarly, cabin flight attendants would not be able to reliably assess damage and report to flight deck crew. In fact, damage may be hidden from view.

Need to evaluate the effects that immediate exposure to various cabin altitudes will have on flight deck crew cognitive function if not wearing mask and if at least one crewmember will always be wearing oxygen higher than 41,000 ft. as required by FAA regulation (Note: FAA and Transport Canada requirement only. There is no European operational requirement for a crewmember to wear an oxygen mask at flight levels above 41,000 ft.). It is recommended that all regulatory authorities require that at least one flight deck crewmember be always wearing a pressure breathing oxygen mask above 41,000 ft. altitude.

Depending on the size of the hole and the net volume of the aircraft, depressurization may not occur within a few seconds. Therefore, the time to depressurize the aircraft after the hole is created should be considered.

Flight attendants are to put on masks, sit or hold on, and await flight deck crew instructions before attempting to help passengers. It is assumed for the purposes of showing compliance to the design rule that flight attendants are able to don masks and achieve a minimal level of protection within some reasonable number of seconds following mask drop. Following flight deck crew instructions, flight attendants will move about the cabin performing emergency procedures.

It will be assumed that not all passengers are able to effectively don masks. Healthy passengers will self-resuscitate, i.e., regain consciousness without any direct action of the crew and/or other occupants. Passengers must recover sufficient cognitive function to exit the aircraft following emergency descent, safe flight and landing. Some assistance may be required for passengers with pre-existing impairments.

It is understood that the flight deck crew and the way the airplane is operated can affect the survivability of the aircraft and its occupants following decompression. Therefore, requirements may be written into airplane flight manuals (AFM) to mitigate the severity of the post-decompression environment's impact on occupant health. A partial list of operational procedures that may accomplish this are:

- One member of the flight deck crew always wearing O_2 mask for flight above FL 410.

- Initial and recurrent emergency decompression training for all crewmembers.

7 - How does this proposed standard address the underlying safety issue (identified under #1)? [Explain how the proposed standard ensures that the underlying safety issue is taken care of.]

The original 14 CFR Part 25.841(a) (2) and (3) had the goal of ensuring no fatalities or permanent physiological harm following a decompression event. However, as a result of the deliberations within this working group and a review of available research material, the working group believes that there is an inherent risk to occupant health and safety associated with any decompression event. The MSHWG has concluded that all occupants are at some level of risk during a decompression event and the resulting emergency descent, flight, and landing. Fatalities may occur during the initial event (i.e., from impact of uncontained engine debris or from being ejected from the airplane). In addition, some cases of permanent physiological harm could result from hypoxia among those occupants at increased risk due to pre-existing health factors (e.g., age, chronic and acute medical conditions, etc.).

The proposed harmonized rule and advisory material will afford reasonable protection to all occupants on commercial transport aircraft, by ensuring that the duration of exposure to the rarified environment following a decompression at high altitude will be unlikely to result in permanent physiological harm to any more than a small number of passengers. The proposed methodology involves the calculation of the DEI. The working group recommends that the FAA obtain additional data to substantiate that the proposed design factors incorporate appropriate safety margins. This design methodology, combined with the historically observed low probability of occurrence, should provide a reasonable measure of safety for all occupants.

Previously certified large transport aircraft incorporating established design practices have safely operated at altitudes in excess of 40,000 ft. for more than 20 years, representing many millions of flight hours. Historically, relatively few accidents or incidents have occurred during cruise. According to the statistics, only 6 percent of accidents in the worldwide commercial fleet history have occurred during cruise; even though the highest percentage of the flight time (57%) is at cruise (Reference 6).

It should also be remembered that very few decompression incidents, if any, have exposed an aircraft cabin to pressure altitude profiles that run the risk of permanent harm to occupants. Industry experience shows that very few cases of catastrophic decompressions at high altitude have occurred, notably in small business jets. The FAA cited 3 cases as examples of rotor burst in cruise. In one case, a DC-10 crossing New

Mexico reported several cases of initial decompression sickness apparently with no permanent injuries. However, it was noted that 24 passengers and crewmembers were brought to the hospital at Kirtland AFB for treatment of symptoms including hypoxia. Because there was no follow-up on these occupants there is no way to assess the extent of injuries sustained during this decompression event. It is believed in this case rotor burst was induced via crew action. In the second case (Sioux City, Iowa), the aircraft damage was aft of the pressure bulkhead, thus no rapid decompression occurred. The FAA cites this event to estimate the damage if the debris field had been forward of the pressure bulkhead. In the third case (Pensacola, Florida), the airplane was on takeoff when the event occurred (not cruise) and the flight deck crew successfully performed a rejected takeoff. Thus, this case did not encounter a rapid decompression. It should be noted that the FAA cited these three cases (Reference 7) because they were "data rich" events. In addition to the "data rich" events discussed above, there have been another 9 uncontained engine failures at cruise identified to the FAA (Reference 8).

Date	Title	Remarks	Event Altitude	Cabin Altitude
05/07/75	OTHER	71 YR OLD MAN WITH CARDIAC PROBLEM DIED.	35,000	13,800
11/11/82	SUPERNUMERY CREW FATALITY	STUDENT FLIGHT ENGINEER BECAME INCAPACITATED HOSPITALIZED BUT DIED SOON THEREAFTER. AEROEMBOLISM.	33,000	20,000
03/09/89	CAB PRESS LOSS-PAX ILLNESS	ELDERLY LADY ON OXYGEN. TRANSPORTED TO HOSPITAL WHERE SHE LATER DIED.	31,000	10,000
11/03/77	EMERGENCY DESCENT/FATALITY	ONE PASSENGER DIED BEFORE LANDING	31,000	19,000
02/09/89	PILOT HYPOXIA	CAPTAIN DONNED A PORTABLE OXYGEN MASK WENT INTO MAIN DECK CARGO AREA . LOST CONSCIOUSNESS AND ULTIMATELY DIED OF HYPOXIA.	30,000	30,000
12/31/97	CREW MEMBER DIED IN FLT	CABIN PRESSURIZATION FAILURE. MAINTENANCE ENGINEER FOUND DEAD IN CARGO AREA OF AIRPLANE.		
02/02/95	RAPID DECOMPRESSION-DUCT FAIL	SEVERAL CREW MEMBERS WERE HOSPITALIZED DUE TO EFFECTS OF DECOMPRESSION.	43,100	28,000
11/03/73	ENGINE FAILURE	Aircraft decompressed to 34,000 ft in 26 seconds. Two F/A lost consciousness almost immediately when they stood up. Aircraft occupants were exposed to altitudes above 30,000 ft for about one minute and altitudes above 25,000ft for more than 2 minutes. One passenger ejected.	39,000	34,000
05/05/66	DEPRESSURE-CABIN ALT 34,000	1 F/A PASSED OUT FROM 2-3 MINUTES, 1 F/A GRAYED OUT, NUMEROUS PSGR RECEIVED EAR BLOCKS, ONE PSGR SEVERELY HE WAS HOSPITALIZED FOR 3 DAYS	39,000	34,000
04/24/63	DEPRESSURE-CABIN ALT=18,000 FT	CABIN CREW STEWARD BECAME HYPOXIC.	38,000	18,000

Date	Title	Remarks	Event Altitude	Cabin Altitude
03/18/99	DIV-DUE TO RAPID DECOMPRESSION	Four passengers 3 F/A lost consciousness for approximately 2 to 3 minutes	37,000	10,000
08/21/83	DEPRESSURE-CABIN ALT=30,000 FT	3 F/A'S COLLAPSED FROM LACK OF OXYGEN, AND ONE LAVATORY PSGR. BECAME HYPOXIC.	37,000	30,000
08/13/98	RAPID DECOMPRESSURIZATI ON	Captain and senior F/A lost consciousness.	35,000	20,001
10/03/74	DEPRESSURIZATION	ONE (OR TWO) F/A'S "CONVULSED AND LOST CONSCIOUSNESS." ONE F/A BECAME HYPOXIC.	35,000	25,000
07/22/81	DEPRESSURE-CABIN ALT=26,000 FT	TWO WOMEN PSGR FAINTED AND WERE ATTENDED TO BY AN ONBOARD DOCTOR	35,000	26,000
07/05/78	DEPRESSURE-CABIN ALT>29,000 FT	FEMALE PAX LOST CONSCIOUSNESS NO PULSE NOR BREATHING. F/A ADMINISTERED HEART MESSAGE AND MOUTH-TO-MOUTH RESUSCITATION. FLIGHT CREW TEMPORARILY DEAF.	35,000	29,001
05/12/96	LOSS OF CABIN PRESSURE	Captain, flight engineer and lead flight attendant all become unconsciousness due to hypoxia.	33,000	22,001
03/15/94	Pilot incapacitation - decompression sickness	CLIMBING TO FL350 WITH SUPP OXYGEN,THE CAPT BECAME INCAPACITATED NITROGEN NARCOSIS (BENDS) TAKEN TO A HOSPITAL SERIOUS CONDITION	33,000	33,000
06/08/75	DEPRESSURE-CABIN ALT=16,000 FT	AIRLINE PSGR-EMPLOYEE SUFFERED COLLAPSED LUNG. HOSPITALIZED FOR 69 HOURS.	31,000	16,000
09/18/01	UNCONTAINED ENGINE FAILURE	When the aircraft landed, one passenger was found dead, apparently due to depressurization. Possible ejection.	30,000	30,000

Date	Title	Remarks	Event Altitude	Cabin Altitude
03/03/87	ATB/PRESSURIZATION LOST	TWO PASSENGERS AND ONE FLIGHT ATTENDANT WERE UNCONSCIOUS FOR A SHORT PERIOD.	28,000	8,500
09/17/79	ATB/EXPLOSIVE DECOMPRESSION	F/A FELL TO FLOOR, UNCONSCIOUS FOR ABOUT 15 SECONDS AND SUSTAINED MINOR LEG, HEAD AND HAND INJURIES.	25,000	25,000
04/28/88	FUSELAGE OPENED IN FLIGHT	ONE FLIGHT ATTENDANT WAS LOST OVERBOARD DURING THE DECOMPRESSION. ANOTHER FLIGHT ATTENDANT AND 7 PASSENGERS RECEIVED SERIOUS INJURIES OF LACERATIONS, SKELETAL FRACTURES AND CONCUSSIONS.	24,000	24,000
02/24/89	CARGO DOOR/FUSELAGE OPENED IN FLIGHT	INJURIES SUSTAINED BY THE SURVIVORS WERE CAUSED BY THE EVENTS ASSOCIATED WITH THE DECOMPRESSION, SUCH AS BARO-TRAUMA TO EARS, AND CUTS AND ABRASIONS FROM THE FLYING DEBRIS IN THE CABIN. Nine passengers ejected.	23,000	23,000
04/11/60	DEPRESSURIZATION AT 20,000 FT	ONE CREW MEMBER FAINTED FROM LOSS OF OXYGEN WHILE AIDING PASSENGERS WITH THEIR MASKS.	20,000	20,000
11/23/93	RAPID DECOMPRESSION-ATB	SOME FLIGHT ATTENDANTS WERE LYING ON THE FLOOR.	19,000	19,000
06/10/90	CAPT PARTLY EJECT THRU WINDSHD	CAPTAIN WAS SUCKED PARTWAY OUT OF COCKPIT SUFFERED FACIAL BRUISES, FRACTURED ELBOW, WRIST AND THUMB, AND FROSTBITE	17,000	17,000
08/26/84	CBN PRESS FAILURE	1 PAX SUFFERED HEART ATTACK		

Table 7-1: Significant Pressurization Events

Notes: Based on a Total of 2866 pressurization events reported since 1959. Transport Category Airplanes over 60,000 lbs.

Event Altitude and Cabin Altitude were reported for 873 events.

Sources: Boeing Airplane Safety Engineering (ASE) and Safety Information System (SIS), National Transportation Safety Board (NTSB)

The above three table sets comprise Table 7-1 and summarize significant transport category decompression events resulting in fatalities (in red) or incapacitation. These events are graphically plotted in Figure 7-1 below. Note that while fatalities were incurred, none are attributable to the scenario identified by FAR 25.841(a), Amendment 25-87 where a large hole is created in the fuselage due to an engine burst, etc.

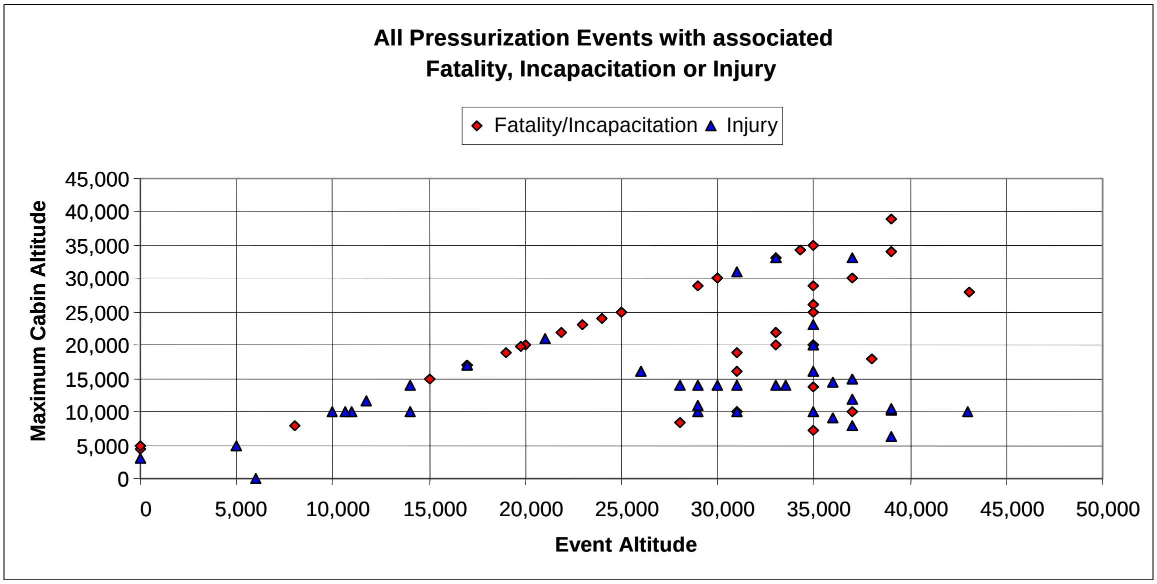


Figure 7-1: Pressurization Events with Fatality, Incapacitation or Injury

Notes: Total of 2866 pressurization events reported since 1959. Transport Category Airplanes over 60,000 lbs.

Event Altitude and Cabin Altitude were reported for 873 events.

Sources: Boeing Airplane Safety Engineering (ASE) and Safety Information System (SIS), National Transportation Safety Board (NTSB)

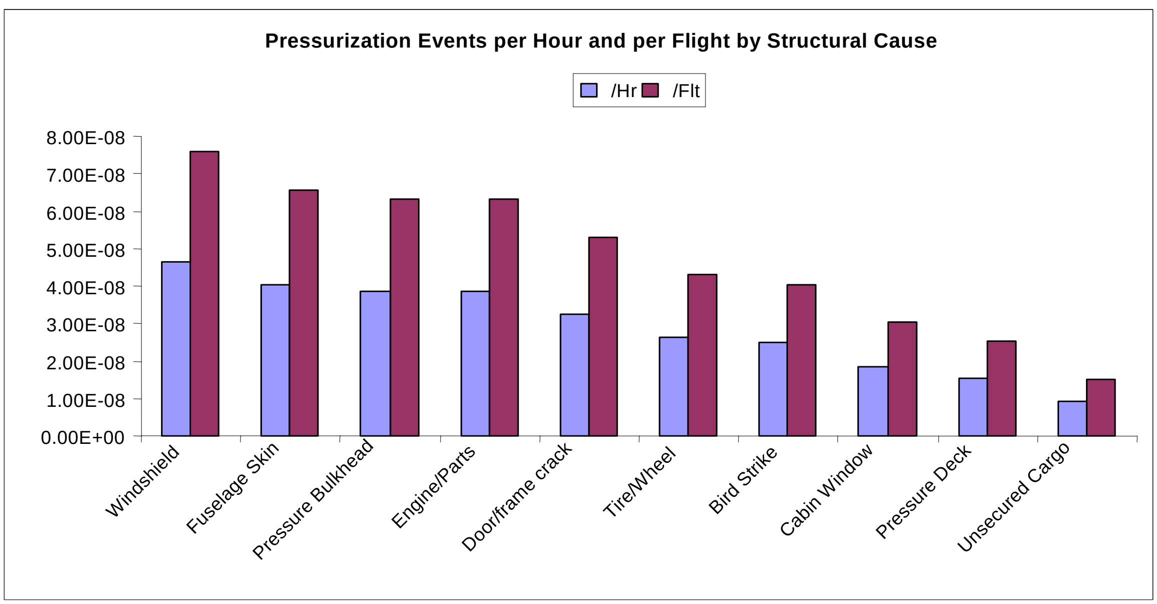


Figure 7-2: Pressurization Events by Structural Cause

Notes: Total of 2866 pressurization events reported since 1959. Transport Category Airplanes over 60,000 lbs.

Event Altitude and Cabin Altitude were reported for 873 events.

Sources: Boeing Airplane Safety Engineering (ASE) and Safety Information System (SIS), National Transportation Safety Board (NTSB)

Figure 7-2 portrays pressurization events per hour and per flight due to structural cause. Note that the probability in all cases is on the order of 10^{-8}.

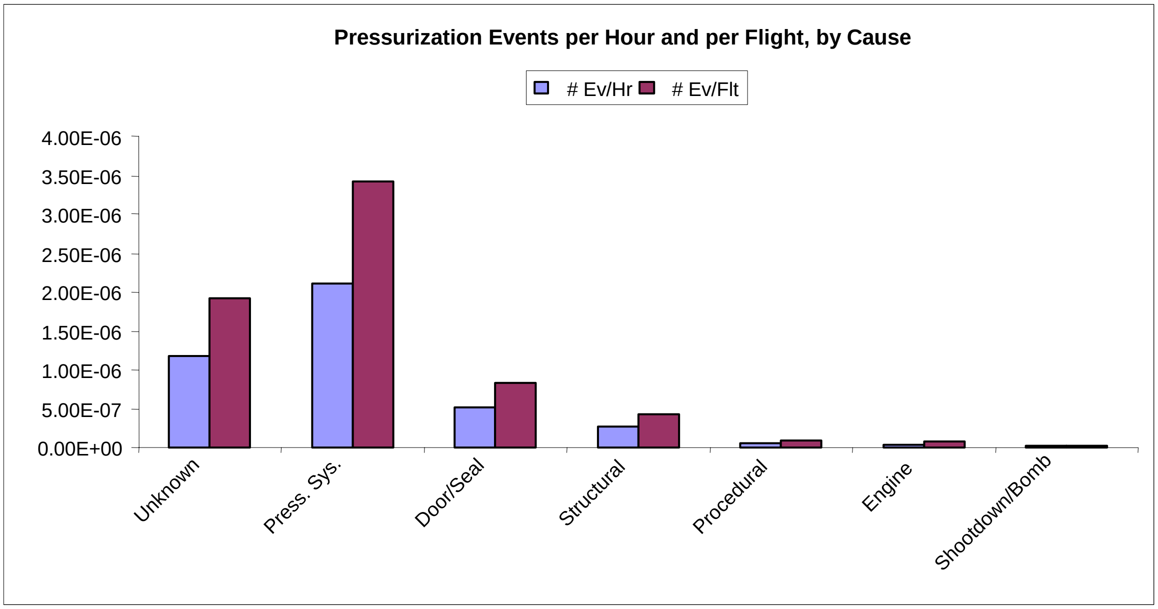


Figure 7-3: Pressurization Events by Cause

Notes: Total of 2866 pressurization events reported since 1959. Transport Category Airplanes over 60,000 lbs.

Event Altitude and Cabin Altitude were reported for 873 events.

Sources: Boeing Airplane Safety Engineering (ASE) and Safety Information System (SIS), National Transportation Safety Board (NTSB)

Figure 7-3 depicts pressurization events by cause. Note that those caused by engine uncontained failures contribute very little to the total.

- Pressurization system faults predominate in the identified causes of decompression events
  - During initial climb up to and including maximum pressure differential (as pressure differential increases),
  - In cruise (flight phase with longest time duration),
  - At/after top of descent (pressurization system mode changes, idle engine operation)
- Maintenance and operational procedure errors are important contributors to events (doors/seals, crew management of ECS)
- Decompressions due to engine rotor bursts are rare, albeit highly unpredictable events

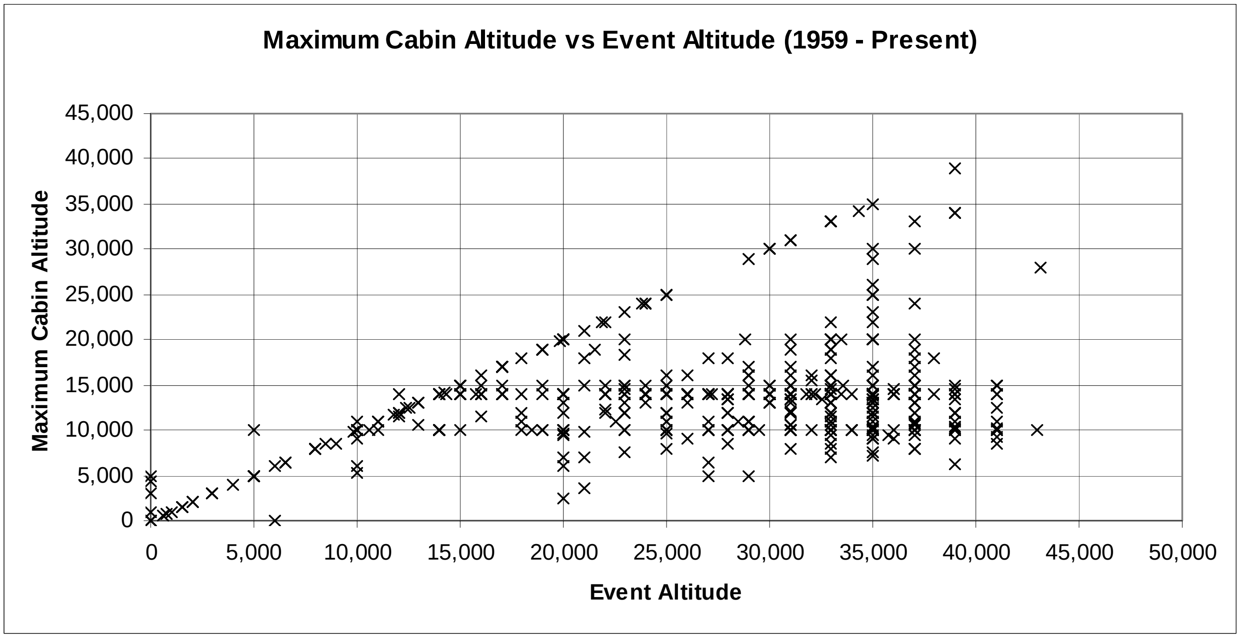
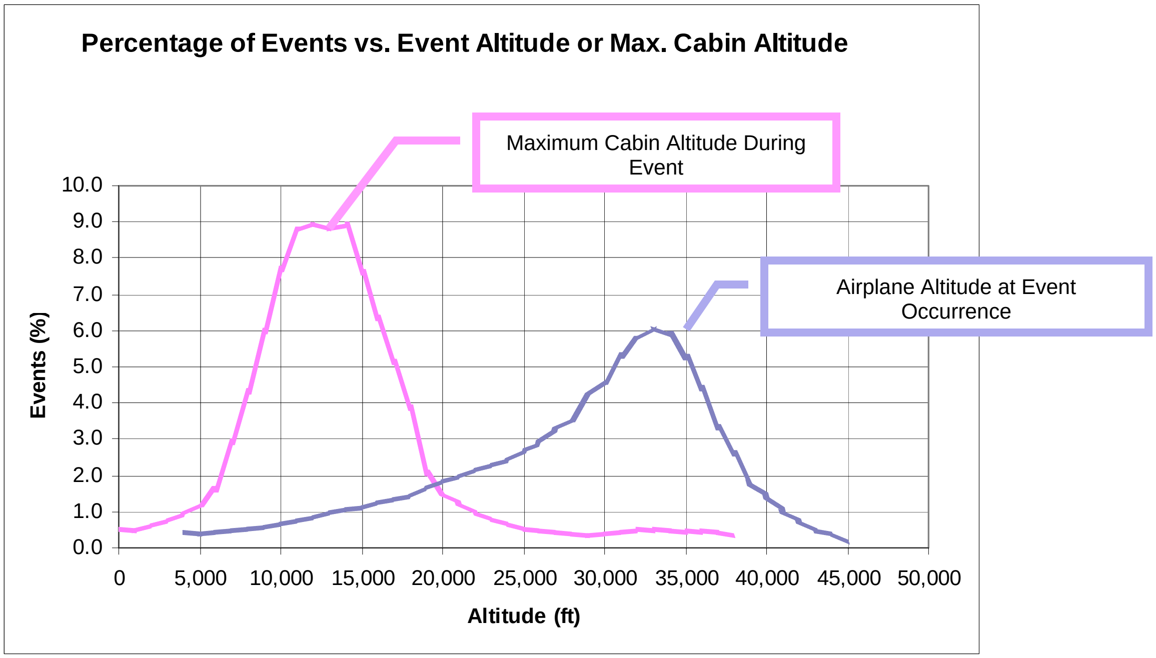


Figure 7-4: Pressurization Events from 1959 to 2001

Notes: Total of 2866 pressurization events reported from 1959 to 2001. Transport Category Airplanes over 60,000 lbs.
All points in which the cabin altitude is shown as zero, the airplane altitude is unknown.
Event Altitude and Cabin Altitude were reported for 873 events.
Sources: Boeing Airplane Safety Engineering (ASE) and Safety Information System (SIS), National Transportation Safety Board (NTSB)

Figure 7-4 presents decompression events that have occurred from 1959 to 2001 in transport category airplanes. It depicts the maximum cabin altitude reached during a decompression event vs. the airplane flight altitude. Note that no decompression event has resulted in a maximum cabin altitude above 40,000 ft, although it should be noted that the vast majority of flight hours in transport category aircraft since 1959 have been at altitudes below 40,000 feet.



Notes: Total of 2866 pressurization events reported from 1959 to 2001.
Airplane altitude is the primary parameter, since it defines the pressure differential, time duration of exposure to potentially unsafe cabin pressure altitudes, and emergency descent performance.
Cabin altitude is a secondary parameter, since it is the resultant of airplane design, maintenance practices and operational procedures Sources: Boeing Airplane Safety Engineering (ASE) and Safety Information System (SIS), National Transportation Safety Board (NTSB)

Figure 7-5: Pressurization Events: Percentage of Events vs. Altitude

This figure depicts the distribution of cabin altitude and airplane altitude during decompression events. Note that the average cabin altitude reached is well below the average airplane altitude. Note also that cabin altitude has rarely ever exceeded 25,000 ft.

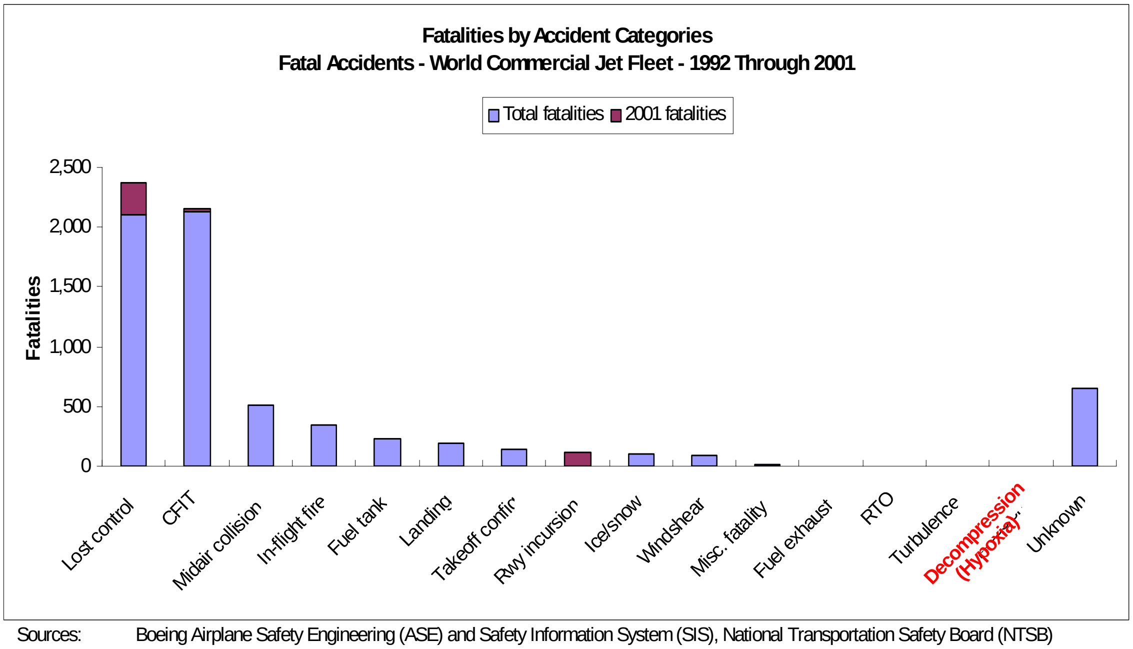


Figure 7-6: Fatal Accidents by Category

This figure shows fatal accidents by category for the world commercial jet fleet for the period of 1992 to 2001. Note that no hypoxia related fatalities were due to in-flight decompression events. Relative to other causes, decompressions resulting in hypoxic fatalities are not a significant accident contributor. Of 7,171 fatalities for the period of 1992 – 2001, no hypoxia related fatalities were due to in-flight decompression events.

Due to the uncertainty in the potential severity of the cabin environment following decompression and the uncertainty in the response of the occupants to that environment, the MSHWG recommends that regulatory authorities impose both quantitative and qualitative means to demonstrate compliance. This is not unlike the requirements that exist in 14 CFR Part 25.671 or 25.1309.

Other design solutions such as improved passenger masks, improved engine fragment shielding, emergency ram air pressurization system, or advanced engine blade failure warning devices may exist in the future that will afford additional mitigation strategies to be utilized. The measure of severity of the environment may include the use of an uncontained engine failure debris model validated by existing data, that provides a realistic pressure vessel cumulative hole area and damage to the associated aircraft systems. Consideration must be given to loss of those systems that directly impact cabin pressurization and airplane descent.

8 - Relative to the current FAR, does the proposed standard increase, decrease, or maintains the same level of safety? Explain. [Explain how each element of the proposed change to the standards affects the level of

safety relative to the current FAR. It is possible that some portions of the proposal may reduce the level of safety even though the proposal as a whole may increase the level of safety.]

Amendment 25-87 was developed using one researcher's work (Reference 9) that focused on a concept called, "Time of Safe Unconsciousness"(TSU) as applied to passengers. Data described within this report is in relationship to the "Time of Useful Consciousness" (TUC) that is applicable to pilots or "time of consciousness". The author selects 25,000 feet pressure altitude as a reference state because most subjects can tolerate several minutes of hypoxia up to this altitude. The author concludes, "a relatively safe time may be considered as 1 minute and 40 seconds to 2 minutes" (above 25,000 feet). Dr Gaume's paper did not refer to, nor reference the experimental data utilized by this ARAC working group to formulate the DEI methodology.

In addition, the FAA in promulgating this regulation did not refer to, nor reference the experimental data utilized by this ARAC working group to formulate the DEI methodology.

The overall level of safety for systems failure conditions may be increased. As this rule allows the use of probability for systems failure analysis, the manufacturer may be motivated to meet higher reliability levels.

The effects of this rule is that future large transport airplanes may cruise at higher altitudes and for longer periods of time than airplanes compliant to FAR 25.841(a)(2) & (3). If the rate of occurrence of decompression events remains constant, than this carries with it an increase in the future probability of exposing crewmembers and passengers to a high altitude atmosphere following a rapid decompression. This implies a potential reduction in the safety level relative to the current regulation.

The proposed standard has limited data to support it, but it may be validated through further testing and rigorous, critical peer review. In addition, while it is not possible at this time to use a probability argument as a sole means of compliance to the regulation, cabin decompressions resulting from UEF are a rare event. Over the last nearly 30 years of commercial air travel the relative probability of an uncontained engine failure was $6.2x10^{-7}$ per engine hour (Reference 10). Furthermore, there are indications of a reduction in this probability with newer turbofan engines that could result in even lower overall probability of such an occurrence [See Figures 8-1 and 8-2]. Therefore, it is believed that the new standard affords reasonable protection given the rarity of the threat.

Relative to the current standard, the new standard allows exposure of all occupants to higher cabin altitude with a potential increased level of risk and a decrease in safety for the uncontained engine failure decompression scenarios. However, the new standard maintains the same level of safety with respect to system and structural failures. For the UEF scenarios, a new means of compliance is permitted by theoretical means to be validated via additional experimental data in conjunction with the probability of a hole large enough to cause the rapid decompression.

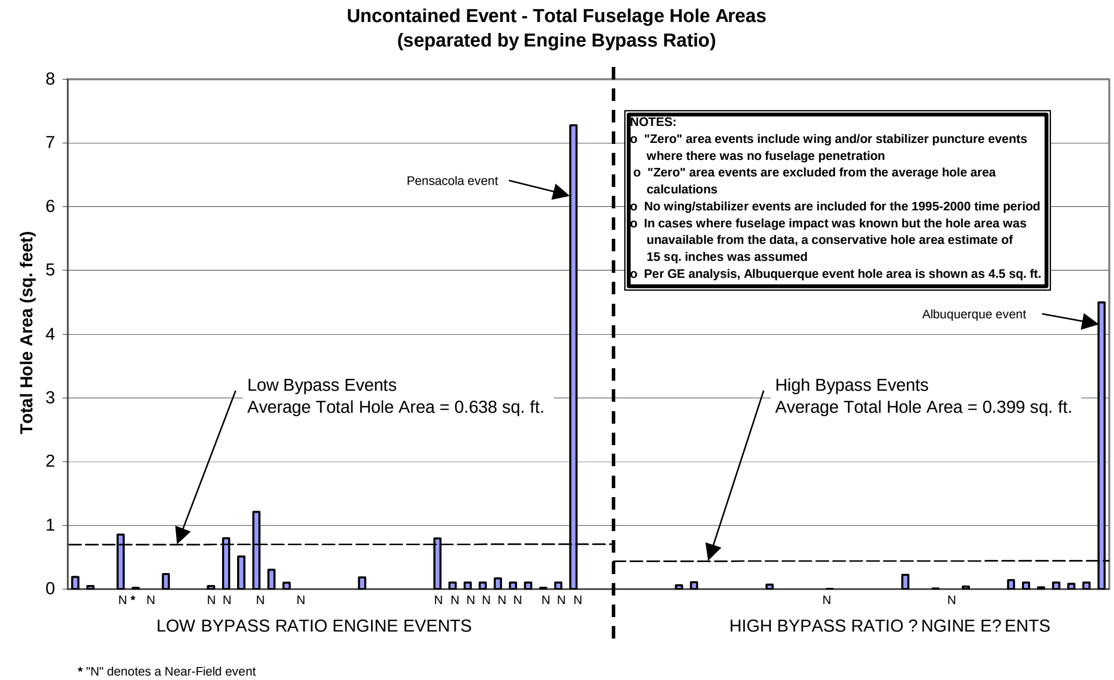


Figure 8-1: Historical Uncontained Engine Failure Total Fuselage Hole Areas Shown with Pensacola and Albuquerque Events Included.

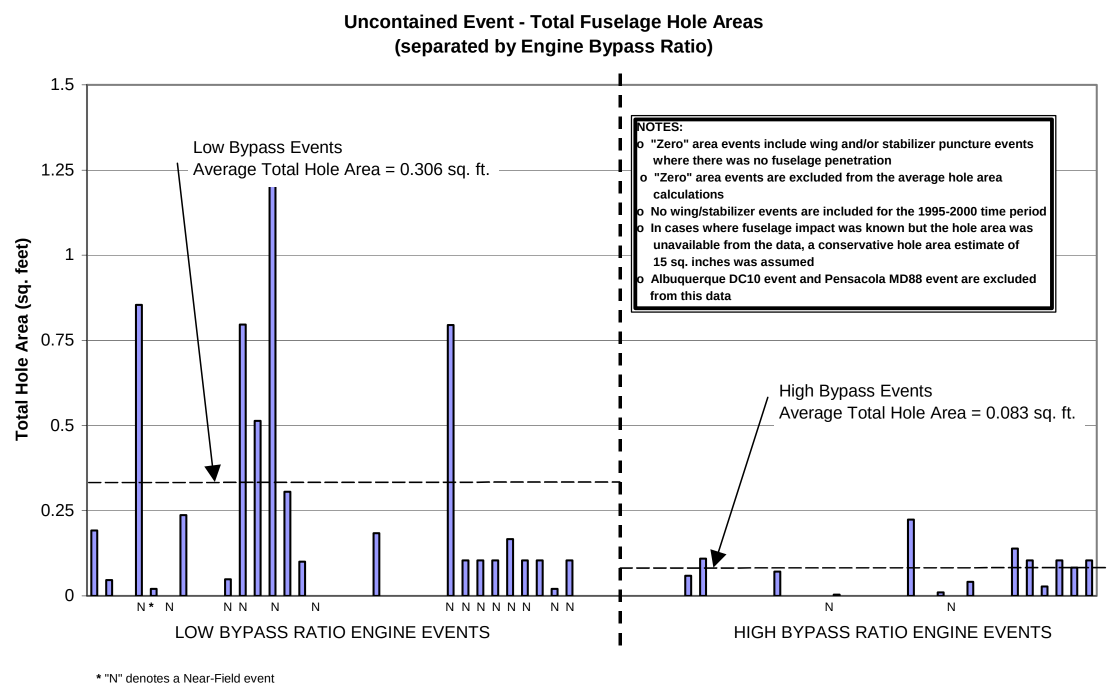


Figure 8-2: Historical Uncontained Engine Failure Total Fuselage Hole Areas Shown with Pensacola and Albuquerque Events Excluded

9 - Relative to current industry practice, does the proposed standard increase, decrease, or maintains the same level of safety? Explain. [Since industry practice may be different than what is required by the FAR (e.g., general industry practice may be more restrictive), explain how each element of the proposed change to the standards affects the level of safety relative to current industry practice. Explain whether current industry practice is in compliance with the proposed standard.]

Transport category airplanes certified previous to introduction of Amendment 25-87 in 1996 have been certified up to altitudes of 45,000 feet. Current design practices for large commercial transports have evolved such that placement of the engines is accomplished via attachment to pylons located underneath the wings. While permitting benefits to stability and airplane performance, this feature exposes a large area to potential penetration of the pressurized vessel in the event of an UEF. Smaller commercial airplanes have typically attached the engines to the fuselage. The aft-pressurized bulkhead has been placed immediately forward of the rotor burst zone (a hypothetical cone, approximately 3 degrees from the rotational plane of the engine). Traditionally this has limited pressurized fuselage penetrations to no more than a few small fragments on the smaller commercial airplanes.

Current airplanes with wing-mounted engines would not meet the requirements of 25.841(a) as modified by Amendment 25-87 at present certified altitudes. Nevertheless, current industry practice maintains an excellent level of safety with respect to rapid decompression at high altitudes. As for the world commercial jet fleet for the period of 1992 to 2001, no hypoxia related fatalities were due to in-flight decompression events (see Figure 7-6). This safety record has been maintained despite the fact that newer airplanes fly at these higher altitudes more often than older airplanes (see Figure 9-1).

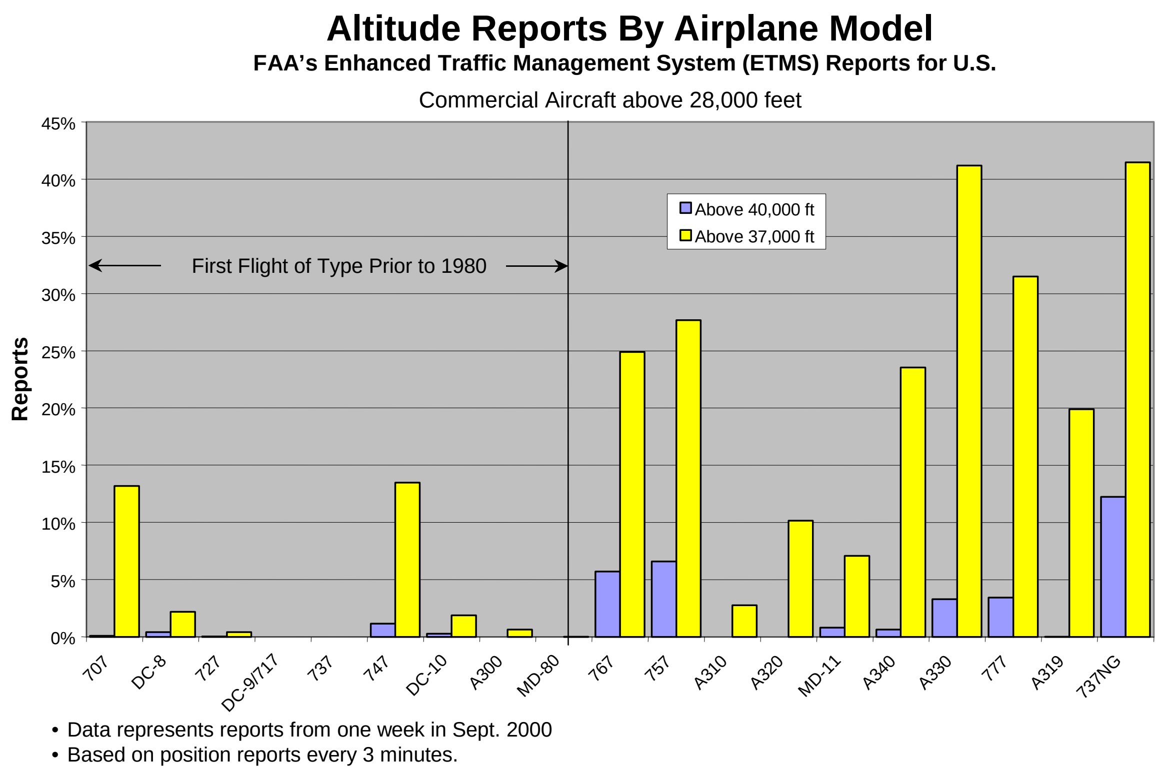


Figure 9-1: Frequency of Flights above 37,000 ft. and 40,000 ft. Altitude of New Design Aircraft vs. Older Design Aircraft.

These newer airplanes incorporated high bypass ratio engines that are designed to reduce the probability of engine rotor burst (see Figures 8-1 and 8-2). In addition, newer airplanes incorporate additional safety features such as quick donning oxygen masks, system separation within the fuselage, and "fail safe" window designs.

The new standard and its means of compliance do not represent the same level of conservatism as present in the existing regulation. However, the proposed standard has corroborating data, albeit limited, to support it and will be validated by further testing. In addition, while not permitted as a sole means of compliance to the regulation, cabin decompressions resulting from UEF are a rare event. Therefore it is believed that the new standard affords reasonable protection given the rarity of the threat. It is believed that newer transport category airplanes in service today could meet the new proposed standards.

The effect of this rule is that future large transport airplanes may cruise at higher altitudes and for longer periods of time than current industry practice. If the rate of decompression events remains constant, then this carries with it an increase in the probability of exposing crewmembers and passengers to a high altitude atmosphere following a rapid decompression. This implies a potential reduction in the safety level relative to current industry practice.

10 - What other options have been considered and why were they not selected?: [Explain what other options were considered, and why they were not selected (e.g., cost/benefit, unacceptable decrease in the level of safety, lack of consensus, etc.]

Use of Video and Sensor Technology:

It was thought that the use of video camera technology could provide the flight deck crew with information regarding the extent of the damage to the airplane to enable them to ascertain if the airplane were capable of a Vmo/Mmo descent and to ascertain the severity of the exposure to the cabin crew and passengers. The consensus was that this technology did not afford sufficient benefits and that while video and sensor technology concepts exist, they are in developmental stages and the technology is not yet mature. Use of data is not established, and training issues further restrict feasibility of damage assessment for maximizing descent rate. In addition, it was determined that, in fact, use of Vmo/Mmo descent is feasible following a survivable decompression event. Finally, concern was also expressed as to whether the flight deck crew could utilize video technology during a rapid decompression event, given the likelihood of condensation fog in the flight deck.

17 Second reaction time:

Another topic that was discussed was the basis of, and possibility of changing, the 17 second reaction time noted in the Advisory Circular. This reaction time includes donning of oxygen mask, isolation of failure and airplane reconfiguration and initiation of emergency descent. Issues that were discussed included the testing of pilot reaction time in donning an oxygen mask and performance of tasks following a simulated decompression (chamber test). The sub-team examined the material and concluded that there was insufficient data to reach a conclusion to shorten this reaction time. The 17 second reaction time is based on mean values from crew responses in simulators from a 1956 study by Dr. E.G. Vail (Reference 11) and further reviewed by Bennett in 1964 (Reference 12).

Emergency Descent Limitation:

Another topic that was discussed was limiting or restricting the descent and concern over the use of this procedure because of possible loss of structural integrity following the UEF. Issues that were considered included dynamic loads during a Vmo/Mmo emergency descent and structural integrity and were conducted with manufacturer's structures and loads engineers. Structural loads following decompression are assessed similar to other "Discrete Damage" (pressurized or unpressurized) type conditions in which the airplane damage is assessed per FAR 25.571(e), i.e. structural damage including non-catastrophic rotor failure. Structural load capabilities of the airplane following a survivable discrete damage event are considered under unpressurized conditions and are associated with reduced inertia load factors (See AC 25.571-1C). However, this does not limit the maximum design descent (Mmo/Vmo) and therefore is not a determining factor in the airplane descent following decompression. The MSHWG examined the material and concluded that if the airplane structure survived the initial UEF event, then per the present regulations there should be sufficient structural integrity of the airplane to enable it to perform a Vmo/Mmo emergency descent.

Use of Probabilities for structural failures:

The application of probability of structural failure is contrary to the basic structural design approach, and therefore probability of structural failure should not be considered in establishing compliance to the subject rule. The regulations governing structures are intended to render structural failures extremely improbable by virtue of choice of design loads, margins of safety, testing, and required maintenance programs, even though a numerical value for extremely improbable is not always computed.

Tire, Wheel and Rim failures:

Based on tire, wheel and rim failure data provided by the representative airplane manufacturers, it was determined by the MSHWG that tire failures must be considered, but not wheel and rim failures.

Aerodynamic Suction

The subject of aerodynamic "suction" has been raised in the MSHWG. This is the effect caused by air moving tangentially to an open hole and causing pressure variations in the cavity on the other side of the hole. Its effect on holes produced in the fuselage of an aircraft was analyzed with the help of computational fluid dynamics-knowledgeable engineers.

TYPES of HOLES PRODUCED during DECOMPRESSION

Figure 10-1 shows the type of hole (hereafter referred to as « Type 1 hole ») produced, usually, by some form of structural failure due to the differential pressure between A/P cabin and the outside ambient pressures, and also shows the relative pressure area(s) relative to the geometry of the hole. This is NOT the type of hole that would be produced by penetration by external debris unless the debris was passing out through the far side of the aircraft.

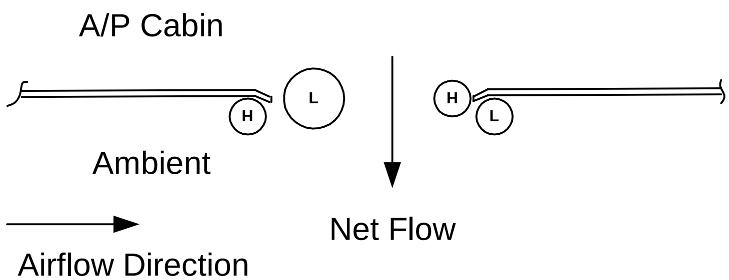


Figure 10-1: Pressure Zones Around a Type 1 Hole

Figure 10-2 shows the type of hole (hereafter referred to as « Type 2 hole ») produced by engine debris penetrating the fuselage structure, and also shows the relative pressure area(s) relative to the geometry of the hole. The figure clearly shows that there is an area of higher pressure towards the aft end of the hole that would result in net air inflow into the cabin at low differential pressures. Any reduction in the net inflow would be as a result of the pressure profile on the outside of the aircraft represented by the coefficient of pressure Cp.

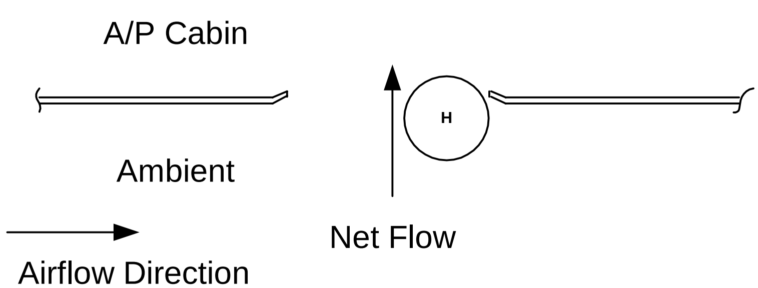


Figure 10-2: Pressure Zones Around a Type 2 Hole

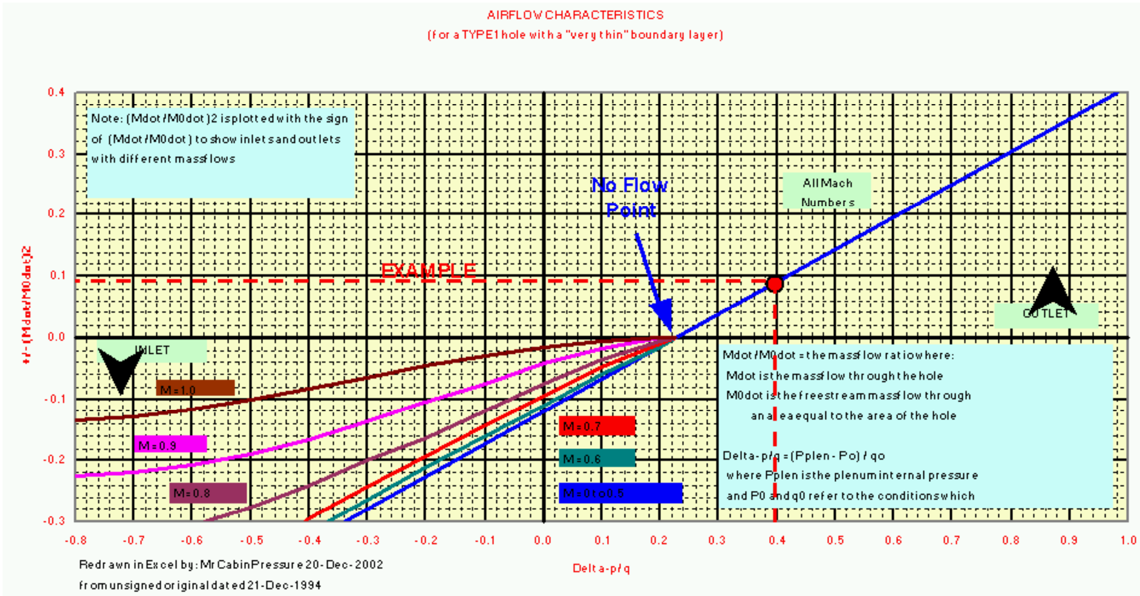


Figure 10-3: Airflow Through a Type 1 Hole

Figure 10-3 describes the pressure and flow relationship for an opening in the fuselage that is parallel to the air stream. The vertical axis is a square of the flow ratio between the predicted flow and the flow that would be obtained if air at free stream conditions were passed through the same area. It is important to note a sign change is carried through to represent flow in or flow out. The horizontal axis is the predicted static pressure across the hole (assuming the hole is connected to a plenum) divided by the free stream (incompressible) velocity pressure, q. The No Flow Point, where $\Delta P/q=0.23$ shows that a certain amount of internal plenum pressure is required to overcome the ram effect of the free stream.

Using Figure 10-3, the following can be considered to be the equilibrium condition:

When a hole has been created, then as time tends to infinity the net mass flow ratio (M/M0)^2 tends to zero. The final equation becomes:

Cpf on fuselage = 0.23 + Cp original

Thus, provided the original Cp on the fuselage before the hole appeared was > -0.23 there will be a net INFLOW into the aircraft cabin. Any inward curvature of the hole will increase the outside Cp on the fuselage.

To convert Cpf into local static pressure, use this formula:

Ps = Pinf [1 + (0.7 * Minf^2 * Cpf)]

Ps = local external static pressure (psia)

Pinf = free stream static pressure (airplane pressure-altitude) (psia)

Minf = free stream Mach number (non-dimensional)

Cpf = net pressure coefficient as described above (non-dimensional)

Conclusion

There is the possibility that some part of the structure of the aircraft could fail due to internal causes (unknown) other than an externally failed engine. The resultant hole would be outwardly bent of the type shown in Figure 10-1. However, due to structural rip-stop fail-safe design, the resultant hole size will usually be small enough that the aircraft will already be well into its emergency descent before the aircraft and cabin altitudes become equalized. Thus, any "suction" effect caused by the hole will not cause the maximum cabin altitude to exceed the cruise altitude of the aircraft prior to its descent. By the time the aircraft levels off at the lowest available en-route altitude, the aircraft will have reduced speed from, say, Mach 0.85 to Mach 0.5, which reduces the effect to negligible levels.

When an engine rotor or fan bursts, the resultant profile of the debris will produce a hole in the fuselage that penetrates from outside to inside the aircraft. This will produce an inwardly bent structure, which is the hole shape shown in Figure 10-2. Obviously, if the debris is large enough and of enough energy, it could exit the fuselage on the opposite side and create a hole of the type shown in Figure 10-1. In this case, it is assumed that the opposing effects of the two holes would cancel out each other and remain neutral. However, there will be more than one piece of debris penetrating the fuselage, most of which will not exit the opposite side of the fuselage. Thus, there will always be a net effect on the flow characteristics out of the aircraft associated with Type 2 holes, which have the "high pressure" characteristic, effectively ensuring that the actual cabin altitude is lower than the aircraft altitude, provided the initial Cp on the area of the fuselage was > -0.23.

For all the DEI analyses, the effect of this is not considered - i.e. the cabin and aircraft altitudes are considered equal in cruise if the hole is large enough to cause the cabin altitude to reach the aircraft altitude prior to initiation of the emergency descent. The only time that the cabin altitude is considered higher than the aircraft altitude is if the aircraft is already in its emergency descent and the aircraft "flies-through-the-cabin". This effect is accounted for in the analysis program.

11 - Who would be affected by the proposed change? [Identify the parties that would be materially affected by the rule change – airplane manufacturers, airplane operators, etc.]

Airplane manufactures and suppliers will benefit from the single well-defined harmonized ruling thereby reducing certification costs. They will also benefit due to allowing the creation of new generation, more efficient airplanes that will give continuity to their business. Their employees will benefit by sustained employment in the airplane manufacturing industry. The public will benefit due to the availability in the future of newer, more efficient airplanes with the possibility of less expensive fares (higher altitudes means less fuel consumption). Newer airplanes should also be more reliable reducing the inconvenience of delays and flight cancellations to the public. Finally, there is a benefit to the public in that newer, more efficient airplanes flying at higher altitudes will burn less fuel with corresponding less emissions of harmful gases and particulates, and the airspace will be more effectively utilized.

12 - To ensure harmonization, what current advisory material (e.g., ACJ, AMJ, AC, policy letters) needs to be included in the rule text or preamble? [Does the existing advisory material include substantive requirements that should be contained in the regulation? This may occur because the regulation itself is vague, or if the advisory material is interpreted as providing the only acceptable means of compliance.]

The relevant advisory material is AC 25-20, which with the exception of structural failure related information, does not contain any additional information that needs to be included in the rule text or preamble. Issues significant in showing compliance to the proposed rule are identified in the response provided for Question 6, above.

13 - Is existing FAA advisory material adequate? If not, what advisory material should be adopted? [Indicate whether the existing advisory material (if any) is adequate. If the current advisory material is not adequate, indicate whether the existing material should be revised, or new material provided. Also, either insert the text of the proposed advisory material here, or summarize the information it will contain, and indicate what form it will be in (e.g., Advisory Circular, policy, Order, etc.)]

While the task of this working group was limited to the working group report, the working group recommends that the FAA consider the following material in promulgating a new Advisory Circular to replace the designated portions of the existing AC 25-20 - PRESSURIZATION, VENTILATION AND OXYGEN SYSTEMS ASSESSMENT FOR SUBSONIC FLIGHT INCLUDING HIGH ALTITUDE OPERATION.

AC 25-20 contains guidance material for pressurized compartment loads (§ 25.365(d)), ventilation (§ 25.831), pressurized cabins (§ 25.841) and equipment standards for oxygen dispensing units (§ 25.1447) that were introduced at Amendment 25-87. However, only those portions of AC 25-20 that provide guidance to 25.841(a)(2) and (3) are addressed in this report.

The working group recommends that the regulatory authorities consider the following material in promulgating new harmonized regulation on 14 CFR Part 25.841 and draft Advisory Material.

Portions of existing Advisory Circular AC 25-20 should be retained. Some sections should be modified slightly while others require major rewrite. The group recommends that:

Portions of AC 25-20 that need to be retained in total are:
Section 1 Purpose, Section 2 Associated FARs,

Portions of AC 25-20 that need minor modification are:
Section 3 Background should be modified to add the information on the new standard and information gained with respect to Amendment 25-87 regulation.
Section 10 Emergency Descent should be modified to reflect the group consensus on the use of a Vmo/Mmo descent.
Section 12 Glossary needs to reflect the new standard and definitions of terms.

Portions of AC 25-20 that will need a complete rewrite:
Section 4 Physiological Limiting Criteria needs to reflect the current consensus on the new standard.
Section 6 Pressurization needs to reflect the new standard.
Section 7 Failure Conditions needs to reflect the current consensus on the new standard.
Section 8 Fuselage Structure
Section 9 Engine needs to reflect the current consensus on the new standard and the use of an uncontained engine failure debris analysis based on historical data.

Section 3 Background section should be modified to add the information on the new standard and information gained with respect to Amendment 25-87 regulation.

3. BACKGROUND. Part 25 was amended to include standards for high altitude operation of subsonic transport category airplanes. The adopted standards differ somewhat from those previously contained in special conditions and from previously established part 25 systems and structural integrity requirements. The standards were written to address physiological limitations at high altitudes and changes in equipment technology. The standards adopted as Amendment 25-XXX pertain to operation of subsonic airplanes to a maximum altitude of 51,000 feet, although many of the requirements addressed therein relate to operations at lower altitudes (below 41,000 feet) as well.

Section 4 Physiological Limiting Criteria needs to reflect the current consensus on the new standard.

The objective of the high altitude standards is to prevent exposing the airplane occupants to environmental conditions that would:

a. Prevent the flight deck crew from safely flying and safely landing the airplane, or
b. Prevent the cabin crew from safely performing their duties, or

c. Result in permanent physiological harm to any occupants for structural and system failure conditions, or
d. Result in permanent physiological harm to more than a small number of passengers as the result of an uncontained engine failure, per the harmonized FAR/JAR 25.1309.

The means of compliance to evaluate crew inflight post-decompression performance shall include:

4.1 Crew Inflight Post-Decompression Performance

Flight Deck Crew Performance

a. The applicant shall evaluate the effects exposures to various cabin altitudes will have on flight deck crew cognitive function if not wearing mask, except if at least one crewmember will always be wearing oxygen higher than 41,000 ft. as required by FAA regulation.

b. The flight deck crew criterion is based on an individual performing useful flying duties in an environment of inadequate oxygen pressure (Reference 13). The applicant shall evaluate increased workload of the flight deck crew following a rapid decompression.

4.2 Cabin Crew Performance

a. The cabin crew criterion is based on assuming the cabin crew is not at rest. Some useful information is contained in Reference 14.
b. Flight attendants are to put on mask, sit or hold on, and await flight deck crew instructions before attempting to help passenger. It is assumed for the purposes of showing compliance to design rule that flight attendants are able to don masks and achieve a minimal level of protection within some reasonable number of seconds following mask drop. Following flight deck crew instructions, flight attendants will move about the cabin performing emergency procedures, as necessary. The applicant shall evaluate increased workload of the cabin crew following a rapid decompression.

4.3 Maximum Operating Altitudes, Cabin and Airplane

Compliance shall be shown for subsonic airplanes at flight altitudes at and below 51,000-feet pressure altitude, and nominal design cabin altitude, per regulations shall be considered up to a maximum of 8,000 feet pressure altitude.

4.4 Passenger Criteria

a. There is the potential that not all passengers will obtain sufficient protection from the cabin supplemental oxygen system. Therefore, it must be assumed that not all passengers are able to effectively don masks.

b. Throughout emergency descent, landing and aircraft egress following a rapid decompression event, all passengers are at some level of risk for permanent physiological harm. Due to numerous factors, including age, pre-existing medical condition, etc., some passengers will face greater levels of risk than others. The current FAR/JAR 25.1309 categorizes this failure condition as hazardous and acknowledges the potential for incurring injuries and/or fatalities to the airplane occupants following this failure event as follows:

Harmonized 25.1309 (Reference 2) (Proposed by SDAHWG)

Serious or fatal injury to a relatively small number of the occupants other than the flight crew.

With the type of failure condition defined above, there exists uncertainty with respect to the level of risk to each passenger's survival associated with exposure to the cabin environment following decompression. To satisfy the harmonized FAR/JAR 25.1309 it is necessary to assess the degree of risk in order to minimize the potential for permanent physiological harm to the airplane's occupants. An analysis that defines the envelope of vulnerability of passengers for permanent physiological harm in a decompression and identifies the continuously available design features of the airplane (i.e., aircraft systems) and the operational features (e.g., crew training, AFM limitations, etc.) to enhance the survivability of those passengers at increased levels of risk, would be an acceptable approach towards determining compliance with the harmonized FAR/JAR 25.1309. Note that the measure of adequacy is the presence of aircraft features (e.g., design and operational) that are commensurate with the level of risk associated with the cruise flight altitude.

Healthy passengers will self resuscitate, i.e., regain consciousness without any direct action of the crew and/or other occupants. Passengers must recover sufficient cognitive function to exit the aircraft following emergency descent, safe flight and landing. Some assistance may be required for passengers with pre-existing impairments.

Section 6 Acceptable Means of Compliance:

a. Sections 25.841 (a)(2)(ii) and (iii) are intended to ensure that system failure conditions not shown to be extremely improbable and certain structural failures shall not result in fatalities or permanent physiological harm. Therefore, the airplane must be designed so that occupants will not be exposed to a cabin pressure altitude that exceeds the following after decompression:
(i) Twenty-five thousand (25,000) feet for more than 2 minutes; or
(ii) Forty thousand (40,000) feet for any duration.

The MSHWG recommends consideration of the following certain structural failures specified in AC 25-20, with the following revisions:

1. Any single failure in the pressurization system combined with the occurrence of a leak produced by the complete loss of a door seal element, or a fuselage leak through an opening having an area 2.0 times the area which produces the maximum permissible fuselage leak rate approved for normal operation.
2. Pressure vessel openings resulting from tire burst, loss of antennas, or stall warning vanes while operating under maximum cabin pressure differential must be considered.
3. The loss of a “typical skin panel” bound by a crack stopper pattern need not be considered. Structural cracks will be addressed as follows:
4. The maximum pressure vessel opening resulting from an initially detectable crack propagating for a period encompassing four normal inspection intervals will be assumed. Mid-panel cracks and cracks through skin-stringer and skin-frame combinations must be evaluated.
5. The wheel rim release need not be considered.

The MSHWG recommends consideration of the uncontained engine failures specified in AC 25-20, with the following revision:

> In the event of an uncontained engine failure, only loss of system capability associated with the failed engine, but not associated with the debris, must be considered.

A means of compliance to the requirements of 25.841(a) may be demonstrated through the use of the Depressurization Exposure Integral (DEI) method, described herein, which provides the quantitative means to ensure that an airplane design meets the intent of the regulation with respect to protecting human physiology following a rapid decompression. The criterion relies upon the use of the DEI method. The foundation of the DEI method is that while human physiological response to a rarefied environment is a dynamic multi-variable problem, the two parameters of dominance are the pressure that the subject is exposed to and the duration of that exposure. Qualitative means could be utilized to assess risk to occupants but the uncertainty of the level of risk necessitates that specific features be incorporated into airplane designs to enhance survivability and lower the risk to the occupants.

The theoretical basis of this approach rests with the results of animal decompression studies (References 4 and 5). Figure 13-1 shows the chamber pressure (in mmHg) time history for both of these experiments [pressure altitude in feet versus time in minutes]. This data provides critical information needed to establish a measure of severity to the occupants of an airplane in the event of a sudden loss of pressure. The first step is obtaining a relationship called the Depressurization Severity Indicator (DSI). This relationship provides a measure of the severity of the depressurization to atmospheric total pressure and was determined from published data (Reference 15) and calculation, see Figure 13-2.

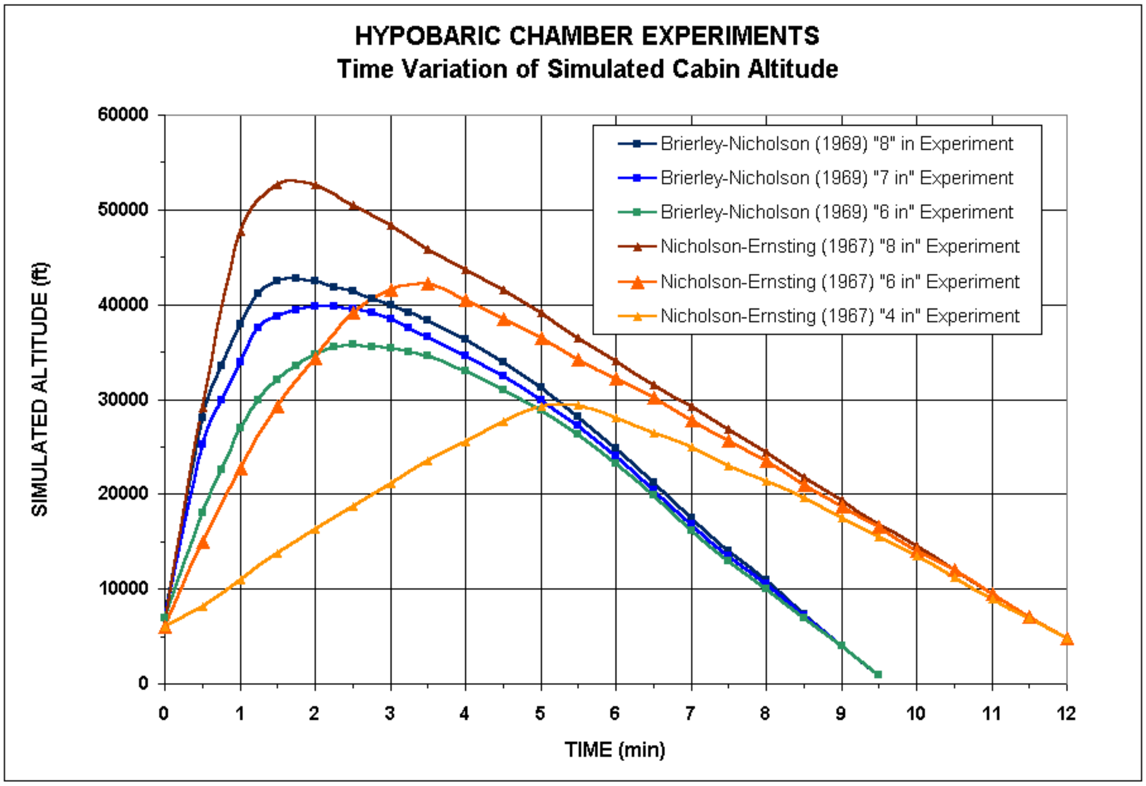


Figure 13-1: Simulated Cabin Altitude versus Time

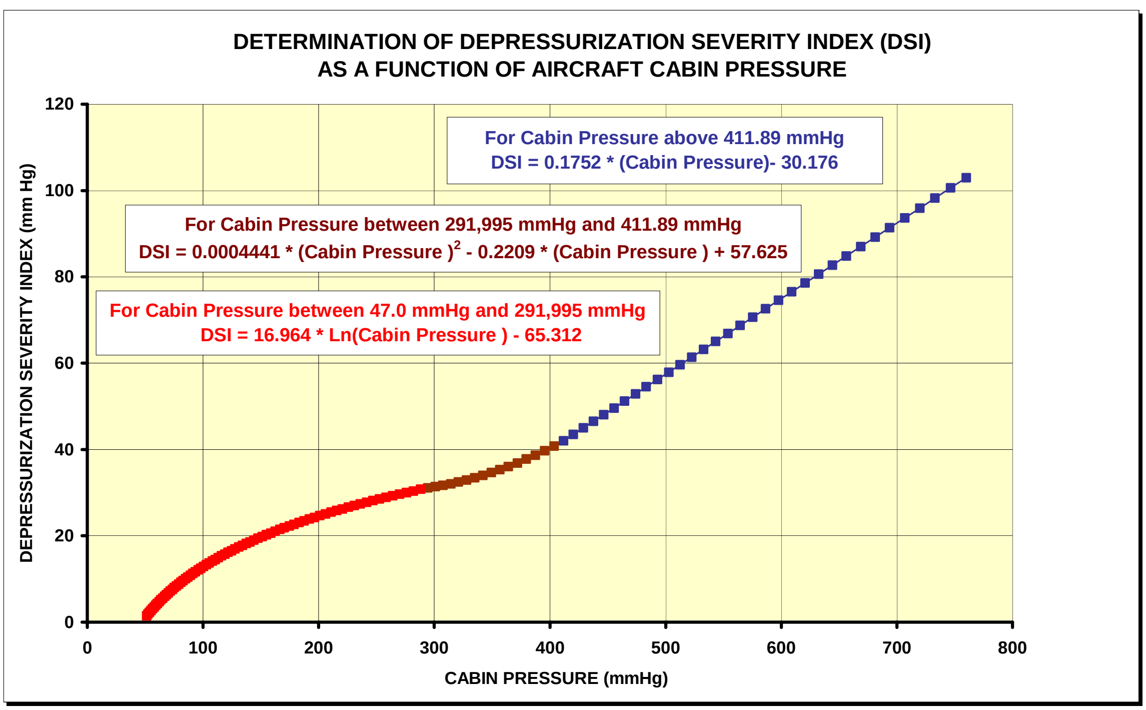


Figure 13-2: Depressurization Severity Indicator (DSI) as a Function of Aircraft Cabin Pressure

Figure 13-2 serves as a mathematical transfer function that converts input from Figure 13-1 [Simulated Cabin Altitude versus Time] into Figure 13-3 [DSI versus time]. The equations that describe the values of DSI as a function of cabin pressure are as follows:

For P_{cabin} greater than or equal to 411.89 mmHg then DSI = (0.1752 * P_{cabin}) - 30.176 [mmHg], based on Table 5-12, pg. 91, Reference 15.

For P_{cabin} greater than or equal to 291.995 AND P_{cabin} less than 411.89 mmHg then DSI = (0.0004441 * P_{cabin} ^2) - (0.2209 * P_{cabin}) + 57.625 [mmHg], based on Table 5-12, pg. 91, Reference 15.

For P_{cabin} greater than or equal to 47 AND P_{cabin} less than 291.995 mmHg then DSI = (16.964 * LN(P_{cabin})) - 65.312 [mmHg], logarithmic extrapolation to zero at 47 mm Hg (62,810 feet altitude), from Table 5-12, pg. 91, Reference 15.

For P_{cabin} less than 47 mmHg then DSI = 0 [mmHg].

In addition, Figure 13-3 includes data from the experiment by Dr. Hans Clamann, (Reference 16), which provides additional corroboration of this approach. Dr. Clamann utilized a chamber to simulate a rapid decompression from 9,800 feet to 49,200 feet (pressure altitude) and then repressurized the chamber at a rate of 24,600 feet per minute (simulating an airplane rate-of-descent). He did not use supplemental oxygen but breathed air at the chamber pressure. It was reported that he retained consciousness during the entire, albeit short, event.

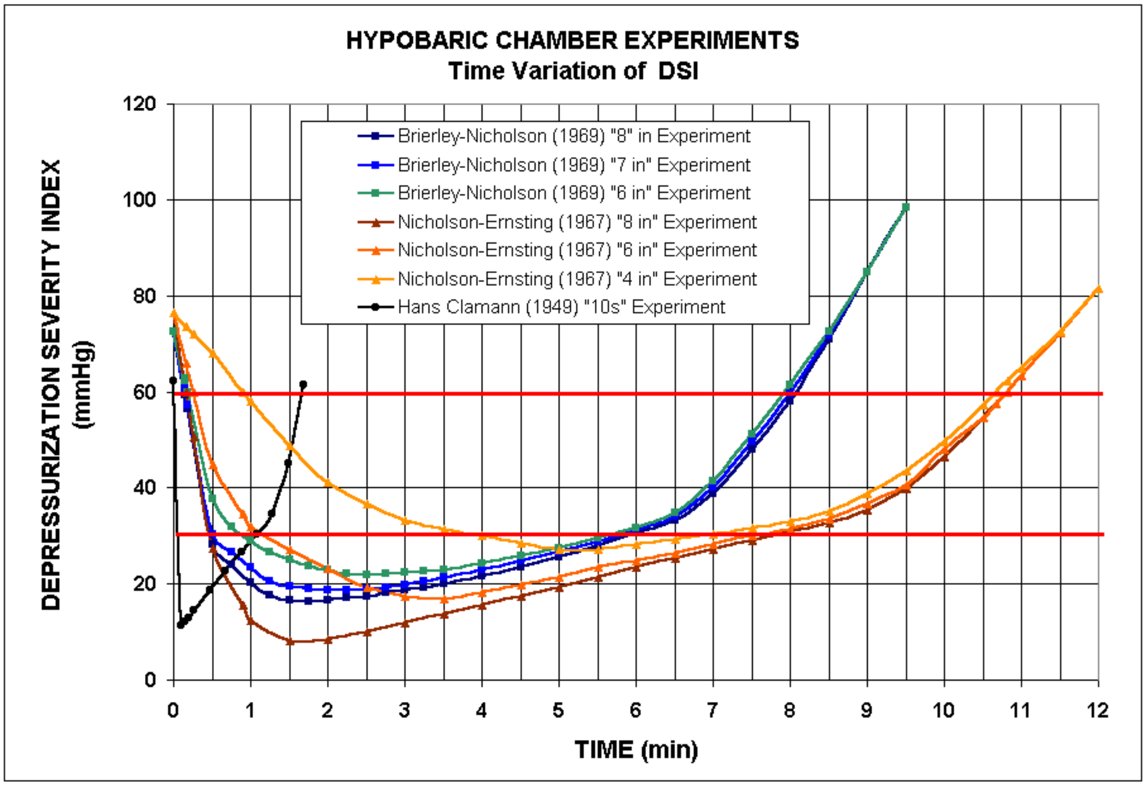


Figure 13-3: Hypobaric Chamber Experiments, Time Variation of DSI

Using the relationship in Figure 13-2, the calculated DSI time history for the experimental results given in Figure 13-1, are presented in Figure 13-3. Historically FAA has referenced 10,000 feet [approximately equivalent to DSI of 60 mmHg] and 25,000 feet [approximately equivalent to DSI of 30 mmHg] as critical points in the cabin pressure altitude, and these were selected as reference conditions. Integrals of the time history of the DSI, defined as Depressurization Exposure Integral (DEI), below 30 mmHg and 60 mmHg provide a measure of the severity of the depressurization event. For the following discussion, the DEI value below 30 mm Hg is defined as DEI30, and the DEI value below 60 mm Hg is defined as DEI60.

It is observed that a direct correlation of the DEI to increasing likelihood of fatalities or permanent physiological harm being sustained by the subjects exists [Figures 13-4 and 13-5]. For example, the experimental data resulted in values ranging from 2,779 mmHg-seconds to 22,241 mmHg-seconds for the integral below 60-mmHg. In addition, data from the experiment by Dr. Hans Clamann as reported in Reference 16 provides additional corroboration of this approach. Dr. Clamann utilized a chamber to simulate a rapid decompression from 9,800 feet to 49,200 feet (pressure altitude) and then repressurized the chamber at a rate of 24,600 feet per minute (simulating an airplane rate-of-descent). He did not use supplemental oxygen but breathed air at the chamber pressure. It was reported that he retained consciousness during the entire, albeit short, event.

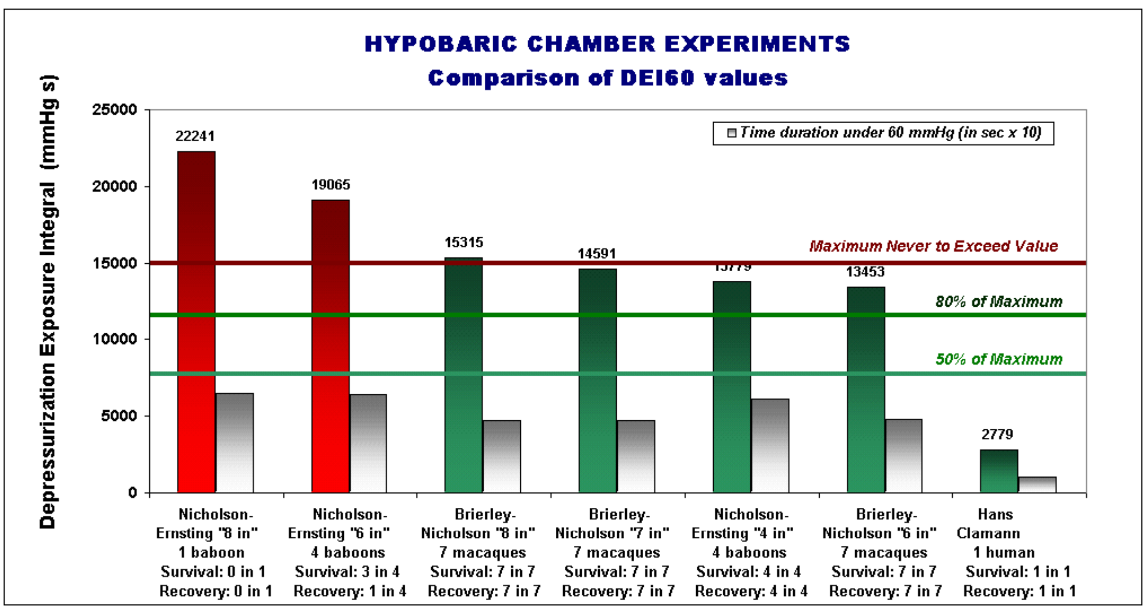


Figure 13-4: Depressurization Exposure Integral Values Referenced to 60 mmHg pressure.

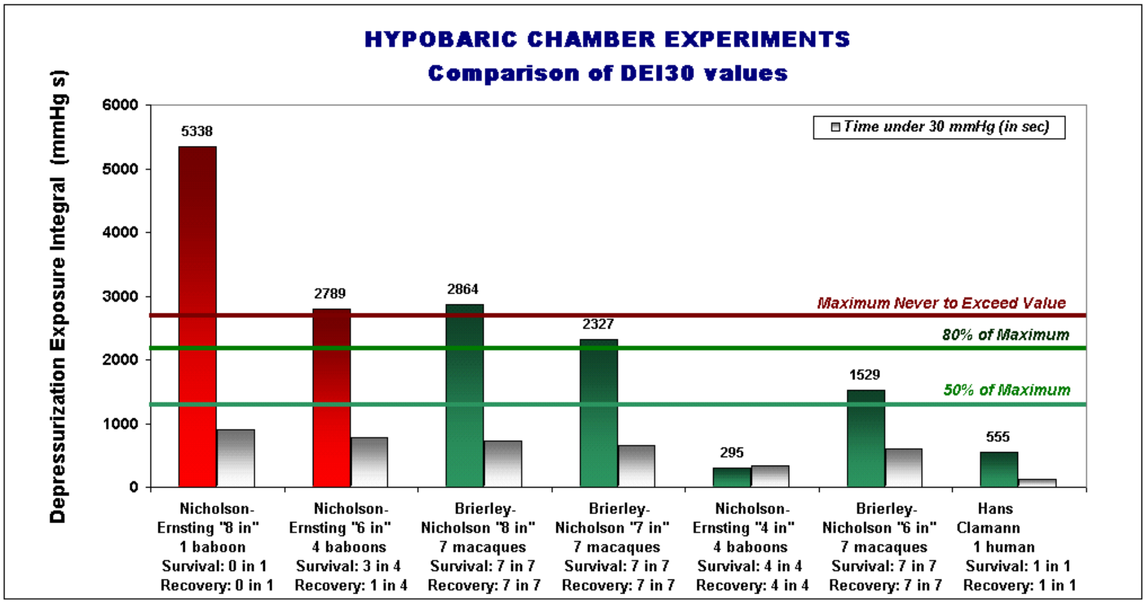


Figure 13-5: Depressurization Exposure Integral values referenced to 30 mmHg pressure.

Due to the observed direct correlation of the DEI to an increasing likelihood of fatalities or permanent physiological harm being sustained by the subjects [Figure 13-4]:

The "Maximum Never to Exceed Value" of the DEI30 (approximate cabin altitudes > 25,000 ft) is 2,700 mmHg-seconds.

The "Maximum Never to Exceed Value" of the DEI60 (approximate cabin altitudes > 10,000 ft) is 15,000 mmHg-seconds.

Note that the magnitudes of these values are dependent upon the functional relationship used between cabin pressure and DSI as shown in Figure 13-2.

Based upon a review of References 1 through 16 and observations of non-human primate and human studies, and due to the paucity of data and the rarity of an engine induced decompression, means of compliance shall be:

- The maximum allowable value of the DEI values referenced to 30 mmHg pressure for the 30 mmHg reference condition (DEI30) (cabin altitude > 25,000 ft) shall be 2,160 mmHg-sec (this equals 80% of the "Maximum Never to Exceed Value").

- The maximum allowable value of the DEI values referenced to 60 mmHg pressure for the 60 mmHg reference condition (DEI60) (cabin altitude > 10,000 ft) shall be 12,000 mmHg-sec (this equals 80% of the "Maximum Never to Exceed Value").

- The manufacturer must include emergency descent procedures that rely upon swift descent to an altitude of 10,000 feet.

- For no decompression event can the cabin altitude exceed the maximum performance capability of the flight deck crew oxygen system.

The applicant will perform a depressurization analysis based upon the maximum cruise flight conditions. A maximum cumulative hole area will be calculated using airplane and engine historical data, and possibly combined with the use of a geometric analysis describing the impact of engine debris on the pressure vessel, pending PPIHWG recommendation. Analysis and test data shall be provided to successfully demonstrate compliance.

Design solutions, which currently exist or are developed in the future, that reduce the potential for permanent physiological harm (as a result of a depressurization event) or enhance airplane survivability can be incorporated into new airplanes. One design feature that may enhance occupant survivability is an automatic descent system, which, in the event of a rapid loss of cabin pressure (e.g., cabin pressure altitude exceeds 16,000 ft), will command the airplane to commence an emergency descent (Vmo/Mmo) to either 10,000 ft or minimum safe altitude over terrain. Potential design solutions that enhance both airplane and occupant survivability include improved engine fragment shielding or advanced engine blade failure warning devices which may exist in the future. Airplane designs which incorporate such features may significantly impact the testing and analysis necessary to demonstrate compliance.

Section 9 Engines.

The measure of threat from an uncontained engine failure may include the use of an uncontained engine failure debris model validated by existing data or other means as identified by the PPIHWG [FAA to reference PPIHWG recommendation]. A future AC to replace AC 20-128A could provide guidance for addressing the hazards associated with uncontained turbine engine and APU rotor failure. That guidance will focus on the use of a debris model analysis (e.g., Uncontained Engine Debris Damage Assessment Model, which is part of the FAA Catastrophic Airplane Prevention Program) or other means acceptable to the cognizant authority [PPIHWG recommendation pending]. Only airplane survivable events, per FAR/JAR 25.571(e), need be considered for uncontained engine failures discrete source damage.

Section 10 Emergency Descent Following Rapid Decompression.

As mentioned in the preamble to Section 25.841(a)(X)(i), it is recommended that the flight deck crew be trained in initiating emergency descent following rapid decompression. It is recommended that flight deck crew flying aircraft certified to fly above 41,000 feet pressure altitude undergo initial and periodic training in the use of positive pressure breathing masks. In demonstrating compliance with proposed § 25.841, the first priority of the flight deck crew shall be to don oxygen masks. The flight deck crew would then presumably perform an emergency descent in accordance with an approved emergency procedure. In order to maximize occupant survivability following a rapid decompression, the flight deck crew shall descend the airplane at the maximum safe descent speed, which is Vmo/Mmo, assuming structural failure as defined by FAR § 25.571. Any additional training components and flight manual revisions necessary for adoption of the Vmo/Mmo descent criterion shall be required.

The flight deck crew should be thoroughly trained on the use of this procedure in order to avoid an incorrect response (i.e., one that includes a reduced speed descent). They need to be trained so that they understand that structural loads following a decompression are assessed similar to other "Discrete Damage" (pressurized or unpressurized) conditions in which the airplane damage is assessed per FAR 25.571(e) (i.e. structural damage including non-catastrophic rotor failure). Structural load capability of the airplane following a survivable discrete source damage event is considered under unpressurized conditions that results in reduced inertial load factors (See AC 25.571-1C). Therefore, maximum design descent rate (Mmo/Vmo) is not a determining factor in the airplane descent rate following decompression. Thus in all survivable uncontained engine failures the airplane is capable of performing a Vmo/Mmo emergency descent.

a. In demonstrating compliance with § 25.841, it should be assumed that an emergency descent is made in accordance with an approved emergency procedure. Crew recognition time for decompression and oxygen mask donning time should be applied between the cabin altitude warning and the beginning of action for descent. The probable system failure having the most severe effect should be demonstrated by flight test at the maximum airplane altitude. For all failures other than probable failures, the cabin altitude should be established by an analysis that is verified, if necessary, by tests conducted at a lower altitude.

b. A 17-second delay after decompression for crew recognition and oxygen mask donning time should be applied between cabin altitude warning and initiation of action to configure for descent. The 17-second reaction time was originally based on mean values of emergency responses on simulators in terms of aircrew responses in a given emergency situation, where there would actually be pressure loss or some other emergency situation. The 17-seconds is a value that represents the 75th percentile of crew reactions (Reference 17). Reaction times were further studied by Bennett (see Reference 12). Forty-two pilots were exposed to airplane decompression for an overall cabin rate of climb of 30,000 feet per minute to a maximum cabin altitude of 30,000 feet. Eighty-three percent of the pilots donned the oxygen mask in 15 seconds. Emergency descent was initiated in all cases within 5 seconds of the fitting of the mask.

Furthermore, the 17-sec reaction time cited by Dr Vail is strongly supported by data presented in Reference 3, pg. 121. Figure 27 in Reference 3 depicts a probability graph of data based on Bennett's 1961 study of 42 BOAC pilots reacting to surprise decompressions in realistic conditions. The graph shows that approximately 95% of the pilots were able to react within 17 seconds of onset of the rapid decompression. This correlates well with the 17-sec rule proposed by Vail based on his Wright Development Center simulator studies: "Seventy-five per cent of the response times were 17 seconds or shorter in his experiments, Dr. Vail expressed the view that though one minute would be a desirable allowance for response tome [sic] to decompression, 17 seconds should be sufficient for thoroughly trained crews."

c. The following example of a pressurization failure, other than uncontained engine failures, should make clear the use of delays and environmental limitations.

Assumption and definitions: H_N = The normal cabin pressure altitude which is less than or equal to 8,000 feet normally.

- H_A = Airplane altitude.
- Tf = Time of pressurization failure.
- T_W = Time of the 10,000 foot cabin pressure altitude warning.
- T1 = Time that the airplane descent begins.
- T_R = Recognition time for crew response to emergency annunciation (17seconds).
- T_S = Time for damage assessment; for example, switching the outflow valve to "manual" to attempt to regain cabin altitude control. Following a rapid decompression, for purposes of showing compliance, a TS=0 seconds can be assumed if an immediate emergency descent is specified.
- T_D = Time to configure the airplane for descent; for example, gear extension.
- $T1-T_W$ = Delay time from cabin altitude warning to time that the airplane begins to descend = $T_R + T_S + T_D$.

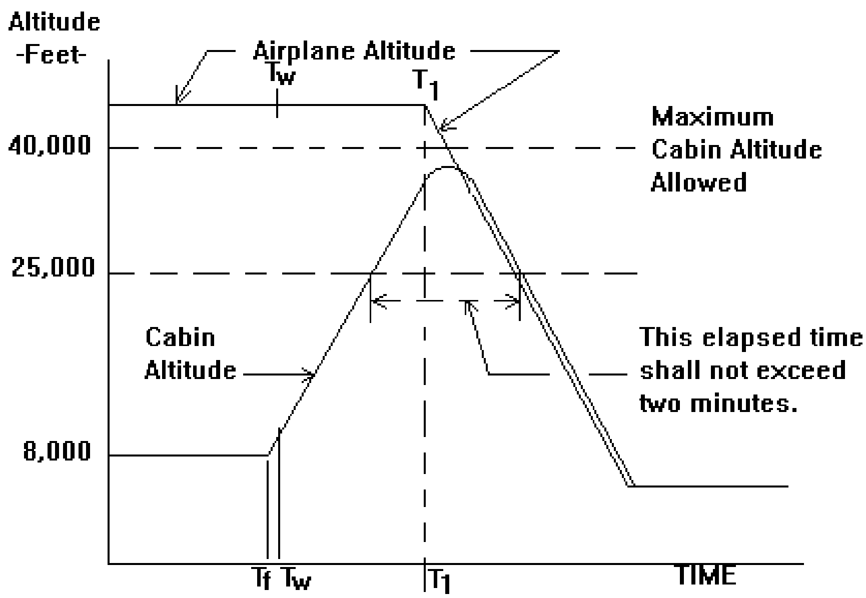


Figure 13-6: Allowable Decompression Profile, Except UEF

d. The limitations specified in § 25.841(a)(x) are not intended to be used in calculating the quantity of oxygen that is needed for emergency descent and sustenance. The flight deck crew may inadvertently, or by intent, delay descent for any number of reasons. However, as noted above, in all failure conditions, including survivable uncontained engine failures, the airplane is capable of performing a Vmo/Mmo emergency descent and this should be clearly stated in any procedure. The operating rules specify the quantity of oxygen that must be carried dependent on route structure.

e. The applicant may use response times less than 17 seconds if they can provide empirical data acceptable to the regulatory authority documenting the time selected. This time may be reduced if, for example, the airplane is equipped with an automatic, or semi-automatic system that initiates the descent based on the 10,000 foot cabin pressure altitude warning, the cabin altitude rate, or other airplane parameters that ensure that there is no delay in beginning the descent.

It is further recommended that the Regulatory Authority develop additional guidance on the following issues and that they be included in the Advisory Circular prepared for this regulation:

The Regulatory Authority should ensure that the operational requirements limit the normal cabin maximum altitude to ensure that the cabin altitude not exceed the design maximum (currently established at 8,000 feet). These requirements may be written into airplane operating manuals (AOM) to mitigate the severity of the post-decompression environment’s impact on occupant health. The Regulatory Authority should ensure that the operational requirement for one pilot at the airplane controls is to don a flight deck oxygen mask above 41,000 feet altitude (standard atmospheric conditions).

The Regulatory Authority should recommend that flight deck crew flying aircraft certified to fly above 41,000 feet undergo initial and periodic training in the use of positive pressure breathing systems.

The Regulatory Authority should consider that improved oxygen breathing systems be provided to flight attendants for flight above 41,000 feet.

The Regulatory Authority should accept use of historical data for engine failure analysis.

The Regulatory Authority should accept that a geometric analysis describing the impact of engine debris on the pressure vessel is allowed to determine the cumulative hole area created by uncontained engine failure.

The Regulatory Authority should ensure that any analysis used to determine cumulative pressure vessel hole size due to an uncontained engine failure event includes historical data probability of occurrence and hole size distribution.

The manufacturer will utilize the result of an analysis as recommended by PPIHWG in determining cumulative hole area.

Other design features that should be considered:

- Lower pressure altitudes for nominal operating cabin pressure and cabin pressure warning;
- Actual cabin pressure measurement saved to the flight data recorder (currently, the FAA requires only a discrete record be saved when cabin pressure is exceeded, see FAR Sec. 121.344, Digital flight data recorders for transport category airplanes);
- Better fitting O_2 masks and more reliable deployment systems;
- Thorough maintenance and pre-flight checks of supplemental O_2 systems.

14 - How does the proposed standard compare to the current ICAO standard? [Indicate whether the proposed standard complies with or does not comply with the applicable ICAO standards (if any)]

The proposed standard is in agreement with the intent of International Civil Aviation Organization (ICAO) Annex 8 "Airworthiness of Aircraft" requirements (Reference 18), as there are no specific ICAO requirements defining cabin environmental limits following a failure.

15 - Does the proposed standard affect other HWG's? [Indicate whether the proposed standard should be reviewed by other harmonization working groups and why.]

The means of compliance to the proposed standard will rely in part on the use of an uncontained engine failure debris model that needs to supplied by the PPIHWG group. In addition, the structurally related AC content described in Question 13 should be reviewed by the General Structures Harmonization Working Group (GSHWG). The standard does not need to be reviewed by any other harmonization working groups. It is recommended that the PPIHWG review AC 20-128A, in order to be consistent with the proposed means of compliance identified in the response provided to Question 13.

16 - What is the cost impact of complying with the proposed standard? [Please provide information that will assist in estimating the change in cost (either positive or negative) of the proposed rule. For example, if new tests or designs are required, what is known with respect to the testing or engineering costs? If new equipment is required, what can be reported relative to purchase, installation, and maintenance costs? In contrast, if the proposed rule relieves industry of testing or other costs, please provide any known estimate of costs.

BACKGROUND

There are now two distinct aviation standards for 25.841(a): the FAR and the Joint Aviation Requirements (JAR). The current FAR 25.841(a), as modified by Amendment 25-87, contains requirements in addition to the current requirement of JAR 25.841(a). The FARs were changed by the FAA via Amendment 25-87 without being harmonized with the Joint Aviation Authorities (JAA). The regulations that we are discussing are not currently harmonized; the JAR reflects these rules, as they existed in the FAR prior to Amendment 25-87. It is noteworthy that the JAA has not adopted the changes in the FAR section as promulgated in Amendment 25-87 and lists it as a significant difference in current FAA/JAA certification/validation programs. The manufacturers must show compliance with both of these standards if they seek both US and JAA type certification, increasing costs of certification.

Further, while it is difficult to quantify, there are other costs associated with FAA and JAA operating under different sets of requirements. For example, airplanes not certificated under the FAR would be able to achieve lower operating costs because they could be designed to higher maximum certified altitude. This may give a competitive advantage to non-FAA certificated airplanes, thus promoting a non-level playing field.

INTRODUCTION

The FAA did not publish documentation that addressed the real cost impact of applying new standards to derivative airplanes, nor whether the new requirement could be met by any practical means for any new or derivative airplane under Amendment 25-87.

The provisions of section 25.841(a)(2) and (3) of Amendment 25-87 of the FAR may limit new or derivative transport airplanes with wing-mounted engines to operating altitudes well below 40,000 feet. This has major cost impacts since new or changed airplane models may not be able to compete with existing certificated airplanes, which did not have to comply with the new requirements. New and derivative airplanes that would be limited to altitudes of 37,000 to 39,000 feet under section 25.841 would no longer be able to compete with currently certificated airplanes that can operate at altitudes above 40,000 feet. The existing airplanes can cruise at the higher altitudes where they are more fuel-efficient. Changes to the regulatory provisions as proposed in this report should allow certification of new and derivative airplane models that are more economical while maintaining the proper safety.

The cost impact of Amendment 25-87 to the aviation industry and the flying public, both here in the United States and in Europe, is predicted to be significant. While it is difficult to place specific dollar impact on these new requirements, it is clear that most new airplane programs are severely impacted. No high altitude (above 39,000 feet maximum altitude) airplane with wing-mounted engines certified today can meet the new altitude limits with the current § 25.841(a)(3).

A primary concern is that new and derivative airplanes with wing-mounted engines designed to meet Part 25 as amended at Amendment 25-87 will have significantly higher design and operating costs than currently certified airplanes. These higher costs will impact the ability of manufacturers to introduce new airplanes that can compete with previously approved airplanes. It is not apparent whether the FAA considered this high cost when assessing the economic impact associated with the amendment.

The current rule is based on previous special conditions for high altitude operation up to 51,000 ft. for small business jets. Current commercial aircraft are designed for operation up to 45,000 ft. Higher altitudes above 45,000 ft. are economically viable not only for small business aircraft but for new proposed commercial aircraft as well. The special conditions applied to small business jets should not be applied in their entirety to commercial aircraft as small jet aircraft have performance comparable to high performance military aircraft. Thus, descending to 25,000 ft. within 2 minutes following an uncontained engine failure is very restrictive for commercial aircraft flying at higher altitudes since their maximum descent speeds are lower. In addition, the limitation of cabin altitude to 40,000 ft. following an uncontained engine failure indirectly limits the aircraft flight altitude to FL400 since worst case failures can decompress the cabin in less time than is required to initiate the descent. This is true for narrow and wide body aircraft.

The economic viability of transport aircraft with wing-mounted engines under development would suffer, because maximum operating altitudes would be limited to around 35,000 to 39,000 ft under the current rule. The proposed harmonized standard in this WG Report should reduce the overall cost and time of the joint certification process and should not increase cost for any present major manufacturer that has a service demonstrated safety record. Any cost change will be negligible compared to the benefits of a clear, concise, and standardized rule that allows new and derivative airplanes to compete economically with the existing fleet. In addition, since the proposed new standard will be harmonized, there will no longer be an additional cost to certify to different FAA and JAA standards.

The following analysis as detailed in Figures 16-1 through 16-5, related to the cost impact of complying to the current Amendment 25-87 for transport aircraft with wing-mounted engines, is provided by The Boeing Company™. This information due to the proprietary nature of its underlying data, has not been evaluated by the MSHWG; it has been provided to assist the FAA in its future economic assessment. Note: In the following figures "current or future generation aircraft" refers to transport aircraft with wing-mounted engines.

Airplane Operation

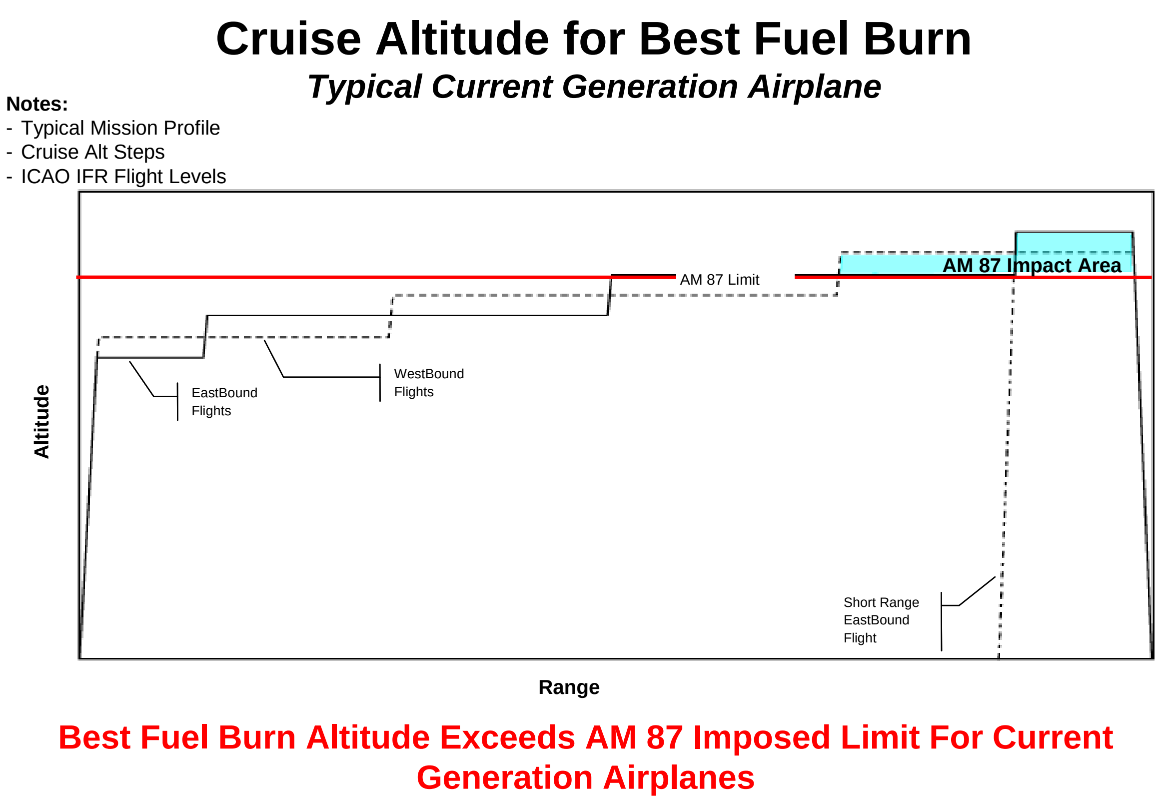


Figure 16-1: Cruise Altitudes for Typical Current Generation Airplanes

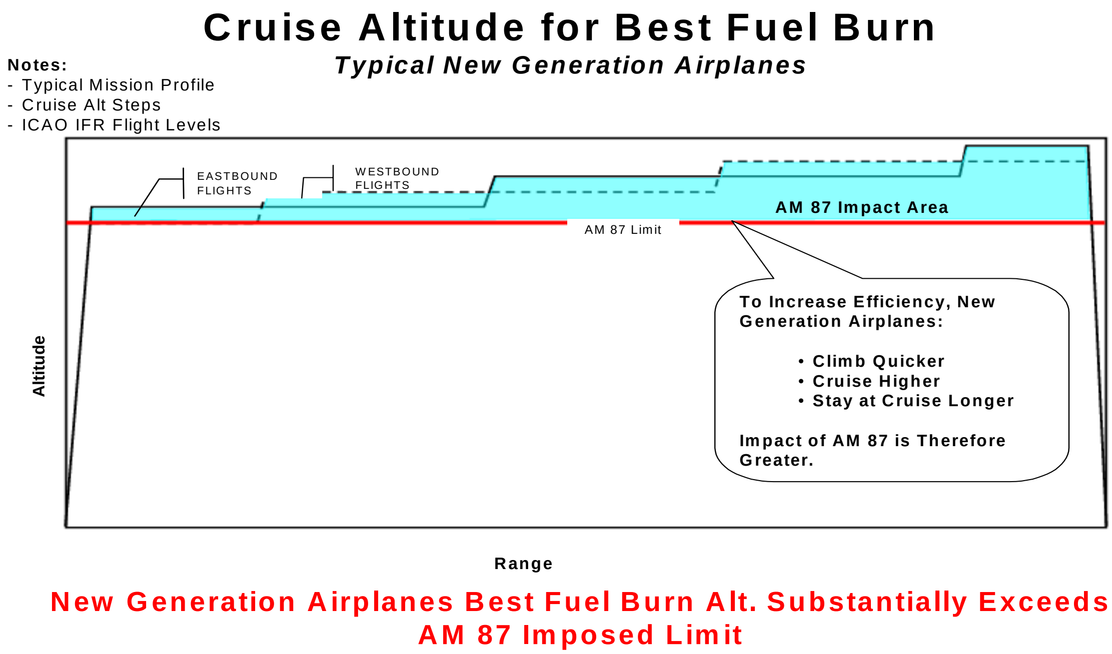


Figure 16-2: Typical Cruise Altitudes for New Generation Airplanes

Figures 16-1 and 16-2 show typical cruise altitudes for current and new generation airplanes. As shown, new generation airplanes flyer higher for longer amounts of time. While current large transport airplanes are certified up to altitudes of 45,000 ft., they must burn off fuel to reach these altitudes. That means that for a large portion of their flight profile they may be below limits imposed by Amendment 25-87, rule 25.841(a). However, newer aircraft are designed to reach higher cruise altitudes quicker and stay there longer. This means they will normally fly above the limits imposed by Amendment 25-87 for most of there flight profile.

Fuel Burn

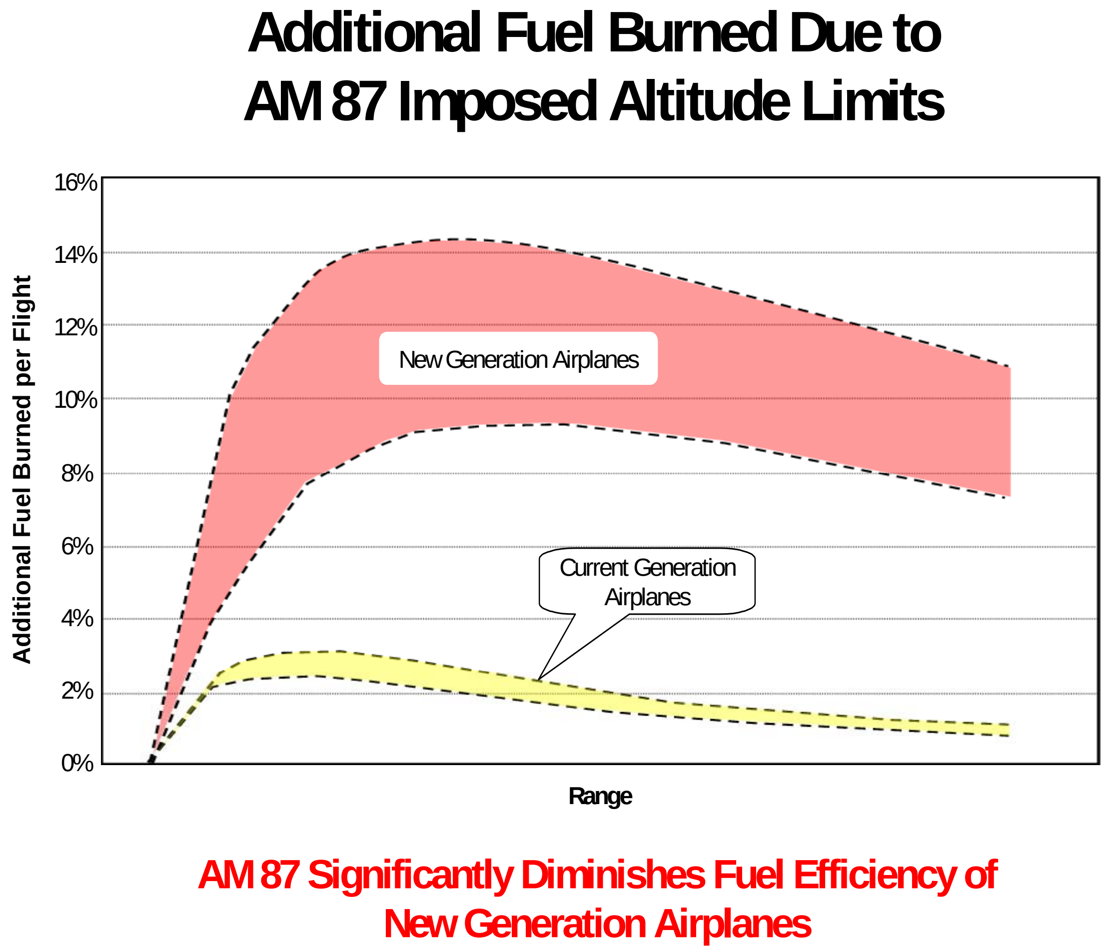


Figure 16-3: Added Fuel Burn due to Amendment 25-87 Imposed Limits

As can be seen from Figure 16-3, the restriction in higher operating altitudes imposed by the current Amendment 25-87, rule 25.841(a) means that if new generation aircraft were built, the fuel penalty would be very significant.

Economics

An economic analysis was based on projected fuel burn increases shown above. The economic penalty was assessed over a 14 year operation for a forecast fleet of airplanes, in terms of 2001 dollars. Fuel cost was assumed to remain constant at $.071 per gallon (Note: fuel costs have ranged in the past from $0.10 in 1970 to $1.045 in 1981).

Results showed a $1billion to $6 billion Net Present Value (NPV)(in 2001 dollars) on a typical fleet of new generation airplanes for the first 14 years of operation. Compliance to FAR 25.841(a), AM 87 would result in economic penalties so severe that new generation airplanes would not be commercially viable. It is estimated that this would result in 41,000 – 75,000 lost U.S. Aerospace jobs for the life of each airplane family.

Environmental Effects

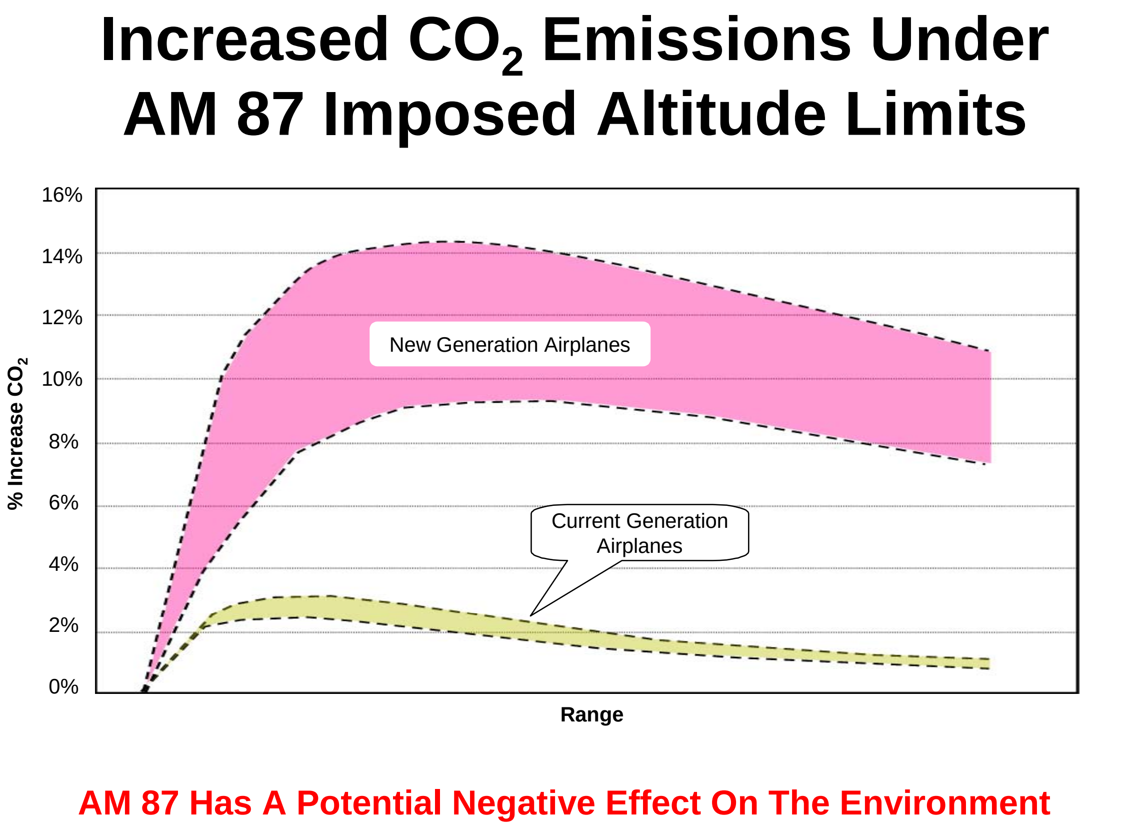


Figure 16-4: Projected Increased CO_2 emissions due to Amendment 25-87

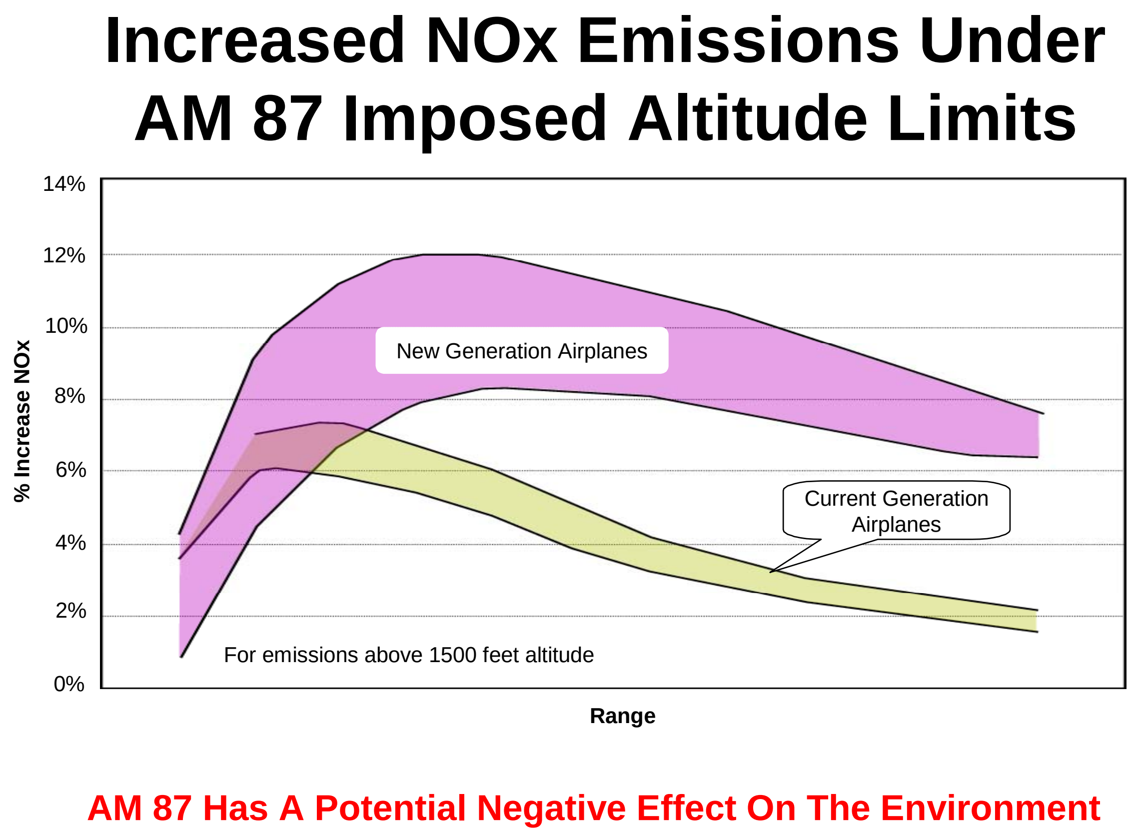


Figure 16-5: Projected increased NOx emissions due to Amendment 25-87

Figure 16-4 and 16-5 project the potential increase in CO2 and NOx emissions that could result from compliance to Amendment 25-87, for both the current generation aircraft and new generation aircraft due to the imposed altitude limits. Note that the increase in both pollutants is very significant.

Air Traffic

The following air traffic data is provided to support economic analyses by the regulatory authorities. Three separate studies were conducted; Air Transport Association, FAA, and The Boeing Company™.

1. Air Transportation Association study.

Information from the ATA Air Traffic Department on number of aircraft flying at or above FL410:

DATE	Air Carrier		Total Operations	
	>FL410	All Alts.	>FL410	All Alts.
8/15/01	871	37,151	1,901	65,162
8/16/01	773	37,783	1,792	65,039
	(2.2%)		(2.8%)	

10/31/01	1,387	31,869	2,303	57,263
11/1/01	1,048	32,163	1,962	58,967
	(3.8%)		(3.7%)	

ATA assessment of the above data: considering the fact that these altitudes are at or above the max altitude limitation for most air carrier aircraft, the percentages shown represent a high utilization of the available altitude capability. Additionally, the capability to operate at these altitudes is critical to the design payload-range capability of the aircraft. These altitudes are frequently required on range-critical missions in order to avoid excessive payload penalties or unscheduled intermediate stops. Furthermore, in order to improve efficiency and flexibility as well as relieve airspace congestion, it is anticipated that future aircraft design will place a greater demand on high altitude operation.

2. FAA Study

FAA Air Traffic Control (ATC) scans also provided information on the number of airplanes flying above 40,000 feet. These scans revealed 0.6% of all active airplanes within the ATC system [Eastern Pacific, Continental US and Western Atlantic] were operating above 40,000 feet. However these scans represent a "snap-shot" of the airplanes flying at the specific time of day and may not be representative of the total airplanes flying at these altitudes on an annual basis. A more exhaustive survey would need to be completed to provide an annual usage rate.

3. Boeing Study of Flight frequency above 37,000 ft.

Vertical Distribution of Traffic

•**US Domestic**

–Approximately 16% of traffic currently operates above FL 370

•**North Atlantic**

–Approximately 21% above FL370

•**North and Central Pacific**

–Approximately 12% of traffic above FL370 in all Oakland's oceanic airspace

–Approximately 9% of traffic above FL370 in Anchorage's oceanic airspace

Note: Data are not long-term statistics; simply a quick look at representative numbers and are based on ATM Center reports for one day in Aug. 2002. Above data shows that 10% to 20% of Today's Fleet Operates Above FL 370.

Effect on Air Traffic System

Far 25.841(a), Amendment 25-87 may also have an unintended negative effect on today's air traffic system. Consider the following:

Limiting operation of new generation airplanes to lower altitudes may result in higher traffic density, which could lead to greater collision risk if not otherwise mitigated. In anticipation of this increased level of risk, additional costs may be imposed on the aviation system, in order to maintain an acceptable level of safety.

According to Boeing Air Traffic Control experts, the following may be collateral impacts of preserving an equivalent level of safety while limiting maximum flight altitudes.

- Larger separation minima may be required, resulting in lower capacity, more delay, and less growth potential. Simply stated, the rationale is that, if more aircraft are forced by altitude restrictions to share the same block of airspace, the potential for loss of separation increases and the achieved level of safety suffers. Just about the only parameter that the system has to deal with this and achieve the target level of safety is increased separation standards. Controllers already do this informally by building in separation buffers to help them handle the excess workload while avoiding losses of separation.

- Use of even lower, less economical altitudes required.

- More sectors, controllers and communications frequencies required.

- More automation tools required.

- Improvements in Flow Management required.

- Earlier implementation of ground system enhancements required.

The above changes to the air traffic system may be costly to implement.

17 – If advisory or interpretive material is to be submitted, document the advisory interpretive guidelines. If disagreement exists, document the disagreement.

The proposed advisory material (i.e., Advisory Circular) and issues that should be included in the AC appear in the response to Question 13.

Below are the initial ground rules (cabin decompression, probability, damage assessment) that were used by the MSHWG for developing the interpretative material for the proposed rule and Advisory Circular.

GROUND RULES

Ground rules for cabin decompression

1. Airworthiness Standards

The pertinent sections from FAA 14 CFR 25, 2001, and JAA JAR-25, 2000 related to the certification of today's aircraft are as follows:

A. Airworthiness Standards, Transport Category Airplanes

FAR 25.841	Pressurized cabins
FAR 25.1443(d)	First aid oxygen
FAR 25.1447(c)(2) & (4)	Oxygen for flight deck crew and flight attendants
FAR 25.1441	Oxygen equipment and supply
FAR 25.1445	Equipment standards for the oxygen distributing system
FAR 25.1449	Means for determining use of oxygen

JAR 25.841	Pressurized cabins
JAR 25.1439	Protective breathing equipment
JAR 25.1441	Oxygen equipment and supply
JAR 25.1443	Minimum mass flow of supplemental oxygen
JAR 25.1445	Equipment standards for the oxygen distributing system
JAR 25.1447	Oxygen for flight deck crew and flight attendants
JAR 25.1449	Means for determining use of oxygen

2. Operating Requirements: Domestic, Flag, and Supplemental Operations

U.S. operators

121.329	Supplemental oxygen for sustenance; turbine engine powered airplanes
121.333.1	Supplemental oxygen for emergency descent and for first aid; turbine engine powered airplanes with pressurized cabins
121.335	Equipment standards
121.337	Protective Breathing Equipment
121.574	Oxygen for medical use by passengers http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-574.rtf

AC 120-43: Influence of Beards on Oxygen Mask Efficiency
http://www1.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/1ab39b4ed563b08985256a35006d56af/f9789ad5efc61df6862569ba00752817/$FILE/AC120-43.pdf

TSO-C78: Crewmember Demand Oxygen Masks
http://av-info.faa.gov/tso/Tsocur/C78.doc

TSO-C89: Oxygen Regulators, Demand
http://av-info.faa.gov/tso/Tsocur/C89.doc

Canadian operators,

Operational Standards-Airline Operations

705.71.1.1	Protective Breathing Equipment
705.71.1.2	First Aid Oxygen
705.94.1.1	Portable Oxygen
605.31(2)	Oxygen Equipment and Supply
605.32.1.1	Use of Oxygen

Operational Standards-Private Operator Passenger Transportation

604.40 Protective Equipment

European operators

JAR-OPS 1.760 First aid oxygen
JAR-OPS 1.770 Supplemental Oxygen -pressurized aeroplanes
JAR-OPS 1.770 Appendix 1 Oxygen – Minimum requirements for supplemental oxygen for pressurized aeroplanes
JAR-OPS 1.780 Protective Breathing Equipment

From JAR-OPS,

a) 'First aid oxygen' means the additional oxygen provided for the use of passengers, who do not satisfactorily recover following subjection to excessive cabin altitudes, during which they had been provided with supplemental oxygen.

b) 'Supplemental oxygen' means the additional oxygen required to protect each occupant against the adverse effects of excessive cabin altitude and to maintain acceptable physiological conditions.

From FAA,

Supplemental oxygen means the additional oxygen required to protect occupants against the adverse effects of excessive cabin altitude and to maintain acceptable physiological conditions during and after decompression.

Suggestions for modifications to the above present FAA airworthiness and operational standards that have evolved over decades of research and flight experience would be better amenable to evaluation and group interchange if each suggestion were tied up front to one of the above regulatory categories.

3. Crew Inflight Post-Decompression Performance

3.1 Flight Deck Crew Performance

a. Need to evaluate the effects that immediate exposure to various cabin altitudes will have on flight deck crew cognitive function if not wearing mask and if at least one crewmember will always be wearing oxygen higher than 41,000 ft. as required by FAA regulation (Note: FAA and Transport Canada requirement only. There is no European operational requirement for a crewmember to wear an oxygen mask at flight levels above 41,000 ft.)

The flight deck crew criterion is based on an individual performing useful flying duties in an environment of inadequate oxygen pressure (Reference 13, pg. 25).

Depending on the size of the hole and the net volume of the aircraft, depressurization may not occur within a few seconds. Therefore, the time to depressurize the aircraft after the hole is created should be considered.

b. Increased workload following a rapid decompression.

3.2 Cabin Crew Performance

a. The cabin crew criterion is based on assuming the cabin crew is not at rest. Some useful information is contained in Reference 14.
b. F/As are to put on mask, sit or hold on, and await flight crew instructions before attempting to help passenger. It is assumed for the purposes of showing compliance to design rule that F/A’s are able to don masks and achieve a minimal level of protection within some reasonable number of seconds following mask drop. Following flight crew instructions, flight attendants will move about the cabin performing emergency procedures.

4. Maximum Operating Altitudes, Cabin and Airplane

a. Recommendation from the team will cover subsonic airplanes at flight altitudes at and below 51,000-ft alt. (contained in Amendment 25-87 preamble).

b. Design cabin altitude, per regulations should be considered up to a maximum of 8,000 ft.

5. Passenger Criteria

a. There is the potential that not all passengers will obtain sufficient protection from the cabin supplemental oxygen system. Therefore, for purposes of this study, it will be assumed that not all passengers are able to effectively don masks.

b. Throughout emergency descent, landing and aircraft egress following a rapid decompression event, all passengers are at some level of risk for permanent physiological harm. Due to numerous factors, including age, pre-existing medical condition, etc., some passengers will face greater levels of risk than others. The current FAR/JAR 25.1309 categorizes this failure condition as hazardous and acknowledges the potential for incurring injuries and/or fatalities to the airplane occupants following this failure event as follows:

Harmonized 25.1309 (Proposed)
Serious or fatal injury to a relatively small number of the occupants other than the flight crew.

With the type of failure condition defined above, there exists uncertainty with respect to the level of risk to each passenger's survival associated with exposure to the cabin environment following a decompression. To satisfy the harmonized FAR/JAR 25.1309 it is necessary to assess the degree of risk in order to minimize the potential for permanent physiological harm to the airplane's occupants. An analysis that defines the envelope of vulnerability of passengers for permanent physiological harm in a decompression and identifies the continuously available design features of the airplane (i.e., aircraft systems) and the operational features (e.g., crew training, AFM limitations, etc.) to enhance the survivability of those passengers at increased levels of risk, would be an acceptable approach towards determining compliance with the harmonized FAR/JAR 25.1309. Note that the measure of adequacy is the presence of aircraft features (e.g., design and operational) that are commensurate with the level of risk associated with the cruise flight altitude.

c. Healthy passengers will self resuscitate, i.e., regain consciousness without any direct action of the crew and/or other occupants. Passengers must recover sufficient cognitive function to exit the aircraft following emergency descent, safe flight and landing. Some assistance may be required for passengers with pre-existing impairments.

6. Environment

a. Flight Deck Environment: Possibility of fog, air movement, vibration, noise, and decreased temperature.

b. Cabin Environment: Possibility of chaos or panic, fog, air movement, vibration, noise, flying objects, and decreased temperature.

c. It must be assumed that the occupied areas of the airplane may experience a sudden decompression (i.e., one occurring within the time allotted the crew to don their mask, isolate the source, reconfigure the airplane for descent and initiate the descent) to ambient pressure. Additional factors that can influence the resulting environment of the occupied areas (e.g., aerodynamic suction) need to be considered.

7. Regarding Choices

Time vs. Altitude

a. There is a physiological basis for determining emergency descent procedures.

b. Relevant, existing data must be available to support claims for physiological limits.

c. These data should provide recommendations for allowable time exposures following cabin decompression for the occupants (i.e. where permanent physiological damage is avoided) at varying cabin altitudes.

d. Requirements should consider different standards for flight crew, cabin crew, and passengers based on their role in supporting continued safe flight and landing (i.e., training, protection, etc.).

8. Crew Duties and Training in the Event of Emergencies

FAR 121.391 Flight attendants (duties)
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-391.rtf

FAR 121.397 Emergency and emergency evacuation duties
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-397.rtf

FAR 121.417 Crewmember emergency training
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-417.rtf

FAR 121.427 Recurrent training
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-427.rtf

FAR 121.557 Emergencies: Domestic and flag operations
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-557.rtf

121.559 Emergencies: Supplemental operations http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-559.rtf

FAR 121.587 Closing and locking of flight crew compartment door
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-587.rtf

AC 120-48 COMMUNICATION AND COORDINATION BETWEEN FLIGHT CREWMEMBERS AND FLIGHT ATTENDANTS
http://www1.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/1ab39b4ed563b08985256a35006d56af/ffeb9277f3866c5b862569f1005f7eb6/$FILE/AC120-48.pdf

ACOB 205 DUTY ASSIGNMENT OF REQUIRED AND NON-REQUIRED FLIGHT ATTENDANTS
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB205.rtf

ACOB 207 PREDEPARTURE CABIN EQUIPMENT CHECKS BY FLIGHT ATTENDANTS
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB207.rtf

ACOB 223 FLIGHT ATTENDANT TRAINING ON CONDITIONS OF AIRCRAFT FOLLOWING AN ACCIDENT
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB223.rtf

ACOB 225 Training of Cockpit and Cabin Crewmembers on the Operational Characteristics of Chemically Generated Supplemental Oxygen System and Updating of Passenger Briefing Information
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB225.rtf

ACOB 226 PREPARATION OF CABIN FOR IMPENDING EMERGENCY LANDING
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB226.rtf

ACOB 227 FLIGHT ATTENDANT RESTRAINT DURING A CRASH AND EMERGENCY EVACUATION SECOND CHOICE EXIT DETERMINATION
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB227.rtf

ACOB 229 FLIGHT ATTENDANT TRAINING ON THE USE OF COCKPIT EMERGENCY EQUIPMENT
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB229.rtf

ACOB 231 CREWMEMBER CABIN SAFETY TRAINING
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB231.rtf

ACOB 928 Crewmembers Procedures for Assessing Damage to Aircraft In flight (F/A reporting hazardous conditions)
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB928.rtf

ACOB 979 Require any Crewmember who Observes a Potential or Actual Emergency Situation to Verbally Call it to the Captain's Attention
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB979.rtf

HBAT 98-18 Air Carrier Manual Instructions Concerning Minimum Equipment List Conditions and Limitations
http://www.faa.gov/avr/afs/hbat/hbat9818.txt

HBAT 98-26 Flight Attendants Operating Experience
http://www.faa.gov/avr/afs/hbat/hbat9826.doc

FSAT 95-27 Use of Oxygen Mask by Cabin Crew During Decompression
http://www.faa.gov/avr/afs/fsat/fsat9527.txt

FSAT 97-02: Approval of Flight Attendant Training Programs and Acceptance of Flight Attendant Manuals(inspector approval).
(especially pages 3-2127 Use of Oxygen and 3-2132 f/a actions)
http://www.faa.gov/avr/afs/faa/8400/8400_vol3/3_015_06.pdf

Ground rules for probability

Airworthiness Standards and References

The pertinent FAA major categories, Title 14, 2001, constituting the certification of today's aircraft are as follows:

FAR 25.365 (e), (f)
FAR 25.571 & ACs Damage-tolerance and fatigue evaluation of structure
FAR 25.1309 & ACs Equipment, systems, and installations

Ground Rules

1. If probability is used in showing compliance then it must be applied only to conditions, which are predictable, and the probability of the event is supported by data.

2. The consequences of an event in terms of severity and the probability of that event occurring should be inversely related such that potentially catastrophic conditions will not occur. See table below, FAR Category "Major, Catastrophic":

Table 1 FAR/JAR Failure/Probability/Criticality Definitions

Effects on aircraft and occupants of the identified failure condition.	FAR - AC 25.1309-1A definitions.	No significant degradation of aircraft capability. Crew actions well within their capabilities.		Reduction of the aircraft capability or of the crew ability to cope with adverse operating conditions.		Prevention of continued safe flight and landing of the airplane.
	ACJ No. 1 of JAR 25.1309 definitions	Slight reduction of safety margins, slight increase in work load, (e.g. routine changes in flight plan), or physical effects but no injury to occupants.		Significant reduction in safety margins, reduction in the ability of the flight crew to cope with adverse operating conditions impairing efficiency, or injury to occupants.	Large reduction in safety margins, physical distress or workload such that the flight crew cannot be relied upon to perform their tasks accurately or completely, or serious injury to or death of a relatively small portion of the occupants.	Loss of the airplane and/or fatalities.
FAR effect category AC 25.1309-1A.		Minor		Major		Catastrophic
FAR qualitative probability terms.		Probable		Improbable		Extremely improbable
JAR qualitative probability terms.		Frequent	Reason-ably Probable	Remote	Extremely Remote	Extremely Improbable
FAR and JAR qualitative probability ranges.		10^{-3} 10^{-5} 10^{-7} 10^{-9} Probability of Failure Condition (for one flight hour or flight if less than one hour).				

Table 2 Relationship Between Probability and Severity of Failure Condition.

Effect on Airplane	No effect on operational capabilities or safety	Slight reduction in functional capabilities or safety margins	Significant reduction in functional capabilities or safety margins	Large reduction in functional capabilities or safety margins	Normally with hull loss
Effect on Occupants excluding Flight Crew	Inconvenience	Physical discomfort	Physical distress, possibly including injuries	Serious or fatal injury to a small number of passengers or cabin crew	Multiple fatalities
Effect on Flight Crew	No effect on flight crew	Slight increase in workload	Physical discomfort or a significant increase in workload	Physical distress or excessive workload impairs ability to perform tasks	Fatalities or incapacitation
Allowable Qualitative Probability	No Probability Requirement	<---Probable--->	<----Remote----->	Extremely <------------------> Remote	Extremely Improbable
Allowable Quantitative Probability: Average Probability per Flight Hour on the Order of:	No Probability Requirement	<------------------> $<10^{-3}$ Note 1	<------------------> $<10^{-5}$	<------------------> $<10^{-7}$	$<10^{-9}$
Classification of Failure Conditions	No Safety Effect	<-----Minor------>	<-----Major------>	<--Hazardous--->	Catastrophic

Note 1: A numerical probability range is provided here as a reference. The applicant is not required to perform a quantitative analysis, nor substantiate by such an analysis, that this numerical criteria has been met for Minor Failure Conditions. Current transport category airplane products are regarded as meeting this standard simply by using current commonly-accepted industry practice.

3. Failure Modes & Effects Analysis (FMEA) and Fault tree methodology for system failures are a means to show compliance to FAR/JAR 25.1309.

4. Damage tolerance and fail-safe design principles are an equivalent methodology to show compliance FAR/JAR 25.571(e).

5. Base recommendation on assumption other FAR/JARs are in their current approved state, except FAR/JAR table 2, "Relationship Between Probability and Severity of Failure Condition", above.

6. The application of probability of structural failure is contrary to the basic structural design approach, and therefore probability of structural failure should not be considered in establishing compliance to the subject rule. The regulations governing structures are intended to render structural failures extremely improbable by virtue of choice of design loads, margins of safety, testing, and required maintenance programs, even though a numerical value for extremely improbable is not always computed.

7. Engine rotor burst related events are not considered as part of this subteam's assessment; however, engine system failures will be considered, (for example loss of engine bleed air).

Ground rules for damage assessment

1. During rapid and/or explosive decompression at cruise altitudes, flight crew would be in a highly chaotic environment with various warning sounds and vision may be severely limited due to fog, etc., in the flight deck air. Similarly, cabin flight attendants would not be able to reliably assess damage and report to flight crew. In fact, damage may be hidden from view.

2. In order to best ensure airplane survivability following a rapid or explosive decompression, flight crew would descend airplane to not exceed Vmo/Mmo. Adoption of the Vmo/Mmo descent criterion may require additional training components and flight manual revisions. Flight crew first priority would be to don oxygen masks.

3. Embedded sensor technology may be utilized to determine extent of structural failures when proven technology is available. Such technology may enhance the flight crew's ability to assess the extent and nature of the structural failure and to respond with appropriate emergency measures.

4. Instruments for measuring and deciphering rapid cabin pressure changes may be utilized to determine extent of structural failures when proven technology is available. Such technology may enhance the flight crew's ability to assess the extent and nature of the structural failure and to respond with appropriate emergency measures.

5. Video cameras or similar devices to monitor the structure, either internally or externally, may be utilized to determine extent of structural failures when proven technology is available. Such technology may enhance the flight crew's ability to

assess the extent and nature of the structural failure and to respond with appropriate emergency measures.

6. Current FAA interpretation is that no other damage is assumed to occur (i.e., airplane has sustained loss of one engine – pressurized vessel punctured – decompression occurs – no loss to control surfaces or controllability of airplane). However, manufacturers shall account for loss of system capability, based on the specific systems architecture of the aircraft (only the systems that may be lost following an engine failure, as would be done in a hazard analysis, etc.), following loss of an engine.

Uncontained Engine Failure as Specific Risk

One major area of continuing disagreement where no majority position was achieved by the MSHWG is that of engine failure being considered a specific risk (i.e. probability of occurrence is one).

Background

The current probability of an engine uncontained failure, which is considered a random, unpredictable event, based on historical data is on the order of 10^{-7}(Reference 10). When combined with a simple geometrical analysis that shows the probability of fragments hitting the fuselage, and subtracting airplane non-survival events, it is possible that the probability of an engine uncontained failure causing a airplane survivable rapid decompression is of the order of 10^{-9} (extremely improbable). The MSHWG achieved agreement on an acceptable means of compliance with the use of DEI methodology for uncontained engine failure. However, there is still a disagreement as to whether a combined probability assessment is also an acceptable means of compliance, vs. consideration of an uncontained engine failure as a specific risk.

The MSHWG notes that the System Design and Analysis Harmonization Working Group, SDAHWG, is currently reviewing the issue of specific risk and its impact on FAR/JAR 25.1309.

The FAA position on Specific Risk is as follows:

The current FAA thinking/policy on this subject is that where there is a significant potential for flight to flight variation in risk and/or significant variability and uncertainty within the computation of average risk; the concept of "specific risk" must be taken into account in order to effectively find compliance with even §25.1309(b). FAA believes that it isn't enough to conclude that an event is not expected to occur during a series of typical flights of mean duration, we must conclude that the event is not anticipated to occur during any one flight.

This is particularly true for the accepted means of compliance for rules like: §25.901(c) where such considerations have traditionally been part of the means of compliance; §25.981 where consideration of the "latent plus one" criteria is specifically called out in the rule; §25.671 where even the ARAC Recommendations include some "specific risk" considerations; §25.841 where FAA historically has called out that structural, system and engine failures must be considered. {With regard to UEF, this has been done in part because of the variability and uncertainty in the likelihood of an UEF worst-case decompression.}

To summarize, the FAA is not currently applying the formal "specific risk" assessment and acceptance policies that it proposed as part of AC 25.1309-1B to "all FAR's". FAA may elect in the future (pending the supplemental tasking mentioned above) to apply the concept to some FAR's that meet guidance requirements within the AC 25.1309-1B. However, the FAA has not found any "grand strategy" or "guidance" provided at this time that would indicate that FAA would preclude a "specific risk" from being a required part of the demonstration of compliance for any FAR's that have historically required that particular "specific risk" be considered in a finding of compliance.

The Aircraft industry position on Specific Risk is as follows:

The SDAHWG reviewed all the compelling data the FAA and industry had assembled and determined that there was no evidence of a “compelling public need” which would justify specific risk inclusion within 1309, (as required by executive order 12866). The committee did however conclude that there is a need to better understand and execute our current design and safety assessment methodology, particularly when it comes to identifying failure modes, validating requirements, modeling failure conditions and the use of proper assumptions and accurate failure rates. The data that the MSHWG has compiled shows that no deaths have ever occurred in commercial airplanes due to a high altitude rapid decompression. There is no compelling public need or justification for specific risk within 25.841(a), and to do so may be in violation of executive order 12866.

The FAA mentioned above that within 25.841(a), UEF is a specific risk due in part to the variability and uncertainty in the likelihood of an UEF worst-case decompression. Yet work in SDAHWG has shown that we do a good job of managing risk by design and analysis using average risk techniques. The deviation from average risk is not significant, certainly not enough to warrant a specific risk approach.

Also in the above argument, it was noted that a grand strategy or guidance to indicate that the FAA would preclude a specific risk from being a requirement was not found. Certainly the opposite is true also. There is no regulatory guidance we are aware of that makes specific risk a grand strategy either in the finding of compliance. In fact the SDHWG draft 1309 product purposefully did not include any mention of specific risk in the preamble, rule body, or advisory material for exactly this reason.

Depressurization Exposure Integral (DEI) Method

In addition, another area that achieved a majority position, but continues to be an area of controversy, is the DEI method.

As noted in Question 6, some members of the medical community have expressed concern over the fact that the human response to the rarified atmosphere following decompression is a dynamic multi-factorial response to changes in, among other things, the tracheal, alveolar, arterial and end-tidal partial pressure of oxygen, carbon dioxide, water vapor, pH of the blood, arterial blood pressure, cerebral vascular resistance and the local cerebral blood flow. While we acknowledge these concerns, the majority of the group believes that through the selection of sufficiently conservative acceptance criteria validated by additional experimental data obtained through an appropriate research program, this approach will permit a realistic numerical appraisal of the severity of the hypoxic environment due to an uncontained engine failure event.

18.- Does the HWG wish to answer any supplementary questions specific to this project? [If the HWG can think of customized questions or concerns relevant to this project, please present the questions and the HWG answers and comments here.]

The MSHWG does not have any supplementary issues to address related to FAR 25.841(a)(2) and (3).

19 - Does the HWG want to review the draft NPRM at "Phase 4" prior to publication in the Federal Register?

A Notice is required for the proposed FAR change and current members of the Mechanical Systems Harmonization Working Group should review any draft Notice of Proposed Rulemaking prior to publication in the Federal Register.

No Notice is required for the advisory material. However, it has been the policy of the Transport Airplane Directorate to provide a Notice of Availability of Proposed Advisory Circular (AC) and request for comments prior to issuing advisory material. Therefore, the current members of the MSHWG would like to review any draft notice prior to publication in the Federal Register.

20 – In light of the information provided in this report, does the HWG consider that the "Fast Track" process is appropriate for this rulemaking project, or is the project too complex or controversial for the Fast Track Process. Explain. [A negative answer to this question will prompt the FAA to pull the project out of the Fast Track process and forward the issues to the FAA's Rulemaking Management Council for consideration as a "significant" project.]

Harmonization of these regulatory issues is beyond the "Better Plan" for Harmonization tasks that are being handled under the Fast Track ARAC process. Therefore, this should not be a "fast track" process, but instead a normal NPRM process. This issue should be forwarded to the FAA's Rulemaking Management Council for establishment as a "significant" project. It should then be given highest priority to complete as quickly as possible. Failure to do will severely impede the design and manufacturer of new commercial airplane designs.

Attachment A - Reference List

1. "Aircraft Standards for Subsonic Transport Aeroplanes to be Operated above an Altitude of 41 000 ft", Generic Special Condition, developed by Panel 08 CSP, JAA/ System D&F Steering group, October 15, 2002.

2. "Draft AC/AMJ 25.1309", Initiated by System Design and Analysis HWG, Arsenal Version, 6/10/2002.

3. An Analysis of the Oxygen Protection Problem at Flight Altitudes Between 40,000 and 50,000 Feet, Final Report, prepared for the Federal Aviation Agency, Contract FA-955, by Blockley and Hanifan, February 20, 1961.

4. Neurological Sequelae of Prolonged Decompression, Aerospace Medicine, A.N. Nicholson and J.R. Ernsting, April 1967

5. Neurological Study of Simulated Decompression in Supersonic Transport Aircraft, Aerospace Medicine, J.B. Brierley and A. N. Nicholson, August 1969.

6. Statistical Summary of Commercial Jet Airplane Accidents, Worldwide Operations, 1959-2002, Published by Boeing Commercial Airplane, May, 2003

7. Uncontained Engine Failure Fuselage Hole Analysis, Draft Technical Note, October 2001.

8. Uncontained Engine Damage Database, ACCESS 2000 Database, FAA UED v001, June 10, 2002.

9. "Factors Influencing the Time of Safe Unconsciousness (TSU) for Commercial Jet Passengers Following Cabin Decompression", James G. Gaume, Aerospace Medicine, April 1970.

10. Society of Automotive Engineers (SAE) studies and their associated Aerospace Information Reports (AIRs) AIR1537, AIR4003, and AIR4770 (Draft).

11. "High Altitude air transport system symposium, May 23, 24, 1956, at the Institute of Aeronautical Sciences," OCLC: 1134264, Dr. E. G. Vail

12. "Reactions and Performance of Pilots Following Decompression by G. Bennett, Aerospace Medicine, February 1964.

13. Human Performance and Limitations in Aviation, Third Edition, R. D. Campbell and M. Bagshaw, Blackwell Sciences Ltd., pg. 25.

14. Effect of Physical Activity of Airline Flight Attendants on Their Time of Useful Consciousness in a Rapid Decompression, Douglas E. Busby, Arnold Higgins, and Gordon E. Funkhouser, FAA/CAMI, Aviation, Space, and Environmental Medicine, February 1976.

15. Fundamentals of Aerospace Medicine, 2nd edition, Roy L. Dehart, Williams and Wilkens Publishers, 1996, Table 5.12, pg.91.

16. "Hypoxia and Performance Decrement", William F. O'Connor, Ph. D., Jim Scow, M.D., George Pendergrass, Capt., USAF, DOT/FAA/AM 66-15, May, 1966.

17. Physiological Requirements by Dr. E.G. Vail, WADC, United States Air Force (USAF) - Presented at a USAF symposium on high altitude oxygen requirements in May 1956

18. International Civil Aviation Organization, Ninth Edition, July 2001.

Attachment B - Bibliography

1. "Prevention of Hypoxia – Acceptable Compromises", Aviation, Space, and Environmental Medicine, J. Ernsting, March 1978.

2. "Quick Response by Pilots Remains Key to Surviving Cabin Decompression", Stanley R. Mohler, M.D., Human Factors & Aviation Medicine, Vol. 47, No. 1, Jan.-Feb., 2000

3. "Concepts Providing for Physiological Protection After Aircraft Cabin Decompression in The Altitude Range of 60,000 to 80,000 Feet above Sea Level", Robert P. Garner, DOT/FAA/AM-99/4, Office of Aviation Medicine, February, 1999.

4. "Performance of a Continuous Flow Passenger Oxygen Mask at an Altitude of 40,000 Feet", Robert P. Garner, DOT/FAA/AM-96/4, February 1996.

5. "Rapid Decompression of a Transport Aircraft Cabin: Protection Against Hypoxia", H. Marotte, C.Toure, J.M. Clere, and H. Vieillefond, Aviation, Space and Env. Medicine, Jan., 1990.

6. "Effects of Decompression on Operator Performance", William F. O'Connor, Ph. D., George E. Pendergrass, DOT/FAA/AM 66-10, April, 1966.

7. "Behaviour of Naïve Subjects During Decompression: An Evaluation of Automatically Presented Passenger Oxygen Equipment", Chisholm DM, Billings CE, Bason R, Aerospace Medicine, February 1, 1974.

8. "Physiologically Tolerable Decompression Profiles for Supersonic Transport Type Certification", Stanley R. Mohler M.D. and P.V. Siegel M.D., DOT/FAA/AM 70-12, July 1970.

9. "Military Standard Climatic Extremes for Military Equipment, MIL-STD-21 OB."

10. Aerospace Information Report (AIR) No. 822 and 825A (Physiology Section); SAE Committee A-10.

11. AC 20-32B, Carbon Monoxide (CO) Contamination in Aircraft - Detection and Prevention.

12. AC 91-8B, Use of Oxygen by Aviation Pilots/Passengers. {Note: AC 91-8B, dated 4/7/82, was canceled by AC 61-107, dated 1/23/91 - Ed.}

13. {Sic} Bioastronautics Data Book, NASA SP-3006, National Aeronautics and Space Administration.

14. Reactions and Performance of Pilots Following Decompression, G. Bennett, Aerospace Medicine, 32:134, February 1961.

Attachment C - Associated Regulatory and Advisory Material

The pertinent sections from FAA 14 CFR 25, 2001, and JAA JAR-25, 2000 related to the certification of today's aircraft are as follows:

A. Airworthiness Standards, Transport Category Airplanes

FAR 25.841	Pressurized cabins
FAR 25.1443(d)	First aid oxygen
FAR 25.1447(c)(2) & (4)	Oxygen for flight deck crew and flight attendants
FAR 25.1441	Oxygen equipment and supply
FAR 25.1445	Equipment standards for the oxygen distributing system
FAR 25.1449	Means for determining use of oxygen
JAR 25.841	Pressurized cabins
JAR 25.1439	Protective breathing equipment
JAR 25.1441	Oxygen equipment and supply
JAR 25.1443	Minimum mass flow of supplemental oxygen
JAR 25.1445	Equipment standards for the oxygen distributing system
JAR 25.1447	Oxygen for flight deck crew and flight attendants
JAR 25.1449	Means for determining use of oxygen

Operating Requirements: Domestic, Flag, and Supplemental Operations

U.S. operators

121.329	Supplemental oxygen for sustenance; turbine engine powered airplanes
121.333.1	Supplemental oxygen for emergency descent and for first aid; turbine engine powered airplanes with pressurized cabins
121.336	Equipment standards
121.337	Protective Breathing Equipment
121.574	Oxygen for medical use by passengers http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-574.rtf
AC 120-43:	Influence of Beards on Oxygen Mask Efficiency http://www1.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/1ab39b4ed563b08985256a35006d56af/f9789ad5efc61df6862569ba00752817/$FILE/AC120-43.pdf
TSO-C78:	Crewmember Demand Oxygen Masks http://av-info.faa.gov/tso/Tsocur/C78.doc
TSO-C89:	Oxygen Regulators, Demand http://av-info.faa.gov/tso/Tsocur/C89.doc

Canadian operators,

Operational Standards-Airline Operations

705.71.1.1	Protective Breathing Equipment
705.71.1.2	First Aid Oxygen
705.94.1.1	Portable Oxygen
605.31(2)	Oxygen Equipment and Supply
605.32.1.1	Use of Oxygen

Operational Standards-Private Operator Passenger Transportation

604.40	Protective Equipment

European operators

JAR-OPS 1.760	First aid oxygen
JAR-OPS 1.770	Supplemental Oxygen -pressurized aeroplanes
JAR-OPS 1.770	Appendix 1 Oxygen – Minimum requirements for supplemental oxygen for pressurized aeroplanes
JAR-OPS 1.780	Protective Breathing Equipment

Airworthiness Standards and References

The pertinent FAA major category, Title 14, 2001, constituting the certification of today's aircraft are as follows:

FAR 25.365 (e), (f)
FAR 25.571 & ACs Damage-tolerance and fatigue evaluation of structure
FAR 25.1309 & ACs Equipment, systems, and installations

Crew Duties and Training in the Event of Emergencies

FAR 121.391 Flight attendants (duties)
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-391.rtf

FAR 121.397 Emergency and emergency evacuation duties
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-397.rtf

FAR 121.417 Crewmember emergency training
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-417.rtf

FAR 121.427 Recurrent training
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-427.rtf

FAR 121.557 Emergencies: Domestic and flag operations
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-557.rtf

121.559 Emergencies: Supplemental operations
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-559.rtf

FAR 121.587 Closing and locking of flight crew compartment door
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-587.rtf

AC 120-48 COMMUNICATION AND COORDINATION BETWEEN FLIGHT CREWMEMBERS AND FLIGHT ATTENDANTS
http://www1.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/1ab39b4ed563b08985256a35006d56af/ffeb9277f3866c5b862569f1005f7eb6/$FILE/AC120-48.pdf

ACOB 205 DUTY ASSIGNMENT OF REQUIRED AND NON-REQUIRED FLIGHT ATTENDANTS
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB205.rtf

ACOB 207 PREDEPARTURE CABIN EQUIPMENT CHECKS BY FLIGHT ATTENDANTS
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB207.rtf

ACOB 223 FLIGHT ATTENDANT TRAINING ON CONDITIONS OF AIRCRAFT FOLLOWING AN ACCIDENT
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB223.rtf

ACOB 225 Training of Cockpit and Cabin Crewmembers on the Operational Characteristics of Chemically Generated Supplemental Oxygen System and Updating of Passenger Briefing Information
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB225.rtf

ACOB 226 PREPARATION OF CABIN FOR IMPENDING EMERGENCY LANDING
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB226.rtf

ACOB 227 FLIGHT ATTENDANT RESTRAINT DURING A CRASH AND EMERGENCY EVACUATION SECOND CHOICE EXIT DETERMINATION
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB227.rtf

ACOB 229 FLIGHT ATTENDANT TRAINING ON THE USE OF COCKPIT EMERGENCY EQUIPMENT
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB229.rtf

ACOB 231 CREWMEMBER CABIN SAFETY TRAINING
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB231.rtf

ACOB 928 Crewmembers Procedures for Assessing Damage to Aircraft In flight (flight attendant reporting hazardous conditions)
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB928.rtf

ACOB 979 Require any Crewmember who Observes a Potential or Actual Emergency Situation to Verbally Call it to the Captain's Attention
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB979.rtf

HBAT 98-18 Air Carrier Manual Instructions Concerning Minimum Equipment List Conditions and Limitations
http://www.faa.gov/avr/afs/hbat/hbat9818.txt

HBAT 98-26 Flight Attendants Operating Experience
http://www.faa.gov/avr/afs/hbat/hbat9826.doc

FSAT 95-27 Use of Oxygen Mask by Cabin Crew During Decompression
http://www.faa.gov/avr/afs/fsat/fsat9527.txt

FSAT 97-02: Approval of Flight Attendant Training Programs and Acceptance of Flight Attendant Manuals (inspector approval).
(Especially pages 3-2127 Use of Oxygen and 3-2132 f/a actions)
http://www.faa.gov/avr/afs/faa/8400/8400_vol3/3_015_06.pdf

Attachment D - Definitions List

Continuous Flow Oxygen System. The oxygen system usually provided for passengers. The passenger mask typically has a reservoir bag, which collects oxygen from the continuous flow oxygen system during the time when the mask user is exhaling. The oxygen collected in the reservoir bag allows a higher inhalation flow rate during the inhalation cycle, which reduces the amount of air dilution. Ambient air is added to the supplied oxygen during inhalation after the reservoir bag oxygen supply is depleted. The exhaled air is released to the cabin.

Decompression event – An event consistent with the complete loss of cabin pressure in 20 to 60 seconds.

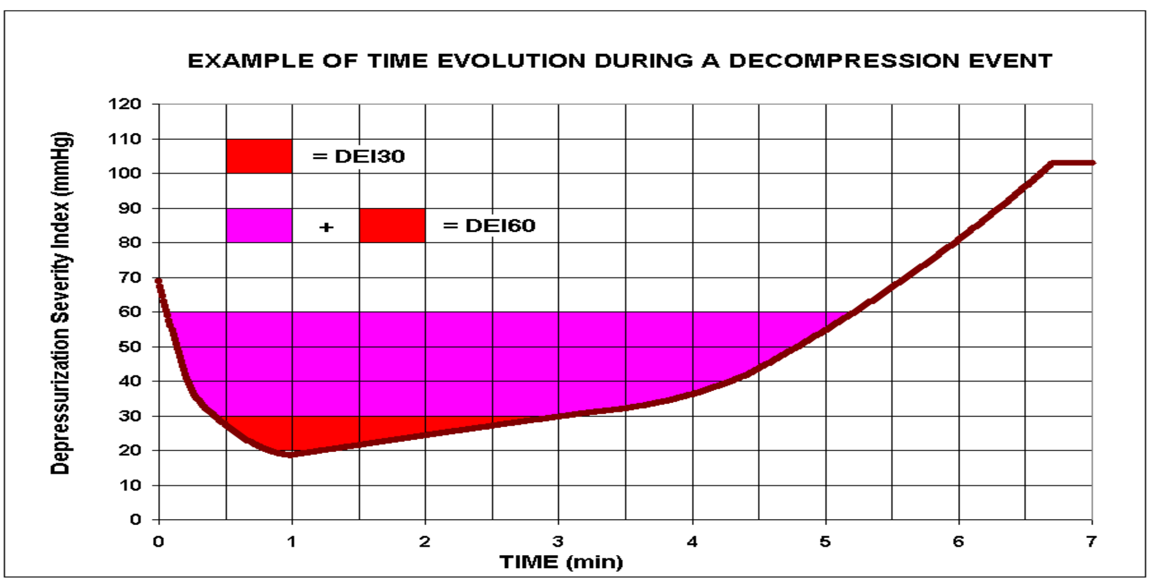
Depressurization Severity Indicator (DSI) - A pressure parameter indicative of the severity to the occupants due to an aircraft depressurization event. It is defined as a function of aircraft cabin pressure, see (reference for set of equation 4). This definition has been chosen to be an estimate of the partial pressure of alveolar oxygen below 25 000 ft, see (DeHart reference).

Depressurization Exposure Integral (DEI) - The time integral of the DSI over a selected period of the depressurization event

DEI30 - DEI for the selected period corresponding to a DSI value below 30 mmHg

DEI60 - DEI for the selected period corresponding to a DSI value below 60 mmHg

The Figure below graphically depicts the DEI for an event where the cabin pressure reaches 51,000 feet pressure altitude. Note that the integral is calculated based upon the difference in DSI and the given reference condition (i.e., 30 mmHg).



Diluter Demand Oxygen System. A flight deck crew oxygen system consisting of a close-fitting mask with a regulator that supplies a flow of oxygen dependent upon cabin altitude. Regulators approved for use up to 40,000 feet are designed to provide zero percent cylinder oxygen and 100 percent cabin air at cabin altitudes of 8,000 feet or less, with the ratio changing to 100 percent oxygen and zero percent cabin air at approximately 34,000 feet cabin altitude. Regulators approved up to 45,000 feet are designed to provide forty percent cylinder oxygen and 60 percent cabin air at lower altitudes, with the ratio changing to 100 percent at the higher altitude. Oxygen is supplied only when the user inhales, reducing the amount of oxygen that is required.

Explosive decompression – complete loss of cabin pressure in 1 to 3 seconds. The above definition is according to DOT/FAA Report DOT/FAA/AM-99/4, “Concepts Providing for Physiological Protection After Aircraft Cabin Decompression in the Altitude Range of 60,000 to 80,000 Feet above Sea Level”, Robert Garner, February 1999:

Extremely Improbable Failures. - Extremely improbable failures are so unlikely that they need not be considered to ever occur, unless engineering judgment would require their consideration. The probability of occurrence is on the order of 1×10^{-9} or less. This category includes failures or combinations of failures that would prevent the continued safe flight and landing of the airplane.

First aid oxygen - The additional oxygen provided for the use of passengers, who do not satisfactorily recover following subjection to excessive cabin altitudes, during which they had been provided with supplemental oxygen.

Flight Level (FL) – Because of continuously changing atmospheric pressure, and because at any one time the pressure varies at different points of the earth’s surface, the standard atmospheric pressure (1013.2 mb or 29.92 in Hg) is used as the datum pressure for en-route flying above a certain altitude. This altitude is referred to as the *transitional altitude*, above which vertical distance is referred to as a *flight level* (FL.). The flight level is stated in 3 digits, representing hundreds of feet. E.g. FL 290 means that the aircraft altimeter indicates 29,000 ft above standard pressure datum of 1013.2 mb. Reference: Human Performance & Operating Limitations in Aviation, by M. Bagshaw, Chapter 2, p. 12.

Hypoxia. - Hypoxia is an insufficient supply of oxygen. Hypoxia results from the reduced oxygen partial pressure in the inspired air caused by the decrease in barometric pressure with increasing altitude.

Improbable Failures. - Improbable failures are not expected to occur during the total operational life of a random single airplane of a particular type, but may occur during the total operational life of all airplanes of a particular type. The probability of occurrence is on the order of 1 x 10-5 or less, but greater than 1 x 10-9. The consequences of the failure or the required corrective action must not prevent the continued safe flight and landing of the airplane.

Pressure Demand Oxygen System – Similar to diluter demand equipment, except that oxygen is supplied to the mask under pressure at cabin altitudes above approximately 34,000 feet. This pressurized supply of oxygen provides some additional protection against hypoxia at altitudes up to 40,000 feet.

Permanent physiological harm – Physical or mental damage (death, injury, or illness) to an organism’s healthy or normal functioning that continues or endures without fundamental or marked change.

Probable Failures. – Probable failures may be expected to occur several times during the operational life of each airplane. The probability of occurrence is on the order of 1 x 10-5 or greater (see Advisory Circular 25.1309-1A). The consequences of the failure or the required corrective action may not significantly impact the safety of the airplane or the ability of the crew to cope with adverse operating conditions.

Rapid decompression – complete loss of cabin pressure in 30 to 60 seconds**.**
The above definition is according to DOT/FAA Report DOT/FAA/AM-99/4, “Concepts Providing for Physiological Protection After Aircraft Cabin Decompression in the Altitude Range of 60,000 to 80,000 Feet above Sea Level”, Robert Garner, February 1999:

Response time **–** The crew recognition and reaction time that is applied between the cabin altitude warning and the initiation of the emergency descent procedure, that includes the donning of O2 masks by the pilots, isolation of failure, configuration of the airplane for descent and initiation of the emergency descent.

Supplemental oxygen – The additional oxygen required to protect each occupant against the adverse effects of excessive cabin altitude and to maintain acceptable physiological conditions during and after decompression.

Time of Safe Unconsciousness (TSU) – The period of time that a person may be rendered unconscious from oxygen deficiency without production of permanent neurological damage or other health problems. (Reference: Concept Providing for Physiological Protection After Aircraft Cabin Decompression in the Altitude Range of 60,000 to 80,000 Feet above Sea Level, Robert P. Garner, Feb., 1999.)

Time of Useful Consciousness (TUC) – The maximum length of time during which an individual can carry out some purposeful activity following a loss of oxygen supply. It is also referred to as the effective performance time (EPT), which is defined as the length of time an individual is able to perform useful flying duties in an environment of inadequate oxygen. (Reference: Human Performance and Limitations in Aviation, R.D. Campbell & M. Bagshaw, 2002)

Uncontained Engine Rotor Failure. – The failure of any rotating part(s) of an engine, including blades, impellers, rim and spacer pieces, seals and spacers, drums, and disc segments, that is subsequently released outside of the main engine compartment (nacelle).

Unhealthy passenger – An airplane occupant other than a crew member who is at elevated risk of permanent physiological harm, the result of exposure to hypoxic conditions following a rapid decompression event, due to one or more pre-existing respiratory (e.g., restrictive or obstructive airway diseases) or circulatory (e.g., peripheral vascular disease, anemia) impairments.

A REPORT OF THE
AIRWORTHINESS ASSURANCE WORKING GROUP

WIDESPREAD FATIGUE DAMAGE
BRIDGING TASK
Multiple Element Damage

FINAL REPORT

July 2003

SIGNED BY

for Kyatsandra Gopinath
Co-Chairperson, AAWG
Boeing Commercial Airplanes

Aubrey Carter
Co-Chairperson, AAWG
Delta Air Lines

REVISION PAGE

LTR	DATE	CHANGE	PAGES ADDED	PAGES DELETED	PAGES CHANGED	APPROVED BY

Table of Contents

List of Figures

Abbreviations and Definitions

AATF	Airworthiness Assurance Task Force
AAWG	Airworthiness Assurance Working Group
AC	Advisory Circular (FAR)
ACJ	Advisory Circular (JAR)
AD	Airworthiness Directive
AECMA	Association des Entreprises de Construction Mécanique et Aeronautique
AIA	Aerospace Industries Association of America
ALI	Airworthiness Limitation Instructions
ALI	Airworthiness Limitation Instructions
ARAC	Aviation Rulemaking Advisory Committee
ART	Authorities Review Team
ATA	Air Transport Association of America
CAA-UK	Civil Aviation Authority - United Kingdom
CTOA	Crack Tip Opening Angle
DGAC	Direction Générale de l’Aviation Civile
DSG	Design Service Goal
EIFS	Equivalent Initial Flaw Size
ESG	Extended Service Goal
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FR	Failure Rate
GARTEUR	Group for Aeronautical Research and Technology in Europe
HMV	Heavy Maintenance Visit
IATA	International Air Transport Association
ICWFD	Industry Committee on Widespread Fatigue Damage
ISP	Inspection Start Point
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirement
LDC	Large Damage Capability
LOV	Limit of Validity
MED	Multiple Element Damage
MSD	Multiple Site Damage
NAARP	National Aging Aircraft Research Program
NDI	Non Destructive Inspection
NP	None Planned at this time
NPRM	Notice of Proposed Rulemaking
NTSB	National Transportation Safety Board
OEM	Original Equipment Manufacturer
PDF	Probability density Function
PMI	Principal Maintenance Inspector (FAA)
POD	Probability of Detection
RS	Residual Strength
RWG	Rule Writing Group
SAETG	Structural Audit Evaluation Task Group
SB	Service Bulletin
SDR	Service Difficulty Report (FAA)
SFAR	Special Federal Aviation Regulation
SIA	Structural Integrity Audit
SIF	Stress Intensity Factors
SMAAC	Structural Maintenance of Aging Aircraft
SMP	Structure Modification Point
SSIP	Supplemental Structural Inspection Program
STC	Supplemental Type Certificate
STG	Structures Task Group
TAEIG	Transport Airplane and Engines Issues Group
TARC	Technical Advisory Regulatory Committee
TC	Type Certification
TOGAA	Technical Oversight Group RE: Aging Aircraft
WFD	Widespread Fatigue Damage

REFERENCES

[1] NTSB Report No. NTSB/AAR - 89/03, RE: 1988 Aloha Airlines 737 Accident.

[2] A Report of the AATF on Fatigue Testing and/or Teardown Issues, February 1991, Available from the ATA.

[3] Ronald Wickens *et.al*, 'Structural Fatigue Evaluation for Aging Airplanes', final report of the Airworthiness Assurance Working Group, October 1993

[4] McGuire et al, 'Recommendations for Regulatory Action to Prevent Widespread Fatigue Damage in the Commercial Airplane Fleet', Revision A, June 29, 1999.

[5] Galella, 'Inspection Capability and Reliability Detection Assessments for Widespread Fatigue Damage,' FAA William J. Hughes Technical Center, Atlantic City New Jersy, To Be Published.

1.0 EXECUTIVE SUMMARY

In 1997, the FAA tasked ARAC, TAEIG and the Airworthiness Assurance Working Group to examine whether or not regulatory action was required to prevent widespread fatigue damage in the commercial airplane fleet. In 2001, ARAC proposed new rules and advisory information as a result of the 1997 tasking. During the study, ARAC examined methodologies used by the industry to characterize Multiple Site Damage, a source of widespread fatigue damage. ARAC did not have sufficient time to examine or characterize Multiple Element Damage, the other form of damage that can lead to WFD. The purpose of this report is to complete the technical work to characterize MED. In the process of examining MED, the AAWG arrived at ten conclusions and six recommendations.

CONCLUSIONS:

The AAWG reached the following conclusions as a result of this tasking.

1. The areas designated as susceptible to MED, and documented in Reference [4], are still valid and are inclusive of the situations found in-service and test.
2. The identification of the failure scenario for SMP is a critical element in defining the MED problem and may involve other failure modes than static or fatigue overload.
3. The subject of the development of adjacent cracks for MED situations was studied and while it was determined that there was only a small probability of this happening at an SMP, adjacency should be enforced for conservatism.
4. Typically, there is no crack interaction in MED situations, however load redistribution should be considered when load path failure occurs.
5. The MED round robins examined several methods with probabilistic elements that appear to give valid and conservative approaches to the establishment of maintenance programs for MED and were effective in defining important parameters in the analysis. The MED round robin demonstrated that the industry was capable of performing the necessary assessments
6. The methodology and procedures outlined in Reference [4] on MSD are generally applicable to evaluating MED situations. Industry is well prepared to perform the analysis.
7. The application of risk assessment methodology for the development of maintenance programs for WFD would require significant changes in the regulations and significant validation that is currently beyond industry capability.
8. The implementation of maintenance programs for WFD is not dependant on the development of new NDI procedures, however more efficient means of inspecting large areas would be desirable.
9. The concept of ISP, SMP, LOV and normal maintenance is still valid for management of MED situations. Other than those concepts already considered for MSD, there are no additional maintenance requirements for the management of MED.

10. Although there has been a high level of safety achieved through implementation of the existing aging airplane programs, rulemaking is still needed to implement programs for the prevention of WFD.

RECOMMENDATIONS:

The AAWG reached six recommendations:

1. With regards to the risk analysis approach, additional studies are recommended to demonstrate the capability of the approach. These studies will lead to a foundation upon which new rules could be crafted for compliance.
2. The AAWG reviewed the capability of the industry to perform probabilistic based analysis of the MED situation and has found that sufficient maturity of the procedures exist to recommend that analysis can be used for development of effective maintenance programs.
3. In performing the MED analysis, the AAWG recommends that the condition of adjacency be enforced unless there is a compelling reason not to do so.
4. The AAWG recommends that no airplane should be allowed to fly past the detail specific SMP without modification. This is a necessity, since allowing airplanes to fly past the established SMP would create a safety situation that would be very difficult to manage and maintain airworthiness.
5. The AAWG recommends that the operational rules for WFD proposed for 14 CFR Part 121, 135 et al and the certification rules proposed for 14 CFR Parts 25 be given the highest priority within the FAA for promulgation.
6. The AAWG recommends that the industry support the FAA to see that there is a timely publication of the necessary rules for WFD.

2.0 AVIATION RULEMAKING ADVISORY COMMITTEE TASKING

On August 28, 1997, the FAA formally notified the Aviation Rulemaking Advisory Committee; Transport Airplane and Engines Group through the Federal Register (Page 62 FR 45690 No. 167 08/28/97) of a new task assignment for action. The complete text of the Tasking Statement appears in Appendix A. Subsequently, the Transport Airplane and Engines Issues Group assigned action to the Airworthiness Assurance Working Group. The Task Assignment involves completion of the following tasks.

Task Title: Task 5: FAR/JAR 25, DEVELOP TECHNICAL POSITION RE: WIDESPREAD FATIGUE DAMAGE

Task Title: Task 6: FAR/JAR 25, TASK 6: AGING AIRCRAFT PROGRAM (WIDESPREAD FATIGUE DAMAGE) (WFD)

Task Title: Task 6A: FAR/JAR 25, WFD BRIDGING TASKS

Task Description Task 5:

(1) ARAC is tasked to review the capability of analytical methods and their validation; related research work; relevant full-scale and component fatigue test data; and tear down inspection reports, including fractographic analysis, relative to the detection of widespread fatigue damage (WFD). Since airplanes in the fleet provide important data for determining where and when WFD is occurring in the structure, ARAC will review fractographic data from representative “fleet leader” airplanes. Where sufficient relevant data for certain airplane models does not exist, ARAC will recommend how to obtain sufficient data from representative airplanes to determine the extent of WFD in the fleet. The review should take into account the Airworthiness Assurance Harmonization Working Group report “Structural Fatigue Evaluation for Aging Aircraft” dated October 14, 1993, and extend its applicability to all transport category airplanes having a maximum gross weight greater than 75,000 pounds.

(2) ARAC will produce time standards for the initiation and completion of model specific programs (relative to the airplane’s design service goal) to predict, verify and rectify widespread fatigue damage. ARAC will also recommend action that the Authorities should take if a program, for certain model airplanes, is not initiated and completed prior to those time standards. Actions that ARAC will consider include regulations to require Type Certificate holders to develop WFD programs, modification action, operational limits, and inspection requirements to assure structural integrity of the airplanes. ARAC will provide a discussion of the relative merits of each option.

This task should be completed within 18 months of tasking.

As a result of the completion of the tasking, the FAA expects a task report detailing the investigations conducted along with recommendations for further FAA Action. While the recommendations may include a requirement to develop regulatory action, the actual writing of that requirement will be reserved to the FAA or assigned as an additional ARAC Tasking.

The Report Ref [4], comprises the recommendations from the AAWG on the Task 5 assignment from ARAC. The recommendations of that report conclude that new or revised Part 25 rules are required to control WFD in the commercial fleet of airplanes.

Task Description Task 6:

On December 15, 1999, **(70104 Federal Register / Vol. 64, No. 240 /)** (See Appendix A for complete tasking statement**)**, the FAA requested that ARAC propose new operating rules (14 CFR parts 91, 121, 125, 129, and 135) that would ensure that no large transport category airplane (>75,000 lbs. Gross Take Off Weight) is operated beyond the flight cycle limits to be specified in the regulation, unless an ``Aging Aircraft Program'' has been incorporated into the operator's maintenance program. This Tasking was complete and the rules submitted for processing in December 2000.

Task Description Task 6A:

In the process of completing these taskings, several technical issues were not thoroughly addressed because the AAWG did not have time to appropriately address them. These issues were identified and submitted with the Draft NPRM and Advisory material and became known as Bridging Tasks. These Bridging tasks are the subject of this report. The submission of this report satisfies all open technical issues with Task 6.

There are four Bridging Tasks

1. MED Technical Considerations

2. Training

3. NDI Round Robin

4. Mandatory Modifications

This Report addresses the first and third Bridging Tasks; MED Technical Considerations, and the NDI Round Robin.

3.0 AIRWORTHINESS ASSURANCE WORKING GROUP

The AAWG is a duly constituted Federal Advisory Committee Act (FACA) entity. The AAWG reports to the Aviation Rulemaking Advisory Committee, Transport Airplane and Engine Issues Group (ARAC TAEIG). The AAWG was formed shortly after the 1988 Accident in Hawaii involving an older Boeing 737 in which a large section of fuselage departed the airplane. The AAWG has been active ever since examining the health of the fleet and proposing additional programs to maintain overall integrity of the commercial fleet. The membership of the AAWG consists of representation from:

Airbus*
Airline Pilot's Association
American Airlines
American West Airlines
Boeing Commercial Airplanes*
Airbus-UK
British Airways
Continental Airlines*
Delta Air Lines Incorporated*
DHL Airways Incorporated
Evergreen International Airlines
Federal Aviation Administration*
Federal Express*
Fokker Service
International Air Transport
Joint Airworthiness Authorities*
Lockheed Martin
Northwest Airlines
Regional Airline Association
United Airlines
United Parcel Service
US Airways

The AAWG established a task group to prepare and finalize the recommendations from this Tasking. The entities identified by an asterisk, together with Gulfstream participated in the task group. In completing the Task, the AAWG met six times in an 18-month period. A list of meeting venues and meeting attendance is documented in Appendices C and D respectively.

4.0 BACKGROUND

In 1988, the industry experienced a significant failure of the airworthiness system. This system failure allowed an airplane to fly with significant unrepaired multiple site fatigue damage to the point where the airplane experienced a rapid fracture and loss of a portion of the fuselage. As a direct result of this accident, the FAA hosted "The International Conference on Aging Airplanes" on June 1-3, 1988 in Washington D. C. As a result of this conference, an organization of Operators, Manufacturers and Regulators was formed under the Federal Advisory Committee Act to investigate and propose solutions to the problems evidenced as a result of the accident. This group is now known as the Airworthiness Assurance Working Group (AAWG) (Formally know as the Airworthiness Assurance Task Force).

During the 1988 conference, several Airline/Manufacturer recommendations were presented to address the apparent short falls in the airworthiness system including Recommendation 3, which stated:

> "Continue to pursue the concept of teardown of the oldest airline aircraft to determine structural condition, and conduct fatigue tests of older airplanes per attached proposal."

In June 1989, the National Transportation Safety Board (NTSB) made Recommendation 89067 (Reference[1]) that requested the FAA to pursue necessary tasks to ensure continued safe operations with probable widespread fatigue damage (WFD). WFD was noted by the NTSB to be a contributing cause of the April 1988 Aloha Airlines 737 accident. The NTSB specifically recommended extended fatigue testing for older airplanes. In November 1989, the FAA responded by issuing a straw man SFAR RE: TWO-LIFE TIME FATIGUE TEST FOR OLDER AIRPLANES.

In June 1990, the AAWG tasked the formal evaluation of the AIA/ATA Recommendation 3. An alternative approach, Reference [2,3], to the straw man SFAR was developed by the AAWG and presented to the FAA in March 1991. The FAA accepted this alternative approach in June 1991. The AAWG was informally tasked to institutionalize the position in July.

The AAWG task objective was:

> The AAWG shall make recommendations on whether new or revised requirements for structural fatigue evaluation can and should be instituted as an airplane ages past its design service goal. These recommendations are limited to the A300 (Models B2, B4-100, B4-200, C4 and F4), BAC1-11, 707/720, 727, 737 (Models 100 and 200), 747 (Models 100 and 200), DC-8, DC-9, DC-10, F-28 and L-1011 airplanes.

In December 1992, the task was formally published in the Federal Register as an Aviation Rulemaking Advisory Committee (ARAC) task directed to the AAWG from the Transport Aircraft and Engine Issues Group (TAEIG). The task assigned was:

> Task 3 - Structural Fatigue Audit: Develop recommendations on whether new or revised requirements for structural fatigue evaluation and corrective action should be instituted and made mandatory as the airplane ages past its original design life goal.

In accomplishing the task, the AAWG assembled a subset of the working group to reach industry consensus. Industry participation in the task group included members from ATA, IATA, AIA, AECMA, FAA and JAA. In October of 1993, the AAWG formally presented their recommendations, Reference [3] to ARAC concerning Task 3. In general, those recommendations included a proposal for revising existing guidance material and that voluntary audits be conducted for the eleven "AAWG" models.

This tasking was followed by two additional taskings in 1997 and in 1999 in which the AAWG was asked to revisit the subject of WFD and evaluate whether or not voluntary audits were working, The AAWG concluded in 1999 that additional rules and advisory material were needed to insure that audits would be done and subsequently were tasked to propose rules and advisory information.

5.0 BRIDGING TASK A – MULTIPLE ELEMENT DAMAGE

A. Description of Task

The purpose of this task is to identify and quantify the variables in the assessment of airplane structure susceptible to developing Multiple Element Fatigue Damage, a precursor of widespread fatigue damage.

B. AAWG Process

The AAWG, in assigning the project to the Rule Writing Group, highlighted six issues that the RWG should consider. These issues were:

- Identification of critical design details susceptible to MED
- Description of initial flaw characterization process (locations, directions, sizes and time distribution)
- Discussion of the acceptability of risk analysis and probabilistic approaches
- Discussion of the probability of MSD/MED interaction
- Identification of MED failure criteria (static instability, large damage capability, crack arrest)
- Discussion of new maintenance requirements necessary for the prevention of WFD caused by MED

The six issues were broadly split into two categories, in-service or in-test MED experience and analytical approaches and accommodations. To begin, the RWG looked at a cross section of in-service/test MED events in order to establish if any special conditions might be present when considering MED. Second, the AAWG took an extended look at the methodologies used for MED characterization. Specifically, the applicability of methodologies developed for MSD for use in MED situations was examined. To develop an understanding of the methodologies, three MED round-robins were performed.

1) In-service/test MED Experience

Each participant was encouraged to present examples of Multiple Element Damage that have occurred either in-service or in test. They were further requested to present any collateral information such as mitigating service action. The specific assignment was:

OEMs and Operators review test and in-service failures for MED situations of baseline structure. Look for unique examples that exemplify the followings residual strength conditions:

- Conditions where failure would occur due to static stability
  - Tension

  - Compression
- Condition where failure could occur due to residual strength (e.g. LDC or crack arrest)
- Conditions involving stack ups or bonded line failures.

As a result of this review, the AAWG did not discover any new MED scenarios in their examination of OEM and Airline MED specific cases. The areas designated as MED in Section 5.2 of Ref [4] are still valid and, at the present, are all inclusive of the situations encountered in service and test.

Table 5.1 summarizes the findings of the review

From the examples presented, the following conclusions were drawn:

- Some MED situations could have been found through normal routine maintenance inspections. However, reliance on routine maintenance generally results in a situation that involves a large number of airplanes with attendant immediate inspection/repair issues.
- Crack Interaction in MED situations appears to be limited to when an element in a multiple element load path is severed.
- The numbers of critical locations are finite compared to MSD situations.
- Inspections tend to be well defined and easily accomplished. There is potentially less dependence on NDI for finding MED.
- It appears that MED tends to happen early in the life of the airplane due to fatigue hot spots in the structure. Manufacturers need to carefully considered hot spots in their structure for potential MED situations.
- Interaction of cracks should be considered after a load path is broken.
- The reduction of in-service data for use in probabilistic models should be carefully considered. Identification of populations of un-cracked, cracked and failed components might require specific reduction techniques to arrive at appropriate maintenance actions. This is especially true of situations where MSD and MED are already prevalent in a detail in a fleet of airplanes.

Figure 5.1 shows a comparison of the interaction differences that exist between MSD and MED.

STRUCTURAL ELEMENT	FATIGUE SENSITIVE DETAIL	SOURCE OF DAMAGE	TEST/SERVICE	ACCESS FOR INSPECTION	NUMBER OF SENSITIVE DETAILS	INTERACTION WITH SIMILAR ELEMENTS BEFORE FAILURE ?	CRACKS APPEARED IN ADJACENT STRUCTURE ?	CATASTROPHIC FAILURE OCCURRED ?
FRAMES (Fig. 5.1, 5.4, 5.6 of Ref [4])	Fastener holes in web at run-out joint	High bending stress	Test and Service	Internal. Visible part. NDT inspection.	<10 both sides	No	No	No
	Stringer mouse hole	High local tension stress	Test and Service	Internal. Visible part. Visual inspection possible.	??	No	No	No
	Open holes in flange, or web	High local tension stress	Test and Service	Internal. Visible part. Visual inspection possible.	??	No	No	No
	Fastener holes at Passenger Service Unit attachment	High bending stress + fretting	Service	Internal. Visible part. NDT inspection.	Around 10 both sides	No	No	No
	Fastener holes in web	High bending stress	Service	Internal. Visible part. NDT inspection.	Around 80 both sides	No	No	No
STRINGERS (Fig. 5.2, 5.5, 5.6 of Ref [4])	Fastener holes at Stringer couplings	High load transfer	Test	Internal. Visible part. NDT inspection.	Around 30 both sides	No	No	No
	Fastener holes at frame attachment	High bending stress	Test and Service	Internal. 2nd layer of assembly. NDT inspection	??	No	No	No
CARGO DOOR (Fig. 5.12 of Ref [4])	Fillet radius at hinge fitting	High bending stress	Test and Service	Internal. Visible part. Visual inspection possible.	<10	No	No	No
	Latch spool bolts	High local stress + corrosion	Service	Bolts are removed for NDT inspection	<10	No	Latch cracking resulting from other failures	No
PRESSURE BULKHEADS (Fig. 5.7, 5.9 of Ref [4])	Fastener holes at stiffener attachment to pressure bulkhead	High bending stress	Test and Service	Internal. Visible part. NDT inspection.	<10	No	No	No
	Fastener holes and fillet radius at intercostals and stringers attachment	High tension and bending stress	Test	Internal. Visible part. Visual inspection possible.	50	No	No	No
RIB TO SKIN ATTACHMENTS (Fig. 5.15 of Ref [4])	Fastener holes in stringers, at rib attachment	High tension and bending stress	Service	Internal. Visible part. NDT inspection.	<10	No	Rib web cracks discovered	No

Table 5.1 – Review of In-service and Fatigue Test Results of MED Situations

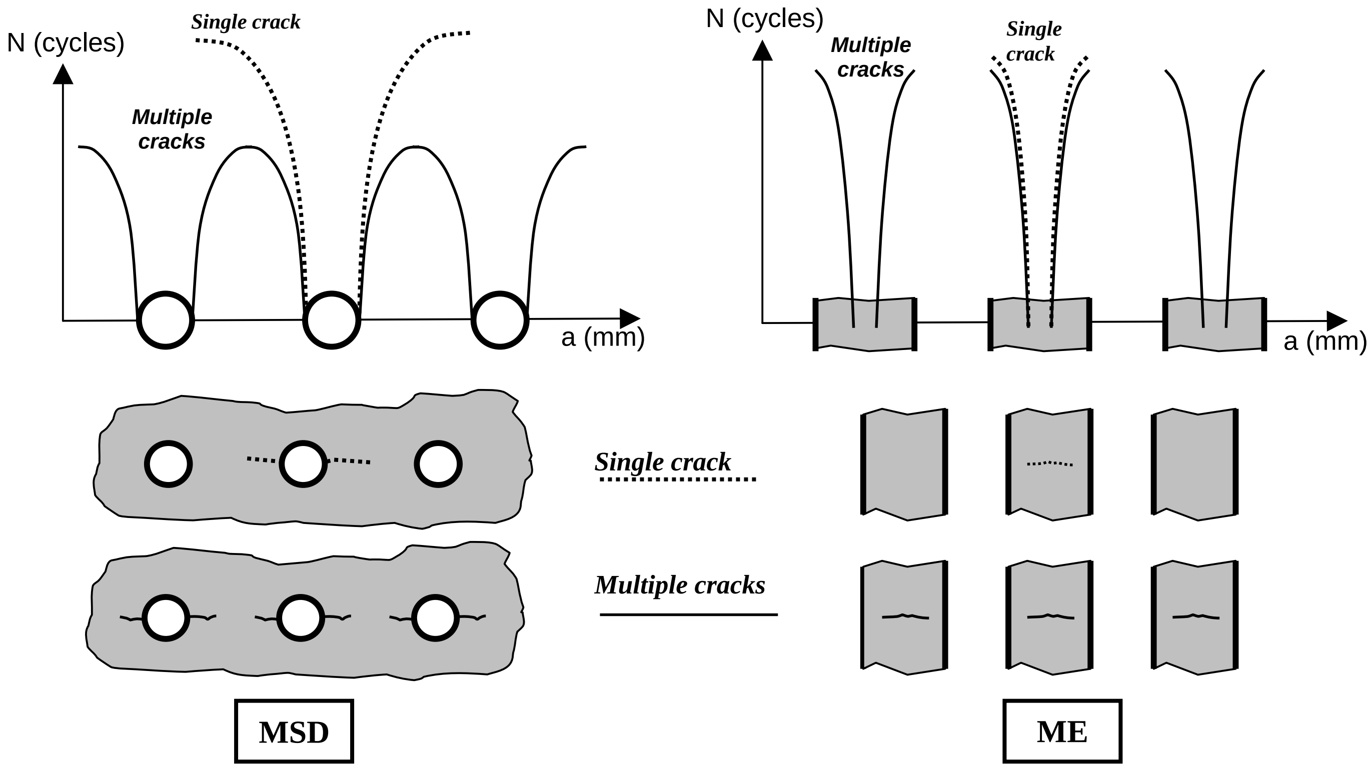


Figure 5.1 – Differences Between Interaction Effects Between MSD and MED

2) Methodology Issues - Applicability of MSD Procedures to MED.

The AAWG determined through a series of Round-Robin example problems that the procedures developed and documented in Reference [4] for MSD are still generally applicable to the MED situation, including the use of probabilistic approaches to determine ISP and SMP. This can be construed to mean that initial flaw size assumptions as well as distributions throughout the structure are definable in a statistical sense.

Further, the application of a Limit of Validity (LOV), Inspection Start Point (ISP) and Structural Modification Point (SMP) as defined in Reference [4] to the MED situation is equally valid. Some adjustments might be necessary to the determination of the ISP because of the less stringent NDI requirements.

On the other side, the determination of failure modes and effects seem not as well defined in the MED case as compared to the MSD case. One of the reasons for this is that crack interaction seems to play a less significant part of the problem for residual strength in the MED case. To this end, the residual strength analysis may need to be done with greater care or conservative analysis stop points may be required, as was done with some MSD approaches. The analytical approach may require one or more of the following:

1. non-linear model using global/local modeling (with iteration of model based on crack length), or
2. Damage states comparable to service or test structural conditions, or
3. a validated conservative approach.

Fatigue tests are no less important in determining potential MED situations or hot spots in the structure. It is always good to remember that observed fatigue test cracks need not always be repaired. Extremely useful data can be obtained by monitoring the crack growth to determine likely failure paths and to determine the amount of load path redistribution as failure progresses.

On the subject of risk assessment as it might apply to managing MSD/MED situations, it was acknowledged that considerable advances had occurred in this area recently. However, additional studies would need to be conducted to establish risk approach capability in this area. Technically the AAWG had not been tasked with this and the rule changes necessary to allow this approach.

The AAWG determined that the discussion contained in Reference [4] concerning the interaction of MSD and MED is still valid. That conclusion was:

> *"The AAWG examined the issue of whether or not it was possible to have a simultaneous occurrence of MSD and MED in a single principal structural element. The AAWG concluded that there was a distinct possibility that this could occur on some details that were equally stressed. This scenario should be considered in developing appropriate service actions for a PSE should this event seem likely.*
>
> *It is suggested that if an area is potentially susceptible to both MSD and MED, then both problems be worked independently. If the thresholds for both MSD and MED indicate a high probability of interaction, then this scenario must be considered".*

3) Necessary Elements of MED Analysis

These statements declared (a) through (g) represent the typical steps that are followed in performing an analysis for MED.

(a) Identify critical design details susceptible to MED.

See Reference [4], Section 5,

(b) Define the WFD condition (*e.g.* number of elements failed).

Identify the structural failure modes for the MED condition, *i.e*. determine the number of elements failed at the point of static instability, or the point at which the residual strength of the structure is degraded below regulatory levels.

The effect of crack interaction on residual strength is less significant in the case of MED than for MSD, and the determination of failure modes is not as well defined as for MSD. Consequently, the residual strength analysis may need to be done with greater attention to detail. An alternative conservative approach would be to terminate the analysis at some point prior to final failure, as has been done in some MSD calculations.

(c) Collect/generate fatigue life data at element level (*e.g.* service inspection findings).

Assemble data that characterize the fatigue life of the element, such as the results of inspections of the fleet, if available.

These data may consist of a variety of different information, such as damage locations, directions, sizes and time distributions. Consequently, there are a range of approaches that may be used in interpreting these data, *e.g.*

1. Consider the inspection results as either cracked or uncracked (null findings), taking no account of crack length information.

2. Adjust the crack length inspection results to some datum crack size, such as initiation crack size, the detectable crack size, or the critical crack size. This may require extrapolation of some inspection results up to the datum, and back calculation for existing cracks greater than the datum. Uncracked locations may be assumed as crack free (*i.e.* suspended or censored data), or as having a crack below the detectable size. Exclusion of suspended data is conservative.

Where no fleet data exists, an applicant will need to characterize the fatigue life of the element from fatigue data based on coupon test results representative of the loading conditions existing in the airplane.

(d) Establish statistical model at element level (*e.g.* PDF for life to detectable crack).

Using the data collected in (c), or other suitable data from test and/or service experience, establish a statistical model that characterizes the element fatigue life.

(e) Establish statistical model at airplane level (*e.g.* PDF for life to WFD condition).

Using the model developed in (d) and the WFD condition defined in (b), establish a statistical distribution for life to failure at the airplane level.

The assumed sequence of cracking can significantly affect this calculation, since the ability of a multiple element structure to tolerate damage is reduced when two adjacent elements are cracked. However, the likelihood of cracks developing in adjacent elements depends on the scatter in the statistical distribution of expected failures. Because of the uncertainty in this analysis, it is recommended that adjacency is enforced, *i.e.* it is assumed that, following crack initiation in an element, the next crack to initiate occurs in an element adjacent to the first cracked element.

(f) Determine Inspection Start Point (ISP).

Using the distribution developed in (e), and appropriate factors to address fleet variability, determine the ISP.

The ISP may be based on initiation probabilities, as in the existing AC guidance material, or on the detectable average behavior. The actual methodology is dependant on assessment procedure.

Where an inspection program is impractical (see Reference [4], Figure 4.4.3), "the only recourse would be to modify the structure before significant cracking occurs in the fleet. Where no other data exists, dividing the average behavior by a factor of three to determine the SMP may be used.

(g) Determine Structural Modification Point (SMP).

Using the distribution developed in (e), and appropriate factors to address fleet variability, determine the SMP.

There should only be a limited number of elements cracked at the SMP (*c.f.* the sparse crack array for MSD). Consequently, the SMP in the case of MED should be defined to ensure that only limited cracking is expected to occur on some airplanes in the fleet, such that the MED will not significantly reduce the residual strength capability of the structure.

In establishing the SMP, the MED scenario should not be combined with other possible 'local' damages, such as the accidental damage, environmental degradation or fatigue damage of conventional damage tolerance assessments, as the possibility of such a combination is considered to be remote. However, it should be subsequently demonstrated that the structure retains LDC in the presence of the state of cracking likely to occur at the SMP.

Figure 5.2 shows a generic application of steps (b) through (g) of the process.

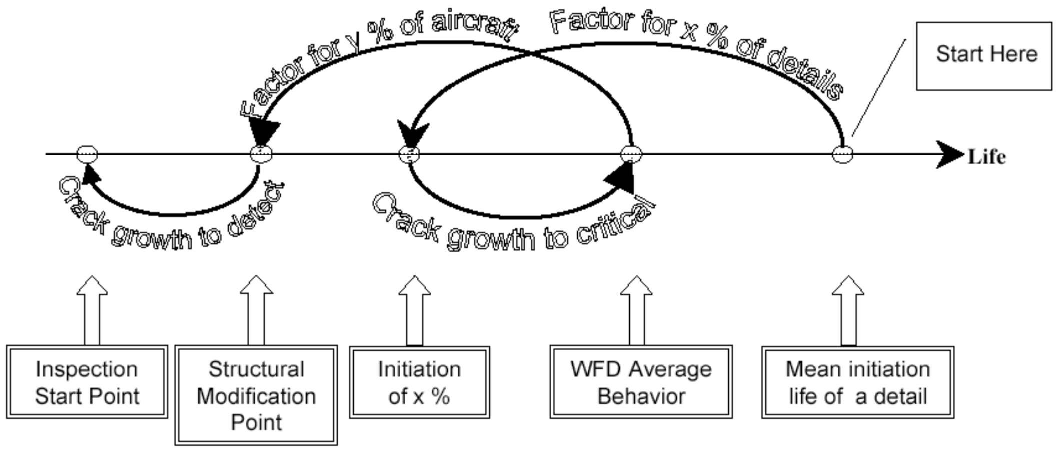


Figure 5.2 - Generic Process to determine ISP and SMP for MED

4) Damage scenarios to be considered.

The AAWG made a determination that the damage scenario assumed at SMP is critical to the results of the analysis. In other words, the condition assumed for residual strength can materially affect the outcome of the problem. The AAWG adopted the following failure model to use in the round robin problems:

> *State at SMP - A percentage (a%) of the elements failed, on a percentage (b%) of the airplanes in the fleet. As for MSD, the SMP for MED should be defined to ensure that only limited cracking is expected to occur on some airplanes in the fleet. Consistent with this, the WFD condition should only exist in 5%* or less of the fleet. This should ensure that the MED damage will not reduce the residual strength capability in the presence of other damage significantly.*

* Dependant on statistical model used. Log-normal is nominally 2%, Weibull is 5%, other models vary accordingly and is based on equivalency of protection to a two lifetime fatigue test for aluminum structure

Other considerations:

1. *Any inspection task in place between ISP and SMP to detect possible cracking should ensure that cracking is found and repaired prior to element failure.*

2. *The apparent rate of development of cracks in adjacent members (i.e. scatter of the distribution e.g. high alpha) in coming up with maintenance program recommendations*

3. *Consideration should be given in establishing the condition at SMP, e.g. shell instability, buckling i.e. failure modes other than fracture.*

4. *In the approach used to establish the SMP, a study should be made to demonstrate that the approach ensures that the expected extent of MED at the SMP still has a LDC to address damage from sources such as accidental damage, fatigue damage, or environmental degradation.*

5) Technical Issue – Adjacency of Initiated Cracks

The AAWG, in the process of addressing the subject of MED, identified one additional issue that was deemed significant, that of the probability that cracks might develop adjacently. The question of the likely hood of cracks developing in adjacent elements of a multi-element structure is a statistically interesting problem. The problem simply stated is - given a statistical distribution of expected failures, what is the probability that following the first crack initiating in an element, that the very next crack to initiate occurs in an element adjacent to the first cracked element? This problem is interesting because when two adjacent elements are cracked, the ability of the structure to tolerate large damage is reduced.

The AAWG ran a Monte-Carlo analysis and examined the results to determine if the issue of adjacency caused significant variance in the results.

The problem considered was a row of frames all containing an identical fatigue detail with fairly low life. The basic assumptions used in the analysis were as follows:

- Alpha ranging from 4 to 8;
- Beta = 120,000;
- 100 frames per airplane;
- 1,000 scenarios run;
- Investigation of the number of frames initiated and their location when 1st frame failed

Results are presented for an average airplane (fleet variability was not taken into account)

Figure 5.3 shows the expected probability density function (PDF) for the various alphas assumed. Figure 5.5 shows the expected state of the frames when the first frame fails. It says that for alphas between 4 and 8, there is a 50% probability that there will be from 10 to 20 other frames cracked when the first frame fails. This is without regard to whether the frames are adjacent or not.

Figure 5.4 takes a first look at adjacency issues. Based on this chart and averaging the data from the alphas, the data says that there is approximately a 75% chance that there will be no adjacent frames cracked at first frame failure. In Figure 5.5, there is a 20% chance that there will be one adjacent frame initiated and a 5% chance that two adjacent frames are initiated.

Figure 5.6 summarized the results of the investigation in terms of what might be expected at WFD Average Behaviour. Even though there is an expected 20% chance of having an adjacent frame initiated when the first frame is failed, there is less than a 1.5% chance of this happening at WFD Average Behaviour. This result is independent of Alpha.

Since the analysis process is not exact, certain areas of the structure may behave differently than expected based on stress levels and design configuration. Because of these situations, the AAWG strongly recommends that an applicant choose to enforce adjacency in his analysis.

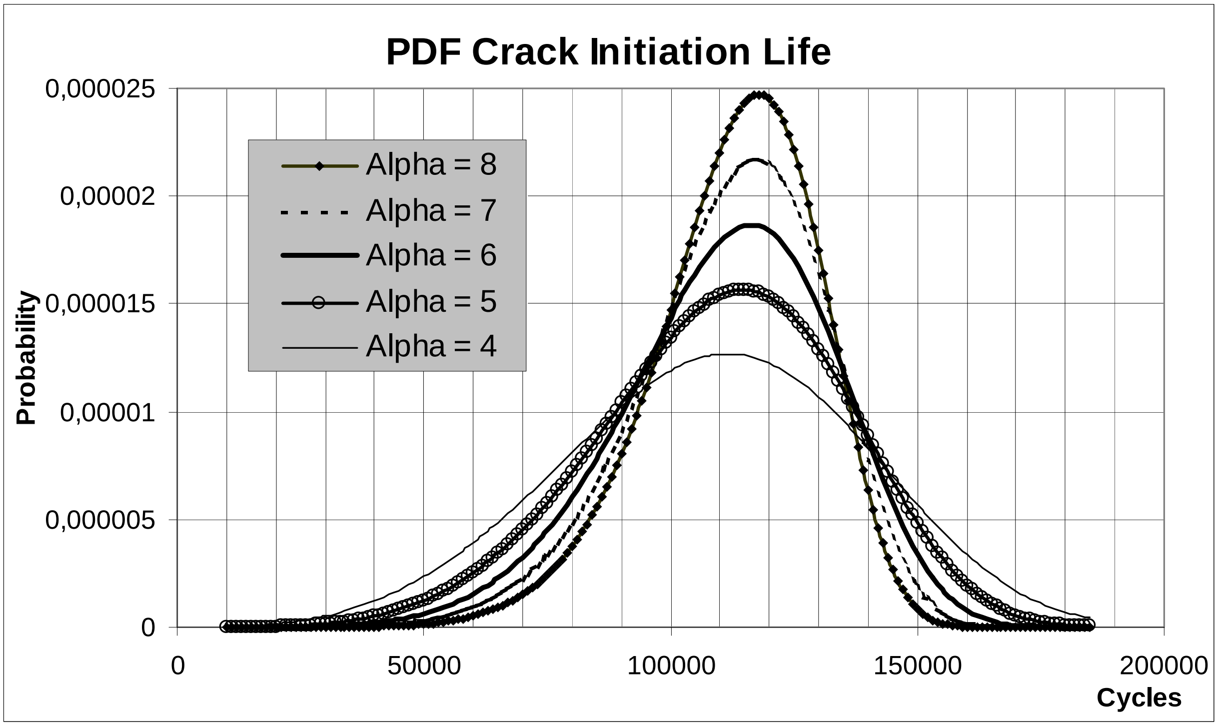


Figure 5.3 – Probability Density Function - Detail Crack Initiation Life Vs. Alpha

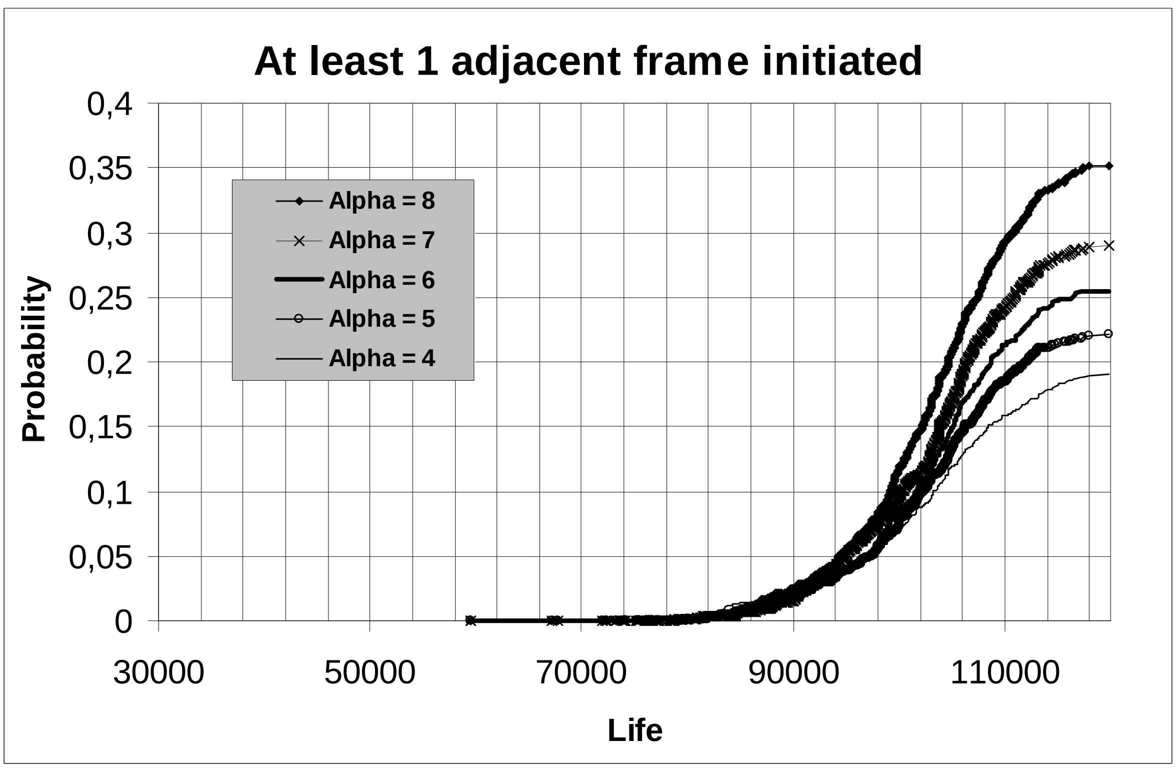


Figure 5.4 - The total number of frames initiated when the 1st frame failure occurs (without consideration of adjacencies)

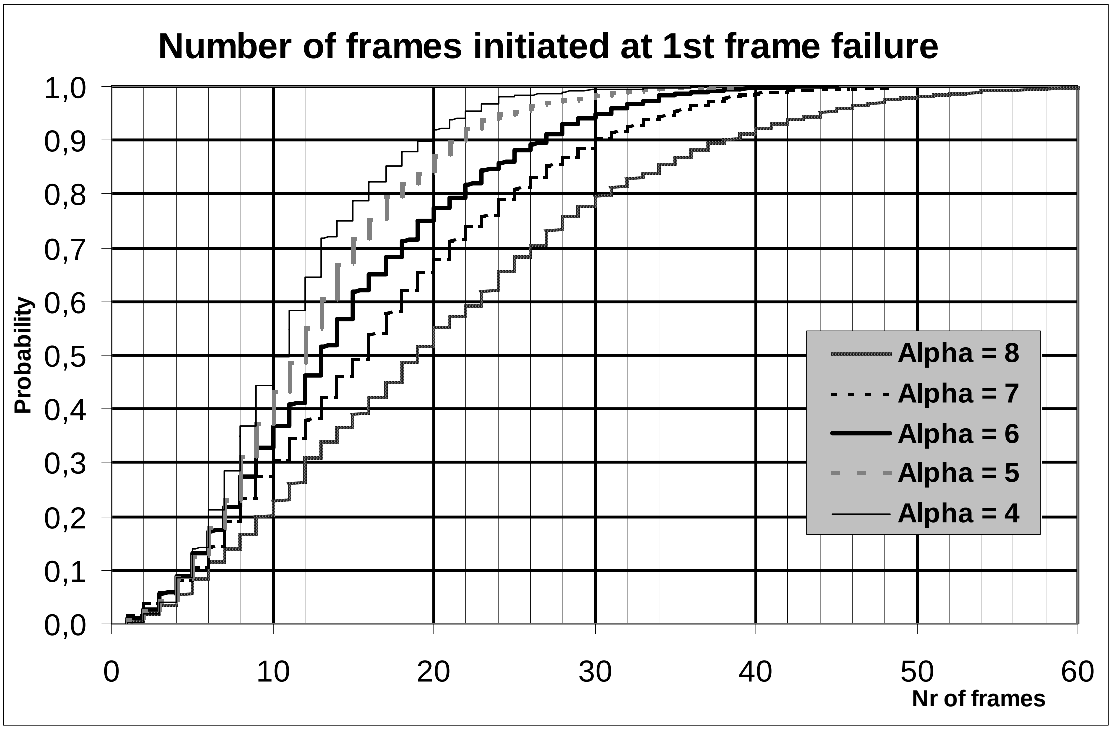


Figure 5.5 – Number of adjacent frames initiated at first frame failure

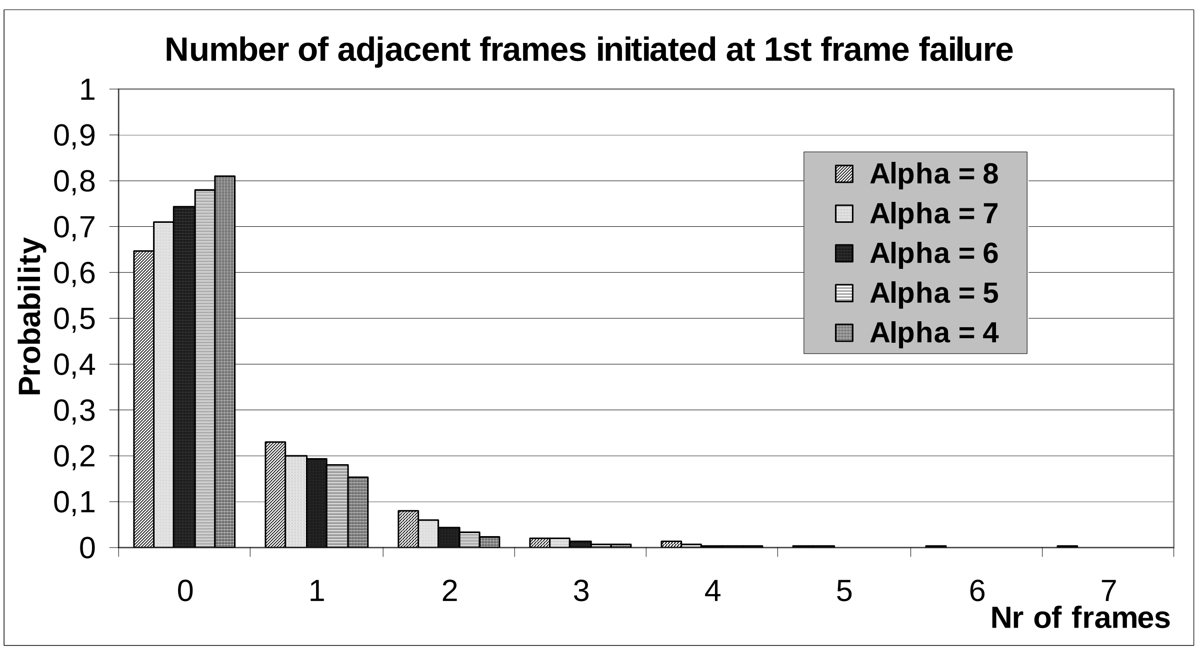


Figure 5.6 – Probability of Having At Least One adjacent Frame Initiated at First Frame Failure Vs. Alpha.

C. MED Round Robin Example Problems

Three MED round robin problems were circulated for each of the participants to consider. The first was a "public" MED round robin where each of the participants solved the same problem, the second, was a private MED round robin where each presented solutions to problems that had occurred in service. The last MED round robin was another "public" MED round robin where each participant used a provided set of data from an in-service MED problem. For the first and third MED round robins, the raw data is presented in Appendix E. The actual problem results are excluded so that other applicants can use these problems to validate their individual procedures.

The first MED round robin was a simple example of a number of frames with a single similar open hole in each frame. Material properties were defined as well as some failure criteria. The purpose of the first MED round robin was to exercise the statistics used and determine where differences existed. The participants agreed to use the same statistical procedures defined in the final report to Task 5 Reference [4].

For the first round robin, it was mutually agreed that the following six issues would be examined:

1. To what degree can the methodology account for variations in fastener type and build standard for determination of when cracking starts?

2. When does load redistribution occur from the failed part to the remaining structure? When is it significant to cause interaction?

3. What are the significant issues that affect the analysis results from the various approaches?

4. Is an ISP viable for MED?

5. What is the significance of test and service data in validating the MED results?

6. We want to understand how the problem answers vary at a few different end points.
   - At a single non-interacting crack, progressive failure to limit load residual strength, may need to look at LDC to postulate failure.
   - Simultaneous frames cracked, go to failure at limit load or LDC requirements.

1) MED Round-Robin Number One Discussion

The discussions that followed the first round robin revealed a number of issues that were not apparent when the problem was formulated. The ground rules for the problem were redesigned and a second attempt was made to solve the problem. The changes in the initial assumptions are documented in Appendix E. A study of the results of the first round-robin indicated that:

1. To the extent that the baseline data for the detail characterizes the build process, it can be expected that the results of the problem reflect such things as fastener fit, etc.
2. Examination of other related data indicated that load redistribution did not occur before there was load path failure. This is quite different than the MSD case where significant redistribution of load is expected as the individual cracks grow.
3. The single most important variable in the analysis is the assessment of the state at SMP.
4. From the results of the analysis, it appears that the methodologies documented in Reference [4] show good promise as being applicable to the MED situation.

2) Discussion of Issues Concerning Data Characterization MED Round-Robin Number 3

A significant issue that became apparent during the third MED round-robin is that there were a variety of methods used to characterize the data set. It should be pointed out that this would only be an issue where a fleet of airplanes is operated well into where MSD or MED might occur. There were five different approaches identified and they are documented below. Please note that the AAWG does not endorse any method. This is simply a summary of approaches that led to reasonable answers.

Five different approaches:

1. Simply consider the data as Cracked (1) / Non-Cracked (0), taking benefit of non-cracked results. No consideration of crack length information.
2. Extrapolation of inspection results up to crack initiation (back calculation for existing cracks). Assume no cracks either crack free or undetected.
3. Extrapolation of inspection results up to detectable crack size (back calculation for some existing cracks). Assume no cracks either as crack free or as a crack < detectable size (not detected).
4. Extrapolation of inspection results up to critical crack size. Assume no cracks either crack free or undetected.
5. Extrapolation of inspection results up to a critical size and assumed some of the frames failed before the inspection but above a threshold time with a range of cracks above critical length. Exclusion of

suspended data will provide a conservative result

D. Authorities Review Team Assessment of MED Round Robin Data.

The Authorities Review Team (ART) is an ad hoc group of regulators from the FAA and JAA who have been enlisted to review and critique the round-robin results. In the review, the ART critique of the various methodologies is aimed at creating a deeper understanding of how MED problems are handled at the OEMs. The ART is composed of:

1. John Bristow (Chair), CAA-UK (JAA)
2. John Van Doeserlaar, CAA-NL
3. Brent Bandley, FAA
4. Bob Eastin, FAA

The AAWG has found that the execution of round robin problems especially helpful in clarifying, understanding and standardizing some parts of the approach. Following the review of the first two MED round robin example problems, the ART issued a series of comments and questions to the AAWG. Specific questions were also handed to each participant concerning their individual work done in the private round robin, Round Robin Number 2. Overall, the approaches reviewed appear to give a safe approach to developing maintenance programs for the preclusion of MED, provided that the points below can be satisfactorily answered.

The ART issued seven comments and observations from the first two MED round robin example problems:

ART Comment or Observation	*AAWG Response*
1. It is worth noting that in the three private Round Robin presented: a. Each one resulted in modification action well in advance of the DSG: and that b. An acceptable and justifiable generic incorporation time needs to be established for aircraft beyond SMP.	See Section 8.A, 8.B
2. The ART believes, based on reviewing the round-robin problems that that the following issues are significant to the results of the analysis. a. The assumed sequence of cracking can significantly affect the inspection interval b. The sequence in which crack growth is added to the initiation behavior seems to influence the final answers.	See Section 8.C
3. For actual design features, the problem is difficult to solve without fleet and/or test data - a way needs to be found and the process outlined.	See Section 8.D
4. Agreement and rationale need to be established for use of 1%, 2%, and 5% probabilities for both detail and aircraft fleet level. *Should the management level be 2% or 5% for SMP?* a. The acceptable extent of cracking / residual strength capability at SMP needs to be defined in some way b. 1 frame versus 2 frame - conduct a review of some real data Boeing and Delta data c. Should a “1 inch crack/link-up” equivalent be established for MED	See Section 8.E
5. The direction given in Reference [4] is not always followed: a. ISP is derived from the detectable average behavior. The AC says it should be based on initiation probabilities b. Inspection intervals are not 1/4 ISP to SMP c. WFD ave is not always established	See Section 8.F
6. It needs to be clearly understood that the extent of cracking at SMP will be small [c.f. the sparse array for MSD] and operators must be clear that all aircraft will need to be modified by SMP not just the cracked ones.	See Section 8.G
7. Consider assigning a probability level to ISP and SMP with respect to fleet distribution	See Section 8.H

Table 5.2 – ART Comments and Observations

6.0 LIMIT OF VALIDITY

A. What is the Limit of Validity

The Program that the AAWG developed contains two distinct issues to be addressed:

1. A Limit of Validity (LOV) of the Maintenance Program
2. A Maintenance Program to ensure WFD will be precluded within the LOV of the maintenance program

Depending on whether or not you are certifying a new airplane or a currently certified airplane, the definitions for LOV are worded slightly differently but they have the same overall objective.

In the certification domain, the LOV is the period of time, expressed in appropriate units (e.g. flight cycles), for which it has been shown that the established inspections and replacement times will be sufficient to preclude development of wide spread fatigue damage.

In the operation domain, the LOV is the point in time in flight cycles or hours where additional inspections and/or modification/replacement actions must be incorporated in to the operators maintenance program in order to continue operation.

LOV designates the extent to which the design data has been duly substantiated and represents an operational limit based on the engineering data that supports the maintenance program. Therefore, all identified service actions are required for operation up to LOV.

For instance, there is or will be a statement included in the Airworthiness Limitation Section to the effect *"the maintenance manual is substantiated for 42,000 flights."* LOV is an airplane level number.

Before the LOV is reached there may well be several maintenance actions for WFD identified by component specific ISPs and SMPs. The maintenance actions for WFD and LOV are independent. LOV is the end of the substantiating data road, the maintenance actions required before LOV are for the preclusion of WFD up to the LOV.

Any LOV extension requires additional fatigue test evidence and validation of the maintenance program for efficacy against WFD and other fatigue damage.

Under the proposed rule for WFD, the concept of LOV is a regulatory requirement.

B. Data Required to establish a LOV

The process used to establish a LOV requires data that extends the fatigue test evidence. The AAWG looked at conditions to be met in defining and extending the LOV for in-service airplanes.

The defining and moving of the LOV for in-service airplanes involves four independent tasks.

The first task is to ensure that the basics of the aging airplane program are in existence. This means that the following programs are active and are achieving the desired program goals:

- Mandatory Modifications
- Corrosion Prevention and Control
- Pressure Boundary Repair Assessment
- Supplemental Structural Inspections or Airworthiness Limitations

In addition, all currently known structural airworthiness issues, including WFD, have been recognized and service actions have been initiated under existing applicant processes.

The second is the collection of data necessary to extend fatigue test evidence. Fatigue Test Evidence consists of reductions of data collected from more than one of the following sources:

- Full Scale Fatigue Test with or without tear down
- Full Scale component tests with or without tear down
- Tear down and refurbishment of a high time airplane
- Less than full scale component tests
- Fleet Proven Life Techniques
- Evaluation of in-service problems experienced by other airplanes with similar design concepts
- Analysis methods which have been parametrically developed to reflect fatigue test and service experience.

Normally this data is airplane level data and does not reflect on any detail or component level behavior. The data collected can be used in the applicant's methods and procedures to predict a new LOV (e.g. LOV_2). In some cases, data may not exist for a component or area of the structure. In this case, the applicant may want to consider the collection of additional data as a conditional requirement before any particular airplane is allowed to operate beyond the initial LOV. Detailed teardown and refurbishment inspections are particularly effective in these conditions. Sufficient data is required to establish that WFD will be precluded to a high degree of confidence.

Third, a formal analysis of the structure for MSD/MED, done in agreement with Advisory Circular 91-56C (to be published), is required to establish specific maintenance actions for MSD/MED. This analysis predicts when MSD and MED is likely to occur and the maintenance programs required (e.g. ISPs and SMPs) to preclude the occurrence of widespread fatigue damage. During this analysis, it may be determined that additional experimental and service data is required to support analyses (tests, tear-down of retired high time aircraft).

Fourth, maintenance documents will need to be created/updated to include maintenance actions (e.g. inspections (ISP, RI), and modifications (SMP)) for those areas where it has been predicted that MSD/MED will occur before the newly established LOV (e.g. LOV_2). The ALI will also need to be updated with LOV_2.

Subsequently when airplanes reach LOV_2, another similar process should be followed to establish LOV_3. There are some important differences however. First, the MSD/MED analysis done for LOV_2, should still be applicable following review of any specific in-service findings. The structural modifications, as a result of airplanes reaching an SMP during the period from LOV_1 to LOV_2 will need to be evaluated for additional maintenance actions necessary to achieve LOV_3.

Figure 5.7 gives a notional presentation of this subject.

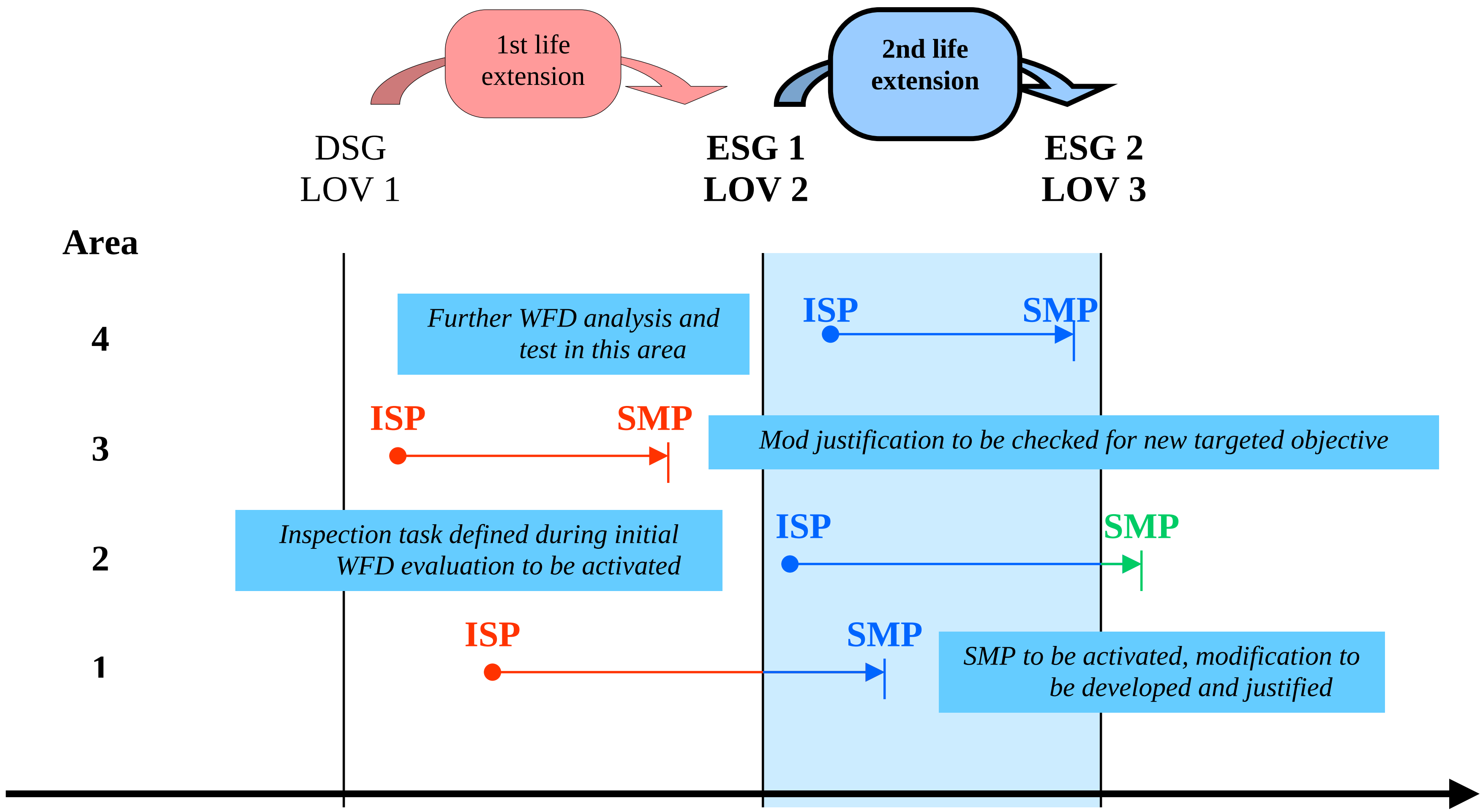


Figure 6.1 – Process to Move LOV

7.0 BRIDGING TASK C – NDI ROUND ROBIN

Residual strength reductions due to multiple site damage scenarios require appropriate measures in order to maintain the structural integrity over the period of planned flight cycles. Among other measures, improved and advanced NDI technologies may provide potential for detection of MSD. Significant improvements in comparison with the currently available NDI technologies are expected from using the following technologies and computer software algorithms:

- Semi-automatic crack detection systems (manually operated probe systems with fully automated signal pattern evaluation)
- Improved multiple frequency eddy current systems
- SQUID sensor technology

All of the technologies mentioned above already exist today and have entered into advanced field trials. Further information on each of these technologies is given below. In order to fulfill the requirements for detection systems capable of reliably resolving the cracks associated with MSD, the improved NDI technologies must provide:

- A significant improvement in resolution capacity (20 to 40% over today's capability)
- Low false call rates (<1%)
- A reduction of the human factors element
- Semi-automatic signal pattern evaluation

To this end, the AAWG requested and the FAA Technical Center agreed to perform two round robin trials to investigate some of these areas. The results of these studies that included two round-robin trails are documented in a separate, yet to be published, report, Reference [5].

For the purposes of documentation of these studies, the two round robins consisted of the construction and evaluation of the small coupon specimen detailed in Appendix E subpart C, and a set of simulated highly characterized lap join specimens with natural fatigue cracks of many lengths and directions. The FAA Technical Center was asked to evaluate the following specific issues:

- Baseline Current NDI Capabilities.
- Identify new emerging NDI Technologies for detecting small cracking typical of MSD/MED situations.

8.0 OTHER TECHNICAL ISSUES

During the review of the round robin problems the ART raised a number of technical and programmatic issues. These issues were documented in Table 5.2. The following subsections represent the AAWGs response to those issues

A. SMP Below DSG

The ART Observed that in the three private Round Robin presented, each one resulted in modification action well in advance of the DSG.

The AAWG acknowledges that this is a clear possibility especially with the older airplanes. Situations could exist today where the SMP is below the DSG. Appropriate service actions must be put in place. That process should include at least the three following steps:

1) An exploratory inspection program of the fleet leader airplanes.
2) Upon verification that the situation exists appropriate service action should be extended to other airplanes in the fleet.
3) It is expected that the Regulatory Authority will promptly execute an Airworthiness Directive that mandated the action.

B. Airplanes Beyond SMP

An acceptable and justifiable generic incorporation time needs to be established for aircraft beyond SMP.

The AAWG believes that there is a possibility that this will happen in a few circumstances. In this case, the applicant should follow the recommendations contained in 1) above to establish appropriate service actions and repair any airplane found cracked. The remaining airplanes that are not cracked and are above the SMP when the modification becomes available should be given the option to continue to inspect for a period of time not to exceed the next major scheduled down time or two years whichever is greater.

C. Variation in Methodologies

The ART believes, based on reviewing the round-robin problems that the following issues are significant to the results of the analysis.

1) *The assumed sequence of cracking can significantly affect the inspection interval*

2) *The sequence in which crack growth is added to the initiation behavior seems to influence the final answers.*

The assumed sequence of cracking can affect the inspection interval. This is probably more an issue with MED situations than MSD. The AAWG recommends that the crack growth interval chosen to determine repeat intervals is based on a model that assumes that adjacent cracks develop. This would develop the most conservative crack growth scenario and provide the smallest repeat interval.

The AAWG acknowledges that there is some variation within the different approaches on how crack growth is added to determine WFD Average Behavior. One approach adds the crack growth before factoring, another adds the crack growth during a Monte Carlo Simulation and a third adds a portion of the crack growth after factoring. The AAWG has concluded that these variations, within the context of each methodology, are reasonable and do not adversely affect or produce unconservative results. It should be pointed out that any particular method of analysis is subject to regulatory review and approval.

D. The Need for Fleet Data to Support Analysis

For actual design features, the MED problem is difficult to solve without fleet and/or test data - a way needs to be found and the process outlined.

The AAWG agrees. There will be cases where no fleet data or fatigue test data is deemed applicable to the situation under consideration. In these cases it is incumbent on the applicant to provide a conservative estimate of the detail or element fatigue life using coupon fatigue test results and/or fatigue S-N diagrams appropriately adjusted for the loading state in service. This is discussed in Section 5.B.3)(c).

E. Probability Analysis Basis

Agreement and rationale need to be established for use of 1%, 2%, and 5% probabilities for both detail and aircraft fleet level. Should the management level be 2% or 5% for SMP?

The AAWG has reviewed this issue and has concluded that the main issue here is the statistical model used by the applicant. Based on equivalency, an applicant would use a failure rate of 2% for log-normal and 5% for Weibull. These both provide the same apparent level of protection given by a two-lifetime fatigue test. With respect to SMP and the total estimated probability in the fleet to the defined WFD cracking scenario should not exceed 5%.

F. Extent of Cracking

The acceptable extent of cracking / residual strength capability at SMP needs to be defined in some way

1) *1 frame versus 2 frame -- conduct a review of some real data Boeing and Delta data*
2) *Should a "1 inch crack/link-up" equivalent be established for MED*

The AAWG agrees that the state of damage at SMP needs to be defined. This is however dependant on the design of the structure and the AAWG feels that it this discussion is best left to one between the applicant and his regulator. It is important that the results of the MED analysis are reasonably conservative.

G. OEM Methodology

The direction given in Reference [4] is not always followed:

1) *ISP is derived from the detectable average behavior. The AC says it should be based on initiation probabilities*
2) *Inspection intervals are not 1/4 ISP to SMP*
3) *WFD ave is not always established*

The AAWG agrees. The Reference [4] material was offered as a guide to one way to solve the problem, not the only way. The execution of five round robin problems, two for MSD and three for MED, by as many as four different agencies, all using somewhat different methodologies have all demonstrated results which are acceptable for the development of maintenance programs that are effective to preclude MSD and MED. The purpose of presenting the methodology aspects in the Reference [4] report was to define the problem bounds and expectations. The means to achieve those bounds and expectations should be left up to the applicant and his regulatory authority.

With regards to the Inspection intervals being 1/4 of the time between ISP and SMP, it is true that that is what is shown in figure 4.2.2 (Reference [4]). However there is no specific requirement for a factor of 4. This factor will be agreed to in discussions between the applicant and his regulatory authority.

H. Sparse Array

It needs to be clearly understood that the extent of cracking at SMP will be small [c.f. the sparse array for MSD] and operators must be clear that all aircraft will need to be modified by SMP not just the cracked ones.

The AAWG still believes this to be the case. The extent of cracking in the fleet is expected to be small and with the inspection program, no crack will ever reach a critical length. Furthermore, no airplane should be allowed to fly past the detail specific SMP without modification. This is a necessity, since allowing airplanes to fly past the established SMP would create a safety situation that would be very difficult to manage and maintain airworthiness.

9.0 CONCLUSIONS

The AAWG reached the following conclusions as a result of this tasking.

1. The areas designated as susceptible to MED, and documented in Reference [4], are still valid and are inclusive of the situations found in-service and test.
2. The identification of the failure scenario for SMP is a critical element in defining the MED problem and may involve other failure modes than static or fatigue overload.
3. The subject of the development of adjacent cracks for MED situations was studied and while it was determined that there was only a small probability of this happening at an SMP, adjacency should be enforced for conservatism.
4. Typically, there is no crack interaction in MED situations, however load redistribution should be considered when load path failure occurs.
5. The MED round robins examined several methods with probabilistic elements that appear to give valid and conservative approaches to the establishment of maintenance programs for MED and were effective in defining important parameters in the analysis. The MED round robin demonstrated that the industry was capable of performing the necessary assessments
6. The methodology and procedures outlined in Reference [4] on MSD are generally applicable to evaluating MED situations. Industry is well prepared to perform the analysis.
7. The application of risk assessment methodology for the development of maintenance programs for WFD would require significant changes in the regulations and significant validation that is currently beyond industry capability.
8. The implementation of maintenance programs for WFD is not dependant on the development of new NDI procedures, however more efficient means of inspecting large areas would be desirable.
9. The concept of ISP, SMP, LOV and normal maintenance is still valid for management of MED situations. Other than those concepts already considered for MSD, there are no additional maintenance requirements for the management of MED.
10. Although there has been a high level of safety achieved through implementation of the existing aging airplane programs, rulemaking is still needed to implement programs for the prevention of WFD.

10.0 RECOMMENDATIONS

.
The AAWG reached six recommendations:

1. With regards to the risk analysis approach, additional studies are recommended to demonstrate the capability of the approach. These studies will lead to a foundation upon which new rules could be crafted for compliance.
2. The AAWG reviewed the capability of the industry to perform probabilistic based analysis of the MED situation and has found that sufficient maturity of the procedures exist to recommend that analysis can be used for development of effective maintenance programs.
3. In performing the MED analysis, the AAWG recommends that the condition of adjacency be enforced unless there is a compelling reason not to do so.
4. The AAWG recommends that no airplane should be allowed to fly past the detail specific SMP without modification. This is a necessity, since allowing airplanes to fly past the established SMP would create a safety situation that would be very difficult to manage and maintain airworthiness
5. The AAWG recommends that the operational rules for WFD proposed for 14 CFR Part 121, 135 et al and the certification rules proposed for 14 CFR Parts 25 be given the highest priority within the FAA for promulgation.
6. The AAWG recommends that the industry support the FAA to see that there is a timely publication of the necessary rules for WFD.

APPENDIX A – FAA/ARAC TASK 5 and 6 –AAWG

TASK 5: DEVELOP TECHNICAL POSITION RE: WIDESPREAD FATIGUE DAMAGE

PAGE: 62 FR 45690 NO. 167 08/28/97

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Aviation Rulemaking Advisory Committee; Transport Airplane and Engine

Issues—New Task

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of a new task assignment for the Aviation Rulemaking Advisory Committee (ARAC).

SUMMARY: Notice is given of a new task assigned to and accepted by the Aviation Rulemaking Advisory Committee (ARAC). This notice informs the public of the activities of ARAC.

FOR FURTHER INFORMATION CONTACT: Stewart R. Miller, Manager, Transport Standards Staff, ANM-110, FAA, Transport Airplane Directorate, Aircraft Certification Service, 1601 Lind Ave. SW., Renton, WA 98055-4056, telephone (425) 227-2190, fax (425) 227-1320.

SUPPLEMENTARY INFORMATION:

Background

The FAA has established an Aviation Rulemaking Advisory Committee to provide advice and recommendations to the FA Administrator, through the Associate Administrator for Regulation and Certification, on the full range of the FAA's rulemaking activities with respect to aviation-related issues. This includes obtaining advice and recommendations of the FAA's commitment to harmonize its Federal Aviation Regulations (FAR) and practices with the aviation authorities in Europe and Canada.

One area ARAC deals with is Transport Airplane and Engine Issues. These issues involve the airworthiness standard for transport category airplanes in 14 CFR part 25, 33, and 35 and parallel provisions in 14 CFR parts 121 and 135. The corresponding European airworthiness standards for transport category airplanes are contained in Joint Aviation Requirements (JAR)-25, JAR-E and JAR-P, respectively. The corresponding Canadian Standards are contained in Chapters 525, 533 and 535 respectively.

The Task

This notice is to inform the public that the FAA has asked ARAC to provide advice and recommendation on the following harmonization task:

FAR/JAR 25 Aging Aircraft

1. ARAC is tasked to review the capability of analytical methods and their validation; related research work; relevant full-scale and component fatigue test data; and tear down inspection reports, including fractographic analysis, relative to the detection of widespread fatigue damage (WFD). Since aircraft in the fleet provide important data for determining where and when WFD is occurring in the structure, ARAC will review fractographic data from representative "fleet leader" airplanes. Where sufficient relevant data for certain airplane models does not currently exist, ARAC will recommend how to obtain sufficient data from representative airplanes to determine the extent of WFD in the fleet. The review should take into account the Airworthiness Assurance Harmonization Working Group report "Structural Fatigue Evaluation for Aging Aircraft" dated October 14, 1993, and extend its applicability to all transport category airplanes having a maximum gross weight greater than 75,000 pounds.
2. ARAC will produce time standards for the initiation and completion of model specific programs (relative to the airplane's design service goal) to predict, verify and rectify widespread fatigue damage. ARAC will also recommend action that the Authorities should take if a program, for certain model airplanes, is not initiated and completed prior to those time standards. Actions that ARAC will consider include regulations to require Type Certificate holders to develop WFD programs, modification actions, operational limits, and inspection requirements to assure structural integrity of the airplanes. ARAC will provide a discussion of the relative merits of each option.
3. This task should be completed within 18 months of tasking.

ARAC Acceptance of Task

ARAC has accepted this task and will assign it to a working group. The working group will serve as staff to ARAC to assist ARAC in the analysis of the assigned task. Working group recommendations must be reviewed and approved by ARAC. If ARAC accepts the working group's recommendations, it forwards them to the FAA and ARAC recommendations.

Working Group Activity

The working group is expected to comply with the procedure adopted by ARAC. As part of the procedures, the working group is expected to:

1. Recommend a plan for completion of the task, including rationale, for FAA/JAA approval within six months of publication of this notice.
2. Give a detailed conceptual presentation of the proposed recommendations, prior to proceeding with its work.
3. Provide a status report at each meeting of ARAC held to consider Transport Airplane and Engine Issues.

Participation in the Working Group

The working group will be composed of experts having an interest in the assigned task. A working group member need not be a representative of a member of the full committee.

An individual who has expertise in the subject matter and wishes to become a member of the working group should write to the person listed under the caption FOR FURTHER INFORMATION CONTACT expressing that desire, describing his or her interest in the task, and stating the expertise he or she would bring to the working group. The request will be reviewed by the assistant chair, the assistant executive director, and the working group chair and the individual will be advised whether or not the request can be accommodated.

The Secretary of Transportation has determined that the formation and use of ARAC are necessary and in the public interest in connection with the performance of duties imposed on the FAA by law.

Meetings of ARAC will be open to the public, except as authorized by section 10(d) of the Federal Advisory Committee Act. Meetings of the working group will not be open to the public, except to the extent that individuals with an interest and expertise are selection to participate. No public announcement of working group meetings will be made.

Issued in Washington, DC, on August 21, 1997.

Joseph A. Hawkins,

Executive Director, Aviation Rulemaking Advisory Committee.

[FR Doc. 97-22922 Filed 8-27-97; 8:45 am]

BILLING CODE 4910-13-M

TASK 6: AGING AIRCRAFT PROGRAM (WIDESPREAD FATIGUE DAMAGE) (WFD)

[Federal Register: December 15, 1999 (Volume 64, Number 240)]
[Notices]
[Page 70104-70105]
From the Federal Register Online via GPO Access [wais.access.gpo.gov]
[DOCID:fr15de99-112]

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DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Aviation Rulemaking Advisory Committee; Transport Airplane and
Engine Issues--New Task

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of a new task assignment for the Aviation Rulemaking Advisory Committee (ARAC).

SUMMARY: Notice is given of a new task assigned to and accepted by the Aviation Rulemaking Advisory Committee (ARAC). This notice informs the public of the activities of ARAC.

FOR FURTHER INFORMATION CONTACT: Kristin Larson, Transport Standards Staff, ANM-110, FAA, Transport Airplane Directorate, Aircraft Certification Service, 1601 Lind Ave. SW., Renton, WA 98055-4056, telephone (425) 227-1760, fax (425) 227-1100.

SUPPLEMENTARY INFORMATION:

Background

The FAA has established an Aviation Rulemaking Advisory Committee to provide advice and recommendations to the FAA Administrator, through the Associate Administrator for Regulation and Certification, on the full range of the FAA's rulemaking activities with respect to aviation-related issues. This includes obtaining advice and recommendations on the FAA's commitment to harmonize its Federal Aviation Regulations (FAR) and practices with the aviation authorities in Europe and Canada.

One area ARAC deals with is transport airplane and engine issues. These issues involve the airworthiness standards for transport category airplanes in 14 CFR parts 25, 33, and 35 and parallel provisions in 14 CFR parts 121 and 135. The corresponding European airworthiness standards for transport category airplanes are contained in Joint Aviation Requirements (JAR)-25, JAR-E and JAR-P, respectively. The corresponding Canadian Standards are contained in Chapters 525, 533, and 535, respectively.

The Task

This notice is to inform the public that the FAA has asked ARAC to provide advice and recommendation on the following harmonization task:

Task 6: Aging Aircraft Program (Widespread Fatigue Damage) (WFD)

The FAA requests that ARAC propose new operating rules (14 CFR parts 91, 121, 125, 129, and 135) that would ensure that no large transport category airplane (>75,000 lbs. Gross Take Off Weight) is operated beyond the flight cycle limits to be specified in the regulation, unless an ``Aging Aircraft Program'' has been incorporated into the operator's maintenance program.

[[Page 70105]]

The proposed rule and advisory material will establish:
1. The content of the Aging Aircraft Program (e.g., the necessary special inspections and modification actions for prevention of WFD), and
2. A limit of the ``validity'' (in terms of flight cycles or hours) of the Aging Aircraft Program where additional reviews are necessary for continued operation.

Additionally, ARAC is asked to review 14 CFR 25.1529 and 14 CFR part 25, Appendix H, and recommend changes to establish:
1. The required content of an Aging Aircraft Program.
2. The criteria by which to determine the validity of the Aging Aircraft Program (in terms of flight cycles or flight hours). This would effectively prohibit the operation of airplanes beyond the limited validity of the maintenance program. In order to operate beyond the declared limit, further evaluation of the design must be accomplished and the additional inspections and/or modifications added to the Aging Aircraft Program as necessary.

The FAA may ask ARAC to recommend disposition of any substantive comments the FAA receives in response to any of the notices of proposed rulemaking that result from ARAC's recommendations.

The FAA expects ARAC to forward its recommendations to the FAA within 9 months after tasking.

ARAC Acceptance of Task

ARAC has accepted this task and has chosen to assign it to the existing Airworthiness Assurance Working Group. The working group serves as staff to ARAC to assist ARAC in the analysis of the assigned task. Working group recommendations must be reviewed and approved by ARAC. If ARAC accepts the working groups recommendations, it forwards them to the FAA as ARAC recommendations.

Working Group Activity

The working group is expected to comply with the procedures adopted by ARAC. As part of the procedures, the working group is expected to:
1. Recommend a work plan for completion of the task, including the rationale supporting such a plan, for consideration at the meeting of ARAC to consider transport airplane and engine issue held following publication of this notice.
2. Give a detailed conceptual presentation of the proposed recommendations, prior to proceeding with its work.
3. Draft appropriate regulatory documents with supporting economic and other required analyses, and any other related guidance material or collateral documents to support its recommendations.
4. Provide a status report at each meeting of ARAC held to consider transport airplane and engine issues.

The Secretary of Transportation has determined that the formation and use of ARAC are necessary and in the public interest in connection with the performance of duties imposed on the FAA by law.

Meetings of ARAC will be open to the public, except as authorized by section 10(d) of the Federal Advisory Committee Act. Meetings of the Airworthiness Assurance Working Group will not be open to the public, except to the extent that individuals with an interest and expertise are selected to participate. No public announcement of working group meetings will be made.

Issued in Washington, DC, on December 9, 1999.
Anthony F. Fazio,
Executive Director, Aviation Rulemaking Advisory Committee.
[FR Doc. 99-32462 Filed 12-14-99; 8:45 am]
BILLING CODE 4910-13-M

APPENDIX B - AAWG TASK GROUP MAKE-UP

NAME	*Organization*	*E-Mail*
Bandley. B.	FAA-LAACO	Brent.Bandley@faa.gov
Boetsch, R.	Airbus	regis.boetsch@airbus.com
Bristow, J.	CAA-UK	john.bristow@srg.caa.co.uk
Burd, J.	Gulfstream	james.burd@gulfaero.com
Carter,A.	DeltaA/ L	Aubrey.Carter@delta-air.com
Collins, R.	Airbus UKLtd.	richard.collins@airbus.com
Eastin, R.	FAA	Robert.eastin@faa.gov
A. Hoggard	BCA	Amos.w.hoggard@boeing.com
Hoogeland,B.	KLM	AC.Hoogeland@td.klm.nl
Horne,B.	FedEx	Bhorne@fedex.com
Ingram,E.	Lockheed-Martin	ed.ingram@lmco.com
Knight, D.	UPS	deknight@ups.com
Marsh, D.	BCA	Douglas.Marsh2@West.Boeing.com
Perrin, F	DGAC	frank.perrin@aviation-civile.gouv.fr
Peltz, J.	FedEx	Jpeltz@fedex.com
Santgerma, A.	Airbus France	alain.santgerma@airbus.com
Schmidt, B.	Airbus Deutschland	Bianka.Schmidt-Brandecker@airbus.com

APPENDIX C - MEETING VENUES

Meeting Schedule

AAWG - RWG Meetings

RWG Meeting No.	***Location***	***Dates Week of***
11	Gatwick UK	Aug 20, 2001
12	Long Beach CA	Jan 28, 2001
13	Gatwick UK	Apr 22, 2002
14	Savannah GA	Jun 24, 2002
15	Dresden GER	Sep 23, 2002
16	Seattle WA	Jan 20, 2002
17	Gatwick UK	April 2003

APPENDIX D – MEETING ATTENDANCE

MEETING ATTENDANCE
Regular Members

Name	*Representing*	Meeting Number															
		1	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17
A. Santgerma	Airbus	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
R. Boetsch	Airbus	X	X	X	X	X	X	X	X	X	X	X	X		X		
R. Collins	Airbus	X	X	X	X	X	X	X	X	X			X				X
A. Hoggard	BCA	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
B. Bandley	FAA	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
B. Eastin	FAA										X	X		X	X	X	X
D. Marsh	BCA	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
J. Bristow	CAA-UK	X		X	X	X	X	X	X	X	X		X	X	X	X	X
A. Carter	Delta A/L	X	X	X	X	X	X		X	X	X	X	X	X		X	X
B. Schmidt	Airbus	X	X	X		X		X	X	X	X						
J. Peltz	FedEx				X	X	X	X	X	X	X	X	X	X		X	
D. Horne	FedEx				X	X	X	X	X	X	X	X	X	X		X	
M. Yerger	FedEx	X	X	X	X												
James Burd	Gulfstream					X	X	X	X	X	X	X	X	X	X	X	
Bert Hoogeland	KLM	X	X			X	X	X	X	X							
Ed Ingram	Lockheed-Martin	X	X		X	X	X										
Frank Perrin	DGAC-FR											X	X	X	X		
Donn Knight	UPS		X														

Also in Attendance at Meeting 14

Jeff Kollgaard, Boeing

Richard Minter represented John Bristow at the meeting.

APPENDIX E – ROUND ROBIN EXAMPLE PROBLEMS

A. MED Round Robin Number 1

Round-Robin

Problem For

MED

January 29, 2002

Output Data

1. ISP
2. SMP
3. Repeat interval
4. Applicable inspection process.
5. Applicant should describe how end point one differs from SSID approach.

Data Needed

Stress levels – Constant Amplitude, Open Hole -

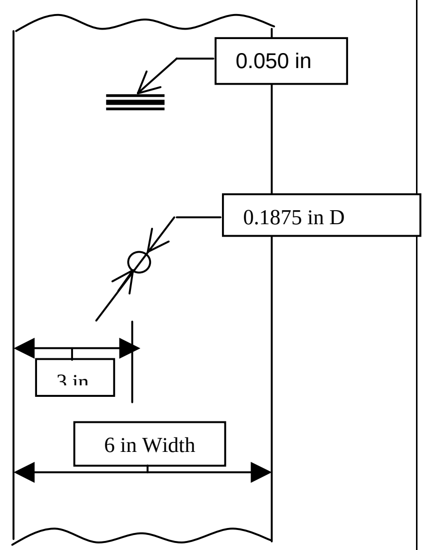
- So Max =100 MPA * 0.145 = 14.5 KSI frame stress
- R=0.0

7075-T6 Sheet, L-T Direction

- da/dn – See NASGROW
- fty, ftu – See B values in Mil Hndbk 5
- R curve/ Kc - See ESDU

Hole diameter = 0.1875 inches
Detectable Size = .12 inches
Frame Thickness = 0.05
Width of inner/outer cap = 1.25 inches
Frame depth – 4.5 inches
Frames per Airplane – 50 frames (100 locations)
Number of airplanes in fleet – 500

Characteristic Life – Beta – 120,000
Alpha - 6



OEM should use the above Weibul Distribution and assume it is to a 0.01 inch crack. Further OEM should estimate his own Weibul parameters and use them in a second analysis of this problem.

End Points

1. time for lead crack to reach 1" crack in frame
2. time to failure of lead crack at a_{crit} at limit load (first frame) – If there is a complete failure of a frame, the adjacent frames should assume an increase in load of 5% and they should be checked for residual strength at the higher load.

In reviewing the outcome of the first attempt on the round robin, it became quite clear that there were significant differences in the assumptions used by each of the participants. The AAWG quantify those differences to the extent they could but finally decided to redo the round-robin using the following assumptions:

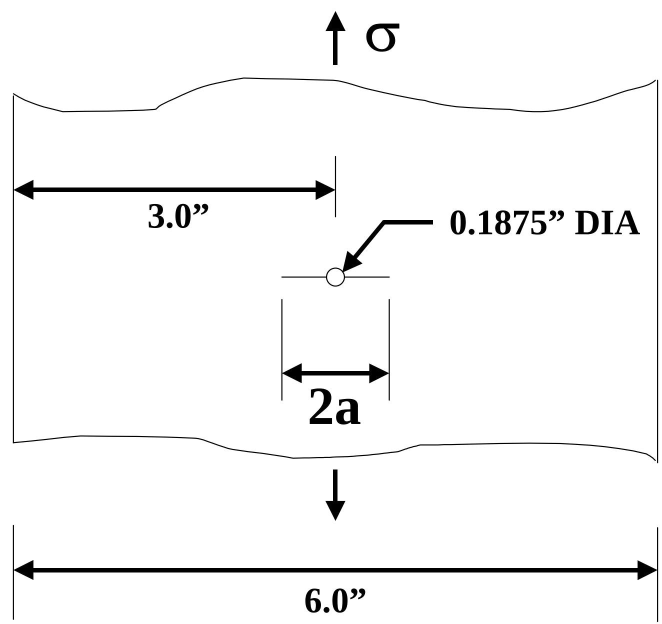
1. Assume cracks out of both sides of the hole
2. Assume fleet variability in ISP and SMP use alpha = 5 and in-house assumptions
3. Assume 1% of frames failed for average behavior
4. Assume the Beta=120,000 alpha =6 is to initiation of a 0.01 inch crack on both sides of hole
5. Assume 6 inch width
6. Assume average behavior does not include fleet variability
7. Detectable crack size is 0.12 inch cracks on both sides of hole.
8. State if ISP is to detectable, initiation or, neither
9. When does the adjacent frame crack
10. Problem ends at second frame failed
11. Supply the results in the tabular format.
12. To what degree can the methodology account for variations in fastener type and build standard for determination of when cracking starts?
13. When does load redistribution occur from the failing part to the remaining structure? When is it significant to cause interaction?

B. MED Round Robin Number 3

MED Round Robin #3

Given -

- **100 Airplanes in the fleet**
- **Inspections were performed on 14 airplanes, (each having accumulated a different number of flight cycles), at 78 detail locations on each airplane.**
- **Inspection findings are given on page 3 and 4.**
- **Each of the 78 locations is the same basic detail and is defined as follows:**



- **7075-T6 Sheet, t = .05”, LT**
- **da/dN per NASGROW**
- **F_{tu} and F_{ty} ‘B’ Basis per MIL-HDBK-5**
- **Once per flight cycle**
  σ_{max} = 23.0 KSI, σ_{min} = 0 KSI

Assumptions/Definitions –

- **All cracking is symmetric (i.e. equal size cracks at each side of hole).**
- **Initiation = .01” cracks at each side of hole.**
- **Detectable crack size is .12” cracks each side of hole.**
- **Failure condition(s) to be assumed**
- **Single detail will cause residual strength to drop below required residual strength level.**
- **Failure of any two details will cause residual strength to drop below required residual strength level.**
- **Failure of any two adjacent details will cause residual strength to drop below required residual strength level. Only if you want too.**
- **Critical crack size for required residual strength condition is 2a = 1.0”**

Determine -

1. ISP	**4. Number of details with 2a = 1.0” in a fleet of 100 airplanes at ISP.**
2. $WFD_{AVE\ BEHAVIOR}$	**5. Number of details with 2a = 1.0” in a fleet of 100 airplanes at SMP.**
3. SMP	

INSPECTIONS FINDINGS

NOTE: “1” indicates crack was $\geq$ the critical size of 2a = 1.0”

AC / FRAME	001	002	003	004	005	006	007	008	009	010	011	012	013	014
CYCLES	**22,896**	**32,824**	**32748**	**32,551**	**32897**	**30112**	**32,760**	**32,889**	**32,202**	**29,926**	**22,479**	**24,770**	**20,303**	**24,950**
01 RH							1							
01 LH														
02 RH											1			
02 LH														
03 RH				1										
03 LH				1				1						
04 RH														
04 LH					1			0.5						
05 RH		1												
05 LH														
06 RH					1		1							
06 LH			1											
07 RH			0.363	1										
07 LH														
08 RH		1	1		1	1		1	1			1		
08 LH					1									
09 RH			1	1		1		1	1		1	1		
09 LH														
10 RH		1	1		1	1	1		1	1		1		
10 LH														
11 RH		1	1			0.488								
11 LH														
12 RH						0.488								
12 LH														
13 RH			0.269				1							
13 LH														
14 RH		1					1							
14 LH														
15 RH														
15 LH			0.269											
16 RH							1			1				
16 LH					1									
17 RH				1			1		1					
17 LH		0.5		1		0.488	1	1						
18 LH			1	1	1		1							
18 RH				1	1			0.5	1					
19 LH		0.5		1			1	1						
19 RH				1	1				1					

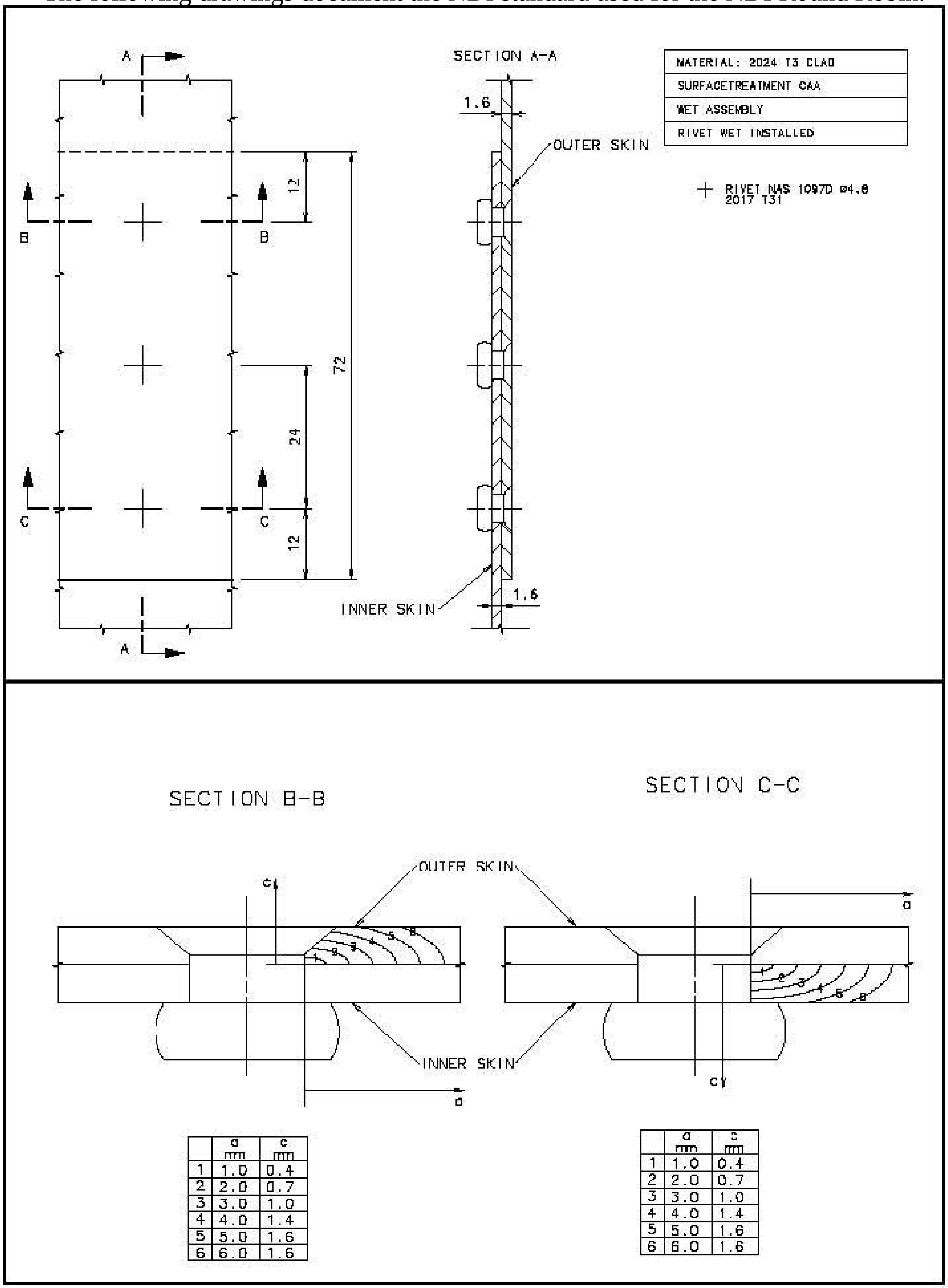
INSPECTION FINDINGS (continued)

NOTE: "1" indicates crack was ≥ the critical size of 2a = 1.0"

AC / FRAME	001	002	003	004	005	006	007	008	009	010	011	012	013	014
CYCLES	**22,896**	**32,824**	**32,748**	**32,551**	**32,897**	**30,112**	**32,760**	**32,889**	**32,202**	**29,926**	**22,479**	**24,770**	**20,303**	**24,950**
20 LH			1	1			1			1				
20 RH									1					
21 LH			0.269		1		1		1					
21 RH				1	1		1	1	1	1				
22 RH					1			1						
22 LH								1						
23 RH							1							
23 LH														
24 RH				1										
24 LH														
25 RH														
25 LH					1									
26 LH			0.269				1							
26 RH														
27 LH			1	1	1	1		1	1					
27 RH														
28 RH														
28 LH					1			1						
29 LH			1		1			1						
29 RH														
30 RH														
30 LH			1		1				1					
31 RH														
31 LH								1						
32 RH														
32 LH			0.269		1			1						
33 RH		1	0.75											
33 LH														
34 RH									1					
34 LH			0.269	1	1	1								
35 RH								1		1				
35 LH					1	1		1			1			
36 RH			1		1	1		1	1	1				
36 LH			0.75	1				1						
37 RH		0.5	1	1					1					
37 LH		0.375	1	1		1				1				
38 RH														
38 LH			1	1										
39 RH														
39 LH			0.269											

C. NDI Round Robin

The following drawings document the NDI standard used for the NDI Round Robin.



Section B-B:

	a mm	c mm
1	1.0	0.4
2	2.0	0.7
3	3.0	1.0
4	4.0	1.4
5	5.0	1.6
6	6.0	1.6

Section C-C:

	a mm	c mm
1	1.0	0.4
2	2.0	0.7
3	3.0	1.0
4	4.0	1.4
5	5.0	1.6
6	6.0	1.6

A REPORT OF THE
AIRWORTHINESS ASSURANCE WORKING GROUP

WIDESPREAD FATIGUE DAMAGE
BRIDGING TASK
Mandatory Modifications

FINAL REPORT

July 2003

SIGNED BY

Kyatsandra Gopinath
Co-Chairperson, AAWG
Boeing Commercial Airplanes

Aubrey Carter
Co-Chairperson, AAWG
Delta Air Lines

REVISION PAGE

LTR	DATE	CHANGE	PAGES ADDED	PAGES DELETED	PAGES CHANGED	APPROVED BY

Table of Contents

Abbreviations and Definitions

AATF	Airworthiness Assurance Task Force
AAWG	Airworthiness Assurance Working Group
AC	Advisory Circular (FAR)
ACJ	Advisory Circular – Joint (JAR)
AD	Airworthiness Directive
ALI	Airworthiness Limitation Instructions
ARAC	Aviation Rulemaking Advisory Committee
ATA	Air Transport Association of America
CAA-UK	Civil Aviation Authority - United Kingdom
DGAC	Direction Générale de l'Aviation Civile - France
DSG	Design Service Goal
EAAWG	European Ageing Aircraft Working Group
ESG	Extended Service Goal
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirement
MED	Multiple Element Damage
MSD	Multiple Site Damage
NAA	Natonal Airworthiness Authority
NDI	Non Destructive Inspection
NPRM	Notice of Proposed Rulemaking
NTSB	National Transportation Safety Board
OEM	Original Equipment Manufacturer
PCA	Primary Certificating Authority
SB	Service Bulletin
SSIP	Supplemental Structural Inspection Program
STC	Supplemental Type Certificate
STG	Structures Task Group
TAEIG	Transport Airplane and Engines Issues Group
TC	Type Certification
TCH	Type Certificate Holder
WFD	Widespread Fatigue Damage

REFERENCES

[1] Anon., *"Continued Airworthiness of Ageing Aircraft Structures"* NPA 20-10, Section 4 re ACJ GAI20X11, Joint Aviation Authorities, Hoofddorp, The Netherlands (March 2003)

[2] Anon., *Continuing structural integrity program for large transport category airplanes*, FAA Advisory Circular No. 91-56A, Federal Aviation Administration, U.S. Department of Transport (April 1998)

[3] McGuire J.,*" Structures Task Group Guidelines Document"*, A report of the Airworthiness Assurance Working Group, Revision 1, (June 1996)

1.0 - Executive Summary

In July1999 the AAWG issued a report establishing a methodology to ensure that an airframe structure remains free from widespread fatigue damage. The report was in response to an ARAC tasking issued in 1997. The approach envisaged, and subsequently established as viable by an industry wide "Round Robin" comparative analysis, relied on a number of basic assumptions. One of which was the assumption that essential service bulletin modification actions had been embodied on the airframe. This report defines an acceptable procedure to establish which service bulletin modification actions are an essential element of the long term structural integrity of an airframe.

It is recommended that the advisory circular AC91-56 be updated along the lines of the technical text drafted by our European counterpart EAAWG to address the issue of service bulletin reviews and mandatory modification action. In particular the proposed text establishes:

(1) A standard way of assessing service bulletins for mandatory modification action
(2) The Structural Task Group way of working, clearly defined as a process
(3) Guidance on appropriate implementation times for ageing aircraft program actions.

2.0 - AVIATION RULEMAKING ADVISORY COMMITTEE TASKING

On August 28, 1997, the FAA formally notified the Aviation Rulemaking Advisory Committee; Transport Airplane and Engines Group through the Federal Register (Page 62 FR 45690 No. 167 08/28/97) of a new task assignment for action. The complete text of the Tasking Statement appears in Appendix A. Subsequently, the Transport Airplane and Engines Issues Group assigned action to the Airworthiness Assurance Working Group. The Task Assignment involves completion of the following tasks.

Task Title: Task 5: FAR/JAR 25, DEVELOP TECHNICAL POSITION RE: WIDESPREAD FATIGUE DAMAGE

Task Title: Task 6: FAR/JAR 25, TASK 6: AGING AIRCRAFT PROGRAM (WIDESPREAD FATIGUE DAMAGE) (WFD)

Task Title: Task 6A: FAR/JAR 25, WFD BRIDGING TASKS

The 1999 recommendations of the 1997 tasking [Task 5] were that new rules and advisory material were necessary for the preclusion of WFD in the commercial fleet. As a result, a second tasking was issued on December 15, 1999 **(70104 Federal Register / Vol. 64, No. 240 /)** (See Appendix A for complete tasking statement**)**, for the AAWG to write the required rules and advisory material. This Tasking was completed and the rules submitted for processing in December 2000. Accompanying the submission was an identification of 4 specific technical issues that required resolution before the recommended rules could be successfully implemented. These became known as the Bridging Tasks

A. MED Technical Considerations

B. Training

C. . NDI Round Robin

D. Mandatory Modifications

This Report addresses the fourth Bridging Task - Mandatory Modifications.

3.0 – BRIDGING TASK D – MANDATORY MODIFICATIONS

3.1 Introduction

Of the six initiates originally put forth by the AAWG, the only one that has not been officially documented is the Mandatory Modification Program. This program seeks to identify certain critical structural service bulletins for incorporation into the airplane to maintain continued airworthiness if certain criteria are met. That criteria has four elements:

1. There is a high probability that structural cracking exists
2. Potential structural airworthiness concern.
3. Damage is difficult to detect during regular maintenance
4. There is Adjacent Structural damage or the potential for it.

The European Airworthiness Assurance Working Group working in parallel with the AAWG has prepared guidance material for the mandatory modifications program [ref 1] which it offered to the AAWG for consideration. After discussions at 2 meetings each of the respective groups the technical text was agreed. Section 3.1 below sets out the technical text drafted by the EAAWG. The proposal is based on the format of AC91-56 [ref 2] introducing two new short sections covering the "way of working" and "implementation", an expansion and revision to the existing section on the "Mandatory Modification Program" supported by a new appendix "Guidelines for the Development of a Service Bulletin Review and Mandatory Modification Programme"

3.2 Proposed Advisory Material for Service Bulletin Review / Mandatory Modifications Program

A number of additions to AC91-56 are proposed. Kindly note that in 3.2.1 thru 3.2.4 below the references made are to sections of AC91-56 and the spellings are European [demonstrating the international nature of the industry-wide cooperation of this activity]

3.2.1 Add New Section 5 - "WAY OF WORKING"

5. WAY OF WORKING

a. General

On initiative of the TCH and its PCA, a STG should be formed for each aircraft model for which it is decided to put in place an ageing aircraft programme. The STG shall consist of the TCH, selected operator members and a representative from the PCA. Other NAAs may be included as part of the STG at the option of the individual STG. The objective of the STG is to complete all tasks covered in this AC in relation to their respective model types, including the following:

--Develop model specific programmes
--Define programme implementation
--Conduct recurrent programme reviews as necessary.

It is recognised that it might not always be possible to form or to maintain an STG, due to a potential lack of resources with the operators or TCH. In this case the above objective would remain with the appropriate PCA and operators or TCH as applicable, with a possible involvement of other NAAs.

An acceptable way of working for STGs is described in *"Structures Task Group Guidelines Document" [Ref3]* that was established by the AAWG with the following additional clarifications:

b. Meeting scheduling:
It is the responsibility of the TCH to schedule STG meetings. However if it is found by the appropriate PCA that the meeting scheduling is inadequate to meet the STG working objectives, they might initiate themselves additional STG meetings.

c. Reporting:
The STG would make recommendations for actions via the TCH to the PCA of the TCH. Additionally, the STG should give periodic reports (for information only) to AAWG/EAAWG as appropriate with the objective of maintaining a consistent approach.

d. Recommendations and decision making
The decision making process described in AAWG Report on Structures Task Group Guidelines paragraph 7 leads to recommendations for mandatory action from the TCH to its PCA. In addition it should be noted that the Airworthiness Authorities (the TCH's PCA and/or the NAA of the state of registry) are entitled to mandate safety measures related to ageing of aircraft structure, in addition to those recommended by the STG, if they find it necessary.

e. Responsibilities:
The PCA is responsible for issuing ADs or operational rules to mandate the STG's recommended ageing aircraft model specific programme. The NAAs of states of registry are responsible for ensuring the implementation of the ageing aircraft programme by their operators. The PCA and the TCH are responsible for monitoring the effectiveness of the ageing aircraft model specific programme, and to implement changes in the programme, as necessary.

3.2.2 Expand and Re-title Section 7

7. SERVICE BULLETIN REVIEW and MANDATORY MODIFICATION PROGRAMME

The Type Certificate Holder (TCH), in conjunction with operators, is expected to initiate a review of all structurally related inspection and modification SBs and determine which require further actions to ensure continued airworthiness, including mandatory modification action or enforcement of special repetitive inspections

Any aircraft primary structural components that would require frequent repeat inspection, or where the inspection is difficult to perform, taking into account the potential airworthiness concern, should be reviewed to preclude the human factors issues associated with repetitive inspections

The SB review is an iterative process (see appendix 5) consisting of the following items:

a. The TCH should review all issued structural inspection and modification SBs to select candidate bulletins, using the following 4 criteria:

1) There is a high probability that structural cracking exists
2) Potential structural airworthiness concern.
3) Damage is difficult to detect during routine maintenance
4) There is adjacent structural damage or the potential for it.

This may be done by the TCH alone or in conjunction with the operators as a preliminary STG meeting.

b. The TCH and operator members will be requested to submit information on individual fleet experience relating to candidate SBs. This information will be collected and evaluated by the TCH. The summarised results will then be reviewed in detail at a STG meeting (see c.).

c. The final selection of SBs for recommendation of the appropriate corrective action to assure structural continued airworthiness taking into account the in-service experience, will be made during an STG meeting by the voting members of the STG, either by consensus or majority vote, depending on the preference of the individual STGs.

d. An assessment will be made by the TCH as to whether or not any subsequent revisions to SBs affect the previous decision made. Any subsequent revisions to SBs previously chosen by the STG for mandatory inspection or incorporation of modification action that would affect the previous STG recommended action should be submitted to the STG for review.

e. The TCH should review all new structural SBs periodically to select further candidate bulletins. The TCH should schedule a meeting of the STG to address the candidates. Operator members and NAAs will be advised of the candidate selection and provided the opportunity to submit additional candidates.

3.2.3 Add New Section 12 - Implementation

12. <u>IMPLEMENTATION</u>.

Once the PCA has approved the document covering any of the issues covered in this ACJ, operators must amend their current structural maintenance programmes to comply with and account for the applicable actions. The programmes will either be mandated by ADs or by operational rules, which require operators to amend the current structural maintenance programmes. Any ADs issued as a result of a WFD finding that require structural modification will be handled separately. In all cases, compliance is required in accordance with the applicable regulations.

From the industry/authorities discussions leading to the definition of the programmes detailed in sections 6 to 10, above, appropriate implementation times have emerged. These programme implementation times are expressed as a fraction of the aircraft model's DSG/ESG.

CPCP	1/2 DSG/ESG
SSID	1/2 DSG/ESG
SB-Review	3/4 DSG/ESG
RAP	3/4 DSG/ESG
WFD	DSG/ESG

In the absence of other information prior to the implementation of these programmes the limit of validity of the existing maintenance programmes should be considered as the DSG/ESG. Typically, dependant on the date of the regulatory action mandating these programmes a period of one year to incorporate into an operators maintenance programme should be considered.

3.2.4 Add Appendix 5 - New

APPENDIX 5 GUIDELINES for THE DEVELOPMENT OF a SERVICE BULLETIN REVIEW and MANDATORY MODIFICATION PROGRAMME

1.Introduction

This appendix provides interpretation, guidelines and an acceptable means of compliance for the review of Structural Service Bulletins including a procedure for selection, assessment and related recommended corrective action for ageing aircraft structures.

2.1 SB selection process

The SB selection, review, assessment and recommendation process within the STG is summarised in figure **A**. For the first SB review within the STG meeting, all inspection SB should be selected. Afterwards, the TCH should maintain a list of SB which were already selected for a review with all decisions made, and add to this list all new and revised SB. Moreover, some specific modification SB not linked to an inspection SB may also be selected for review.

When an SB is selected, it is recommended to select also, in the same package, inspection SB that interact with it and all related modification SB.

The main criteria for selecting SB are the following **:**

(a) **High probability that structural cracking exists**

Notes:

- Related to the number and type of finding in service and from fatigue testing
- A “no finding” result should be associated to the number of performed inspections
- The type of finding should include an analysis of its criticality.

(b) **Potential structural airworthiness concern**

Notes:

- Structural airworthiness of the airplane is dependent on repeat inspections to verify structural condition and therefore on inspection reliability.
- A short repeat inspection interval (e.g. short time to grow from detectable crack to a critical length divided by a factor*)* will lead to increased work load for inspectors and possible increased risk of missing damage.
- Special attention should be paid to any single inspection tasks involving multiple repeat actions needed to verify the structural condition that may increase the risk of missing damage (e.g. lap splice inspections).

(c) Damage is difficult to detect during regular maintenance

Notes:

Considerations under this criterion are:

- The areas to inspect are difficult to access;
- NDI methods are unsuitable;
- Human factors associated with the inspection technique are so adverse that crack detection may not be sufficiently dependable to assure safety.

(d) There is adjacent structural damage or the potential for it

Notes:

- Particular attention should be paid to areas susceptible to Widespread Fatigue Damage (WFD) and also to potential interaction between corrosion and fatigue cracking e.g. between fastener damage (due to stress corrosion or other factors) and fatigue cracking.
- It is recommended to consider the potential interaction of modifications or repairs usually implemented in the concerned areas to check whether the inspections are still reliable or not (operators input)

Operators information input should address the points as detailed in figure B. This information should be collected and analysed by the TCH for the STG meeting.

If for a given selected SB there is not sufficient in-service data available before the STG meeting that would enable a recommendation to be made, its review may be deferred until enough data are available. The TCH should then check periodically until these data become available.

The operators and Airworthiness Authorities concerned should be advised by the TCH of the SB selection list and provided the opportunity to submit additional SB. For this purpose, the TCH should give the operators enough information in advance (e.g. 2 months), for them to be able to properly consider the proposed selection and to gather data.

2.2 STG meeting : SB review and recommendations

It is recommended to review at the same time all the SBs that can interact, the so-called SB package in the selection process. The meeting should start with an STG agreement on the selected SB list and on those deferred.

At the meeting the TCH should present its analysis of each SB utilising the collection of operator input data. The STG should then collectively review the ratings (Figure B Section 2) against each criteria to come to a consensus recommendation.

Such a STG recommendation for a selected SB shall consider the following options:

a. to mandate a structural modification at a given threshold
b. to mandate selected inspection SB
c. to revise modification or repair actions

d. to revise other SB in the same area concerned by damages

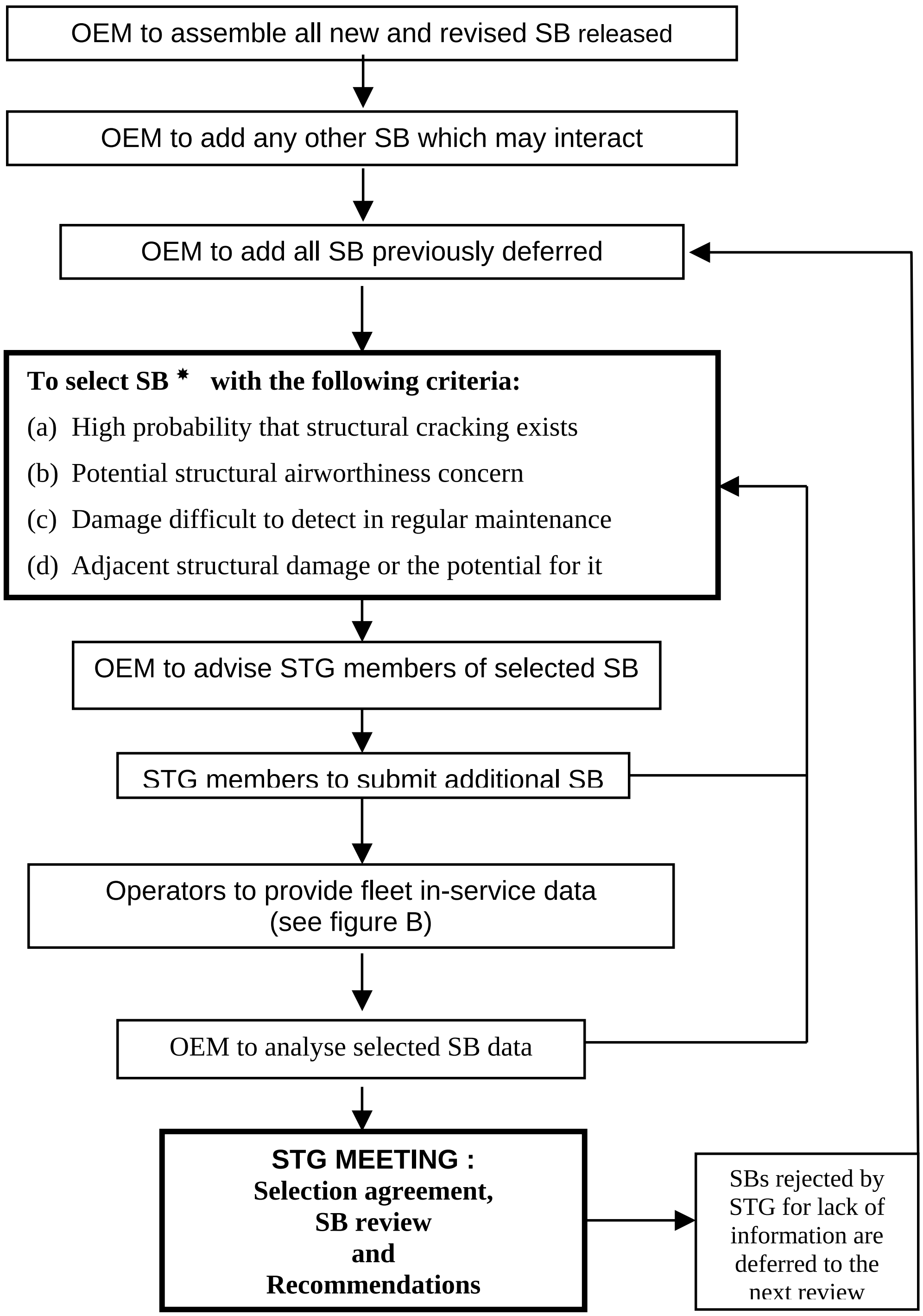
e. to review inspection method and related inspection intervals

f. to review ALI/MRB or other maintenance instructions

g. to defer the review to the next STG and request operators reports on findings for a specific SB or request an inspection sampling on the oldest aircraft

STG recommendations for mandatory action are the responsibility of the TCH to forward to his PCA for appropriate action. Other STG recommendations are information provided to the STG members. It is their own responsibility to carry them out within the appropriate framework.

Figure A SB SELECTION PROCESS AND SB REVIEW



* This may be done by the TCH alone or in conjunction with the operators as a preliminary STG meeting.

Figure B OPERATORS FLEET EXPERIENCE

IN-SERVICE DATA / SECTION 1

NAME OF THE OPERATOR
____

AIRCRAFT MODEL/SERIES
____

SERVICE BULLETIN (SB) NUMBER ________________
TITLE ____

RELATED INSPECTION/MODIFICATION SB :
1/____
2/____
3/____

SB MANDATED ? ☐ YES ☐ NO
IF NOT, SB IMPLEMENTED IN MAINTENANCE PROGRAMME ? ☐ YES ☐ NO

NUMBER OF AIRCRAFT TO WHICH SB APPLIES (INCLUDING ALL A/C IN THE SB EFFECTIVITY)_____________________
NUMBER OF AIRCRAFT EXCEEDING SB INSPECTION THRESHOLD (IF APPLICABLE)
____

NUMBER OF AIRCRAFT INSPECTED PER SB (IF APPLICABLE) ?
____

SPECIFY TYPE OF INSPECTION USED
____

NUMBER OF AIRCRAFT WITH REPORTED FINDINGS
____

TYPE OF FINDINGS
____
____

NUMBER OF FINDINGS DUE TO OTHER INSPECTIONS THAN THE ONE PRESCRIBED IN SB (IF APLICABLE) ______________
SPECIFY TYPE OF INSPECTION USED
____

NUMBER OF AIRCRAFT EXCEEDING SB TERMINATING MODIFICATION THRESHOLD (IF APPLICABLE) _________________
NUMBER OF AIRCRAFT IN WHICH TERMINATING MODIFICATION HAS BEEN ACCOMPLISHED (IF APPLICABLE) ________

NEED THIS SB (OR RELATED SB) BE IMPROVED ? ☐ YES ☐ NO

COMMENTS:____
____
____
____

Figure B [continued]

IN-SERVICE DATA / SECTION 2

	(A)	(B)	(C)	(D)	(E)
CRITERIA	INSPECT-ABILITY ACCESS	FREQUENCY REPETITIVE INSPECTION	FREQUENCY OF DEFECTS	SEVERITY RATING	ADJACENT STRUCTURE DAMAGE
RATING					

(A) INSPECTABILITY/ACCESS RATING

OK	◆ Inspection carried out with little or no difficulty.
Acceptable	◆ Inspection carried out with some difficulty.
Difficulty	◆ Inspection carried out with significant difficulty.

Note: Rating should consider difficulty of access as well as inspection technique and size of inspection area.

(B) FREQUENCY OF REPETITIVE INSPECTIONS RATING

OK	◆ Greater than 6 years.
Acceptable	◆ Between 2 and 6 years.
Difficulty	◆ Less than 2 years.

(C) FREQUENCY OF DEFECTS NOTED RATING = % OF THOSE AEROPLANES BEYOND THRESHOLD ON WHICH DEFECTS HAVE BEEN FOUND

OK	◆ No defect noted.
Acceptable	◆ Defects noted but not of a significant amount (less than 10%).
Difficulty	◆ Substantial defects noted (greater than 10%).

(D) FINDING SEVERITY RATING

OK	◆ Airworthiness not affected.
Acceptable	◆ Damage not of immediate concern, but could progress or cause secondary damage.
Difficulty	◆ Airworthiness affected. Damage requires immediate repair.

(E) ADJACENT STRUCTURE DAMAGE RATING (MULTIPLE SITE DAMAGE, MULTIPLE ELEMENT DAMAGE, CORROSION, ETC.)

OK	◆ Low rate of adjacent structural damage.
Acceptable	◆ Medium rate of adjacent structural damage.
Difficulty	◆ High rate of adjacent structural damage/Multiple service actions in area.

4.0 - Recommendations

The AAWG recommends that the advisory circular AC91-56 be updated along the lines of the technical text given in section 3.1 drafted by our European counterpart EAAWG to address the issue of service bulletin reviews and mandatory modification action. In particular

1. A standard way of assessing service bulletins for mandatory modification action needs to be established
2. The Structural Task Group way of working has proved effective but needs to be defined and adopted
3. Guidance needs to be given on appropriate implementation times for ageing aircraft program actions.

5.0 – Conclusions

In July1999 the AAWG issued a report establishing a methodology to ensure that an airframe structure remains free from widespread fatigue damage. The approach envisaged, and subsequently established as viable by industry wide “Round Robin” comparative analysis, relied on a number of basic assumptions. One of which was the assumption that essential service bulletin modification actions had been embodied on the airframe before the WFD condition was approached.
This report has defined an acceptable procedure to establish those modification actions which are an essential element of the long term structural integrity of an airframe.

APPENDIX A – FAA/ARAC TASK 5 and 6 –AAWG

TASK 5 – DEVELOP TECHNICAL POSITION RE: WIDESPREAD FATIGUE DAMAGE

PAGE: 62 FR 45690 NO. 167 08/28/97

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DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Aviation Rulemaking Advisory Committee; Transport Airplane and Engine

Issues—New Task

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of a new task assignment for the Aviation Rulemaking Advisory Committee (ARAC).

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SUMMARY: Notice is given of a new task assigned to and accepted by the Aviation Rulemaking Advisory Committee (ARAC). This notice informs the public of the activities of ARAC.

FOR FURTHER INFORMATION CONTACT: Stewart R. Miller, Manager, Transport Standards Staff, ANM-110, FAA, Transport Airplane Directorate, Aircraft Certification Service, 1601 Lind Ave. SW., Renton, WA 98055-4056, telephone (425) 227-2190, fax (425) 227-1320.

SUPPLEMENTARY INFORMATION:

Background

The FAA has established an Aviation Rulemaking Advisory Committee to provide advice and recommendations to the FA Administrator, through the Associate Administrator for Regulation and Certification, on the full range of the FAA's rulemaking activities with respect to aviation-related issues. This includes obtaining advice and recommendations of the FAA's commitment to harmonize its Federal Aviation Regulations (FAR) and practices with the aviation authorities in Europe and Canada.

One area ARAC deals with is Transport Airplane and Engine Issues. These issues involve the airworthiness standard for transport category airplanes in 14 CFR part 25, 33, and 35 and parallel provisions in 14 CFR parts 121 and 135. The corresponding European airworthiness standards for transport category airplanes are contained in Joint Aviation Requirements (JAR)-25, JAR-E and JAR-P, respectively. The corresponding Canadian Standards are contained in Chapters 525, 533 and 535 respectively.

The Task

This notice is to inform the public that the FAA has asked ARAC to provide advice and recommendation on the following harmonization task:

FAR/JAR 25 Aging Aircraft

1. ARAC is tasked to review the capability of analytical methods and their validation; related research work; relevant full-scale and component fatigue test data; and tear down inspection reports, including fractographic analysis, relative to the detection of widespread fatigue damage (WFD). Since aircraft in the fleet provide important data for determining where and when WFD is occurring in the structure, ARAC will review fractographic data from representative "fleet leader" airplanes. Where sufficient relevant data for certain airplane models does not currently exist, ARAC will recommend how to obtain sufficient data from representative airplanes to determine the extent of WFD in the fleet. The review should take into account the Airworthiness Assurance Harmonization Working Group report "Structural Fatigue Evaluation for Aging Aircraft" dated October 14, 1993, and extend its applicability to all transport category airplanes having a maximum gross weight greater than 75,000 pounds.
2. ARAC will produce time standards for the initiation and completion of model specific programs (relative to the airplane's design service goal) to predict, verify and rectify widespread fatigue damage. ARAC will also recommend action that the Authorities should take if a program, for certain model airplanes, is not initiated and completed prior to those time standards. Actions that ARAC will consider include regulations to require Type Certificate holders to develop WFD programs, modification actions, operational limits, and inspection requirements to assure structural integrity of the airplanes. ARAC will provide a discussion of the relative merits of each option.
3. This task should be completed within 18 months of tasking.

ARAC Acceptance of Task

ARAC has accepted this task and will assign it to a working group. The working group will serve as staff to ARAC to assist ARAC in the analysis of the assigned task. Working group recommendations must be reviewed and approved by ARAC. If ARAC accepts the working group's recommendations, it forwards them to the FAA and ARAC recommendations.

Working Group Activity

The working group is expected to comply with the procedure adopted by ARAC. As part of the procedures, the working group is expected to:

1. Recommend a plan for completion of the task, including rationale, for FAA/JAA approval within six months of publication of this notice.
2. Give a detailed conceptual presentation of the proposed recommendations, prior to proceeding with its work.
3. Provide a status report at each meeting of ARAC held to consider Transport Airplane and Engine Issues.

Participation in the Working Group

The working group will be composed of experts having an interest in the assigned task. A working group member need not be a representative of a member of the full committee.

An individual who has expertise in the subject matter and wishes to become a member of the working group should write to the person listed under the caption FOR FURTHER INFORMATION CONTACT expressing that desire, describing his or her interest in the task, and stating the expertise he or she would bring to the working group. The request will be reviewed by the assistant chair, the assistant executive director, and the working group chair and the individual will be advised whether or not the request can be accommodated.

The Secretary of Transportation has determined that the formation and use of ARAC are necessary and in the public interest in connection with the performance of duties imposed on the FAA by law.

Meetings of ARAC will be open to the public, except as authorized by section 10(d) of the Federal Advisory Committee Act. Meetings of the working group will not be open to the public, except to the extent that individuals with an interest and expertise are selection to participate. No public announcement of working group meetings will be made.

Issued in Washington, DC, on August 21, 1997.

Joseph A. Hawkins,

Executive Director, Aviation Rulemaking Advisory Committee.

[FR Doc. 97-22922 Filed 8-27-97; 8:45 am]

BILLING CODE 4910-13-M

TASK 6: AGING AIRCRAFT PROGRAM (WIDESPREAD FATIGUE DAMAGE) (WFD)

[Federal Register: December 15, 1999 (Volume 64, Number 240)]
[Notices]
[Page 70104-70105]
From the Federal Register Online via GPO Access [wais.access.gpo.gov]
[DOCID:fr15de99-112]

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DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Aviation Rulemaking Advisory Committee; Transport Airplane and Engine Issues--New Task

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of a new task assignment for the Aviation Rulemaking Advisory Committee (ARAC).

SUMMARY: Notice is given of a new task assigned to and accepted by the Aviation Rulemaking Advisory Committee (ARAC). This notice informs the public of the activities of ARAC.

FOR FURTHER INFORMATION CONTACT: Kristin Larson, Transport Standards Staff, ANM-110, FAA, Transport Airplane Directorate, Aircraft Certification Service, 1601 Lind Ave. SW., Renton, WA 98055-4056, telephone (425) 227-1760, fax (425) 227-1100.

SUPPLEMENTARY INFORMATION:

Background

The FAA has established an Aviation Rulemaking Advisory Committee to provide advice and recommendations to the FAA Administrator, through the Associate Administrator for Regulation and Certification, on the full range of the FAA's rulemaking activities with respect to aviation-related issues. This includes obtaining advice and recommendations on the FAA's commitment to harmonize its Federal Aviation Regulations (FAR) and practices with the aviation authorities in Europe and Canada.

One area ARAC deals with is transport airplane and engine issues. These issues involve the airworthiness standards for transport category airplanes in 14 CFR parts 25, 33, and 35 and parallel provisions in 14 CFR parts 121 and 135. The corresponding European airworthiness standards for transport category airplanes are contained in Joint Aviation Requirements (JAR)-25, JAR-E and JAR-P, respectively. The corresponding Canadian Standards are contained in Chapters 525, 533, and 535, respectively.

The Task

This notice is to inform the public that the FAA has asked ARAC to provide advice and recommendation on the following harmonization task:

Task 6: Aging Aircraft Program (Widespread Fatigue Damage) (WFD)

The FAA requests that ARAC propose new operating rules (14 CFR parts 91, 121, 125, 129, and 135) that would ensure that no large transport category airplane (>75,000 lbs. Gross Take Off Weight) is operated beyond the flight cycle limits to be specified in the regulation, unless an ``Aging Aircraft Program'' has been incorporated into the operator's maintenance program.

[[Page 70105]]

The proposed rule and advisory material will establish:

1. The content of the Aging Aircraft Program (e.g., the necessary special inspections and modification actions for prevention of WFD), and

2. A limit of the ``validity'' (in terms of flight cycles or hours) of the Aging Aircraft Program where additional reviews are necessary for continued operation.

Additionally, ARAC is asked to review 14 CFR 25.1529 and 14 CFR part 25, Appendix H, and recommend changes to establish:

1. The required content of an Aging Aircraft Program.

2. The criteria by which to determine the validity of the Aging Aircraft Program (in terms of flight cycles or flight hours). This would effectively prohibit the operation of airplanes beyond the limited validity of the maintenance program. In order to operate beyond the declared limit, further evaluation of the design must be accomplished and the additional inspections and/or modifications added to the Aging Aircraft Program as necessary.

The FAA may ask ARAC to recommend disposition of any substantive comments the FAA receives in response to any of the notices of proposed rulemaking that result from ARAC's recommendations.

The FAA expects ARAC to forward its recommendations to the FAA within 9 months after tasking.

ARAC Acceptance of Task

ARAC has accepted this task and has chosen to assign it to the existing Airworthiness Assurance Working Group. The working group serves as staff to ARAC to assist ARAC in the analysis of the assigned task. Working group recommendations must be reviewed and approved by ARAC. If ARAC accepts the working groups recommendations, it forwards them to the FAA as ARAC recommendations.

Working Group Activity

The working group is expected to comply with the procedures adopted by ARAC. As part of the procedures, the working group is expected to:

1. Recommend a work plan for completion of the task, including the rationale supporting such a plan, for consideration at the meeting of ARAC to consider transport airplane and engine issue held following publication of this notice.

2. Give a detailed conceptual presentation of the proposed recommendations, prior to proceeding with its work.

3. Draft appropriate regulatory documents with supporting economic and other required analyses, and any other related guidance material or collateral documents to support its recommendations.

4. Provide a status report at each meeting of ARAC held to consider transport airplane and engine issues.

The Secretary of Transportation has determined that the formation and use of ARAC are necessary and in the public interest in connection with the performance of duties imposed on the FAA by law.

Meetings of ARAC will be open to the public, except as authorized by section 10(d) of the Federal Advisory Committee Act. Meetings of the Airworthiness Assurance Working Group will not be open to the public, except to the extent that individuals with an interest and expertise are selected to participate. No public announcement of working group meetings will be made.

Issued in Washington, DC, on December 9, 1999.
Anthony F. Fazio,
Executive Director, Aviation Rulemaking Advisory Committee.
[FR Doc. 99-32462 Filed 12-14-99; 8:45 am]
BILLING CODE 4910-13-M

Appendix B - AAWG Task Group Make-up

NAME	*Organization*	*E-Mail*
Bandley. B.	FAA-LAACO	Brent.Bandley@faa.gov
Boetsch, R.	Airbus	regis.boetsch@airbus.com
Bristow, J.	CAA-UK	john.bristow@srg.caa.co.uk
Burd, J.	Gulfstream	james.burd@gulfaero.com
Carter, A.	Delta A/L	Aubrey.Carter@delta-air.com
Collins, R.	Airbus UK Ltd.	richard.collins@airbus.com
Eastin, R.	FAA	Robert.eastin@faa.gov
A. Hoggard	BCA	Amos.w.hoggard@boeing.com
Hoogeland, B.	KLM	A.C.Hoogeland@td.klm.nl
Horne, B.	FedEx	Bhorne@fedex.com
Ingram, E.	Lockheed-Martin	ed.ingram@lmco.com
Knight, D.	UPS	deknight@ups.com
Marsh, D.	BCA	Douglas.Marsh2@West.Boeing.com
Perrin, F	DGAC	frank.perrin@aviation-civile.gouv.fr
Peltz, J.	FedEx	Jpeltz@fedex.com
Santgerma, A.	Airbus France	alain.santgerma@airbus.com
Schmidt, B.	Airbus Deutschland	Bianka.Schmidt-Brandecker@airbus.com

Appendix C - Meeting Venues

AAWG - RWG Meetings Schedule

RWG Meeting No.	*Location*	*Dates Week of*
11	Gatwick UK	Aug 20, 2001
12	Long Beach CA	Jan 28, 2001
13	Gatwick UK	Apr 22, 2002
14	Savannah GA	Jun 24, 2002
15	Dresden GER	Sep 23, 2002
16	Seattle WA	Jan 20, 2002
17	Gatwick UK	April 28, 2003

Appendix D – Meeting Attendance

Name	Representing	1	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17
A. Santgerma	Airbus	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
R. Boetsch	Airbus	X	X	X	X	X	X	X	X	X	X	X	X		X		
R. Collins	Airbus	X	X	X	X	X	X	X	X	X			X				X
A. Hoggard	BCA	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
B. Bandley	FAA	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
B. Eastin	FAA										X	X		X	X	X	X
D. Marsh	BCA	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
J. Bristow	CAA-UK for JAA	X		X	X	X	X	X	X	X	X		X	X	X	X	X
A. Carter	Delta A/L	X	X	X	X	X	X		X	X	X	X	X	X		X	X
B. Schmidt	Airbus	X	X	X		X		X	X	X	X						
J. Peltz	FedEx				X	X	X	X	X	X	X	X	X	X		X	
D. Horne	FedEx				X	X	X	X	X	X	X	X	X	X			
M. Yerger	FedEx	X	X	X	X												
James Burd	Gulfstream					X	X	X	X	X	X	X	X	X	X		
Bert Hoogeland	KLM	X	X			X	X	X	X	X							
Ed Ingram	Lockheed-Martin	X	X		X	X	X										
Frank Perrin	DGAC-FR [JAA]											X	X	X	X		
Donn Knight	UPS		X														

Also at Meeting 14 – Jeff Kollgaard, Boeing and Richard Minter representing John Bristow.

General Structures Harmonization Working Group Report to TAEIG

October 2003

Andrew Kasowski
Cessna Aircraft Company

General Structures Harmonization Working Group - Current Activities

- No Meetings Since Last Report
- § 25.571 Damage Tolerance and Fatigue Evaluation of Structure
  - Working Group Report Submitted to TAEIG 2 July, 2003
- § 25.603 Materials
  - Working Group Report Submitted to TAEIG 30 June 2003
- § 25.631 Birdstrike Damage
  - Working Group Report Submitted to TAEIG 30 June 2003
    - Harmonization within the group could not be attained
    - Individual Position Papers Included in Working Group Report(FAA, JAA, TC, OEM)
- § 25.365(d)/AC25-20 Pressurized Compartment Loads - High Altitude Flight

§ 25.365(d)/AC 25-20 High Altitude Flight

- Technical agreement on revisions to §25.365(d), §25.841(a), paragraph 8 of AC25-20, §25.571(b), and para. 7 of AC25.571 reached in February 2003 meeting
- Unresolved Issue
  - Cutoff altitude for high altitude requirement (altitude above which additional requirements are imposed)
- Coordinating with group members by e-mail to reach resolution on the issue – minority position paper may be required
- Working Group Report Drafted – Circulation to Group for Review and Approval in November 2003
- Anticipate Submittal to TAEIG by December 2003

June 30, 2003

IN REPLY, REFER TO
L350-03-112

Mr. Craig R. Bolt
Assistant Chair, TAEIG
Pratt & Whitney
400 Main Street
East Hartford, Ct 06108

Dear Craig,

Subject: Submittal of Results of Harmonization Effort on FAR/JAR §25.603, Material

The General Structures Harmonization Working Group herewith submits the Working Group Report on the subject regulatory material to the TAEIG for acceptance and recommendation to the FAA. ARAC tasked the General Structures Harmonization Working Group to review the proposed guidance of Advisory Circular Joint (ACJ) 25.603 paragraph 9 and Advisory Material Joint (AMJ) 25.603 (adopted in Joint Aviation Requirements-25 Change 15, resulting from Notice of Proposed Amendment 25D-256), develop a report based on the review, and recommend the adoption of harmonized guidance material for paragraph 25.603 of the JAR and §25.603 of the FAR.

Consensus of the full Harmonization Working Group (HWG) was achieved for incorporating the guidance material from NPA 25D-256 on Change of Composite Materials, recently incorporated into Change 15 of the JAR, into the existing Advisory Circular 20-107A. There currently exists no specific FAA advisory material for certification of alternative materials for composite structures other than the requirements for initial composite structure certification contained in AC 20-107A. The proposed guidance material to be added to AC20-107A outlines additional methods of compliance when a manufacturer, to provide an alternative source of material to be used on aircraft in production, changes the material for an already certificated composite structure. This guidance material defines the extent of analysis and type and number of tests that should be repeated in order to achieve the necessary level of confidence in structural integrity without undue cost penalties. For the majority of cases, this effort will be less than that previously required for the original certification, thus benefiting the airplane manufacturers and minimizing the oversight efforts of the authorities. No specific cost estimates of the benefit of this change are available. However, minimizing the certification efforts for changes in composite materials will benefit all manufacturers who attempt to qualify alternate materials for previously certificated composite structures.

Sincerely,

Andrew H. Kasowski
General Structures HWG Chairperson
316-517-6008
315-517-1820 FAX
akasowski@cessna.textron.com

Attachment A

General Structures Harmonization Working Group Report

Material FAR/JAR §25.603

General Structures Harmonization Working Group Report

Material FAR/JAR §25.603

Transport Airplane Directorate
WG Report Format

Harmonization and New Projects

1 - BACKGROUND:

- *This section "tells the story."*
- *It should include all the information necessary to provide context for the planned action. Only include information that is helpful in understanding the proposal -- no extraneous information (e.g., no "day-by-day" description of Working Group's activities).*
- *It should provide an answer for all of the following questions:*

a. SAFETY ISSUE ADDRESSED/STATEMENT OF THE PROBLEM

(1) What prompted this rulemaking activity (e.g., accident, accident investigation, NTSB recommendation, new technology, service history, etc.)? What focused our attention on the issue?

Notice of Proposed Amendment (NPA) 25D-256 outlined additional methods of compliance when a manufacturer, to provide an alternative source of material to be used on aircraft in production, changes the material for an already certificated composite structure. Previous to the NPA, no regulatory guidance material existed to cover this situation that was becoming increasingly common as manufacturers sought alternative sources of material to be used on aircraft in production. The text of NPA 25D-256 was incorporated into Change 15 of the JAR. ARAC tasked the General Structures Harmonization Working Group to review the proposed guidance of Advisory Circular Joint (ACJ) 25.603 paragraph 9 and Advisory Material Joint (AMJ) 25.603 (adopted in Joint Aviation Requirements-25 Change 15, resulting from Notice of Proposed Amendment 25D-256), develop a report based on the review, and recommend the adoption of harmonized guidance material for paragraph 25.603 of the JAR and §25.603 of the FAR.

(2) What is the underlying safety issue to be addressed in this proposal?

Most aircraft composite structures are certificated initially with material supplied from only one source. This can lead to manufacturing challenges in continuity of production if the selected source of material becomes unreliable. To overcome this problem manufacturers are certifying structures with alternative materials to allow for dual sources of material supply. Substantiating a composite structure requires a large amount of test data ranging from coupon level to specimens representative of the most complex features of the structural design. Such testing is time consuming and expensive. In seeking certification for an alternative material manufacturers attempt to minimize the amount of new testing by relying as much as possible on the testing done to certificate the structure originally. This guidance material defines the extent of analysis and type and number of tests that should be repeated in order to achieve the necessary level of confidence in structural integrity without undue cost penalties.

(3) What is the underlying safety rationale for the requirement?

See Items 1 and 2 above.

(4) Why should the requirement exist?

See Items 1 and 2 above.

b. CURRENT STANDARDS OR MEANS TO ADDRESS

(1) If regulations currently exist:

(a) What are the current regulations relative to this subject? (Include both the FAR's and JAR's.)

Current CFR 14 Part 25 text:

FAR 25.603 Materials.

The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must--

(a) Be established on the basis of experience or tests;

(b) Conform to approved specifications (such as industry or military specifications, or Technical Standard Orders) that ensure their having the strength and other properties assumed in the design data; and

(c) Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.

Amdt. 25-46, Eff. 10/30/78

Current JAR text:

JAR 25.603 Materials (For Composite Materials see ACJ 25.603.)

The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must--

(a) Be established on the basis of experience or tests;

(b) Conform to approved specifications (such as industry or military specifications, or Technical Standard Orders) that ensure their having the strength and other properties assumed in the design data; and

(c) Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.

(b) How have the regulations been applied? (What are the current means of compliance?) If there are differences between the FAR and JAR, what are they and how has each been applied? (Include a discussion of any advisory material that currently exists.)

The basic material qualification requirements specified in §25.603 of the FAR and JAR are worded the same. Advisory material for FAR 25 is contained in AC20-107A, Composite Aircraft Structure, which also applies to FAR 23, 27, and 29. Identical advisory material (apart from minor editing) for JAR 25 through Change 14 is contained in ACJ 25.603, Composite Aircraft Structure. At Change 15 of JAR 25, requirements for changing composite materials were introduced through the addition of paragraph 9 of ACJ 25.603, *Change of Composite Mate*rials, and the adoption of AMJ 25.603, *Change of Composite Material.*

(c) What has occurred since those regulations were adopted that has caused us to conclude that additional or revised regulations are necessary? Why are those regulations now inadequate?

Most aircraft composite structures are certificated initially with material supplied from only one source. This can lead to manufacturing challenges in continuity of production if the selected source of material becomes unreliable. To overcome this problem manufacturers are certifying structures with alternative materials to allow for dual sources of material supply. Substantiating a composite structure requires a large amount of test data ranging from coupon level to specimens representative of the most complex features of the structural design. Such testing is time consuming and expensive. In seeking certification for an alternative material manufacturers attempt to minimize the amount of new testing by relying as much as possible on the testing done to certificate the structure originally.

Previous to NPA 25D-256, no regulatory guidance material existed to cover this situation that was becoming increasingly common as manufacturers sought alternative sources of material to be used on aircraft in production. Notice of Proposed Amendment 25D-256 outlined additional methods of compliance when a manufacturer, to provide an alternative source of material to be used on aircraft in production, changes the material for an already certificated composite structure. The text of NPA 25D-256 was incorporated into Change 15 of the JAR. This guidance material defines the extent of analysis and type and number of tests that should be repeated in order to achieve the necessary level of confidence in structural integrity without undue cost penalties. Identical requirements for a change of composite material are being proposed for incorporation into the guidance material of AC20-107A.

2. If no regulations currently exist:

(a) What means, if any, have been used in the past to ensure that this safety issue is addressed? Has the FAA relied on issue papers? Special Conditions? Policy statements? Certification action items? Has the JAA relied on Certification Review Items? Interim Policy? If so, reproduce the applicable text from these items that is relative to this issue.

Previously, guidance material contained in AC20-107A and ACJ 25.603 (prior to Change 15) was used to evaluate the use of alternate materials for previously certificated composite structures.

(b) Why are those means inadequate? Why is rulemaking considered necessary (i.e., do we need a general standard instead of addressing the issue on a case-by-case basis?)?

Notice of Proposed Amendment 25D-256 outlined additional methods of compliance when a manufacturer, to provide an alternative source of material to be used on aircraft in production, changes the material for an already certificated composite structure. This guidance material clarifies the extent of analysis and type and number of tests that should be repeated in order to achieve the necessary level of confidence in structural integrity without undue cost penalties. Identical requirements for a change of composite material are being proposed for incorporation into the guidance material of AC20-107A.

2. DISCUSSION of PROPOSAL

- *This section explains:*

→ *what the proposal would require,*

→ *what effect we intend the requirement to have, and*

→ *how the proposal addresses the problems identified in Background.*

- *Discuss each requirement separately. Where two or more requirements are very closely related, discuss them together.*
- *This section also should discuss alternatives considered and why each was rejected.*

a. SECTION-BY-SECTION DESCRIPTION OF PROPOSED ACTION

(1) What is the proposed action? Is the proposed action to introduce a new regulation, revise the existing regulation, or to take some other action?

The proposed action is to incorporate the guidance material from NPA 25D-256 on Change of Composite Materials, recently incorporated into Change 15 of the JAR, into existing Advisory Circular 20-107A.

(2) If regulatory action is proposed, what is the text of the proposed regulation?

Not applicable, no rule changes are proposed, only changes to the advisory material.

(3) If this text changes current regulations, what change does it make? For each change:

- What is the reason for the change?
- What is the effect of the change?

Not applicable, no rule changes are proposed, only changes to the advisory material.

(4) If not answered already, how will the proposed action address (i.e., correct, eliminate) the underlying safety issue (identified previously)?

The proposed guidance material outlines additional methods of compliance when a manufacturer, to provide an alternative source of material to be used on aircraft in production, changes the material for an already certificated composite structure. This guidance material defines the extent of analysis and type and number of tests that should be repeated in order to achieve the necessary level of confidence in structural integrity without undue cost penalties.

(5) Why is the proposed action superior to the current regulations?

Encompassing the existing JAR guidance material into the FAR guidance material will result in a common set of guidance material for changes of composite materials facilitating concurrent certifications, minimizing the effort involved in validation programs, and minimizing cost penalties for such changes.

b. ALTERNATIVES CONSIDERED

(1) What actions did the working group consider other than the action proposed? Explain alternative ideas and dissenting opinions.

The proposed guidance material on change of composite materials (as defined in NPA 25D-256) is the result of the efforts of a working group sponsored by the JAA Structures Study Group and reflects the views of composites specialists from the authorities and industry. Therefore, the material was adopted by the GSHWG with minimal discussion and debate.

(2) Why was each action rejected (e.g., cost/benefit? unacceptable decrease in the level of safety? lack of consensus? etc.)? Include the pros and cons associated with each alternative.

Not applicable.

c. HARMONIZATION STATUS

(1) Is the proposed action the same for the FAA and the JAA?

The proposed guidance material has already been incorporated into the JAR at Change 15.

(2) If the proposed action differs for the JAA, explain the proposed JAA action.

Not Applicable

(3) If the proposed action differs for the JAA, explain why there is a difference between FAA and JAA proposed action (e.g., administrative differences in applicability between authorities).

Not Applicable

3. COSTS AND OTHER ISSUES THAT MUST BE CONSIDERED

The Working Group should answer these questions to the greatest extent possible. What information is supplied can be used in the economic evaluation that the FAA must accomplish for each regulation. The more quality information that is supplied, the quicker the evaluation can be completed.

a. COSTS ASSOCIATED WITH THE PROPOSAL

(1) Who would be affected by the proposed change? How? (Identify the parties that would be materially affected by the rule change – airplane manufacturers, airplane operators, etc.)

The proposed guidance material defines the extent of analysis and type and number of tests that should be repeated in order to achieve the necessary level of confidence in structural integrity without undue cost penalties for alternative composite materials used on a previously certificated composite structure. For the majority of cases, this effort will be less than that previously required for the original certification, thus benefiting the airplane manufacturers and minimizing the oversight efforts of the authorities.

(2) What is the cost impact of complying with the proposed regulation? Provide any information that will assist in estimating the costs (either positive or negative) of the proposed rule.

No specific cost estimates of the benefit of this change are available. However, minimizing the certification efforts for changes in composite materials will benefit all manufacturers who attempt to qualify alternate materials for previously certificated composite structures.

b. OTHER ISSUES

(1) Will small businesses be affected? *(In general terms, "small businesses" are those employing 1,500 people or less. This question relates to the Regulatory Flexibility Act of 1980 and the Small Business Regulatory Enforcement Fairness Act of 1996.]*

Small businesses will not be affected.

(2) Will the proposed rule require affected parties to do any new or additional record keeping? If so, explain. *[This question relates to the Paperwork Reduction Act of 1995.]*

No.

(3) Will the proposed rule create any unnecessary obstacles to the foreign commerce of the United States -- i.e., create barriers to international trade? *[This question relates to the Trade Agreement Act of 1979.]*

No.

(4) Will the proposed rule result in spending by State, local, or tribal governments, or by the private sector, that will be $100 million or more in one year? *[This question relates to the Unfunded Mandates Reform Act of 1995.]*

No.

4. ADVISORY MATERIAL

a. Is existing FAA or JAA advisory material adequate? Is the existing FAA and JAA advisory material harmonized?

There is no specific FAA advisory material for certification of alternative materials for composite structures other than the requirements for initial composite structure certification contained in AC 20-107A. However, JAA advisory material was developed in NPA 25D-256 and was incorporated into ACJ 25.603 and AMJ 25.603 guidance material at Change 15 of the JAR.

b. If not, what advisory material should be adopted? Should the existing material be revised, or should new material be provided?

Based on OEM and regulator experience the guidance material of NPA 25D-256 should be incorporated into the existing AC20-107A.

c. Insert the text of the proposed advisory material here (or attach), or summarize the information it will contain, and indicate what form it will be in (e.g., Advisory Circular, Advisory Circular – Joint, policy statement, FAA Order, etc.)

The guidance material in JAR Change 15 ACJ 25.603 Section 9.0 is proposed to be adopted as a new Section 10.0 in AC20-107A and the guidance material in JAR Change 15 AMJ 25.603 is proposed to be adopted as a new Appendix 3 to AC20-107A. These proposed changes are shown in a revised version of AC20-107A below and are applicable for FAR 25 compliance findings.

U.S. Department
of Transportation

Federal Aviation Administration

ADVISORY CIRCULAR

Subject: COMPOSITE AIRCRAFT STRUCTURE **Date:** 4/25/84 **AC No:** 20-107A
Initiated by: AWS-103 **Change:**

1. PURPOSE. This advisory circular sets forth an acceptable, but not the only, means of showing compliance with the provisions of Federal Aviation Regulations (FAR), Parts 23, 25, 27, and 29 regarding airworthiness type certification requirements for composite aircraft structures, involving fiber reinforced materials, e.g., carbon (graphite), boron, aramid (Kevlar), and glass reinforced plastics. Guidance information is also presented on associated quality control and repair aspects.

2. CANCELLATION. AC 20-107A, Composite Aircraft Structure dated July 10, 1978, is canceled.

3. REGULATIONS AFFECTED. The material contained herein applies to normal, utility, acrobatic, and transport category aircraft type certificated under Civil Aviation Regulations (CARs) 3, 4b, 6, 7; and FARs 23, 25, 27, 29; and produced in compliance with FAR Part 21, sections 21.125, or 21.143 as may be appropriate. The individual FARs applicable to each paragraph are listed in Appendix 1 of this advisory circular.

4. GENERAL

a. The procedures outlined in this advisory circular provide guidance material for composite structures and are considered acceptable to the FAA for showing compliance with certification requirements of civil composite aircraft. This circular is published to aid in the evaluation of certification programs for composite applications and reflects the current status of composite technology. It is expected that this circular will be modified periodically to reflect technology advances. The information contained herein is for guidance purposes and is not mandatory nor regulatory in nature.

b. The extent of testing and/or analysis and the degree of environmental accountability required will differ for each structure depending upon the expected service usage, the material selected, the design margins, the failure criteria, the data base and experience with similar structures, and on other factors affecting a particular structure. It is expected that these factors will be considered when interpreting this advisory circular for use on a specific application.

c. Pertinent definitions are given in Appendix 2.

5. MATERIAL AND FABRICATION DEVELOPMENT. To provide an adequate design database, environmental effects on the design properties of the material system should be established.

a. Environmental design criteria should be developed that identify the most critical environmental exposures, including humidity and temperature, to which the material in the application under evaluation may be exposed. This is not required where existing data demonstrate that no significant environmental effects, including the effects of temperature and moisture, exist for the material system and construction details, within the bounds of environmental exposure being considered. Experimental evidence should be provided to demonstrate that the material design values or allowables are attained with a high degree of confidence in the appropriate critical environmental exposures to be expected in service. The effect of the service environment on static strength, fatigue and stiffness properties should be determined for the material system through tests; e.g., accelerated environmental tests, or from applicable service data. The effects of environmental cycling (i.e., moisture and temperature) should be evaluated. Existing test data may be used where it can be shown directly applicable to the material system.

b. The material system design values or allowables should be established on the laminate level by either test of the laminate or by test of the lamina in conjunction with a test validated analytical method.

c. For a specific structural configuration of an individual component (point design), design values may be established which include the effects of appropriate design features (holes, joints, etc.).

d. Impact damage is generally accommodated by limiting the design strain level.

6. PROOF OF STRUCTURE - STATIC. The static strength of the composite design should be demonstrated through a program of component ultimate load tests in the appropriate environment, unless experience with similar designs, material systems and loadings is available to demonstrate the adequacy of the analysis supported by subcomponent tests, or limit load component tests.

a. The effects of repeated loading and environmental exposure which may result in material property degradation should be addressed in the static strength evaluation. This can be shown by analysis supported by test evidence, by tests at the coupon, element or subcomponent level, or alternatively by relevant existing data.

b. Static strength structural substantiation tests should be conducted on new structure unless the critical load conditions are associated with structure that has been subjected to a repeated loading and environmental exposure. In this case either (1) the static test should be conducted on structure with prior repeated loading and environmental exposure, or (2) coupon/element/subcomponent test data should be provided to assess the possible degradation of static strength after application of repeated loading and environmental exposure, and this degradation accounted for in the static test or in the analysis of the results of the static test of the new structure.

c. The component static test may be performed in an ambient atmosphere if the effects of the environment are reliably predicted by subcomponent and/or coupon tests and are accounted for in the static test or in the analysis of the results of the static test.

d. The static test articles should be fabricated and assembled in accordance with production specifications and processes so that the test articles are representative of production structure.

e. When the material and processing variability of the composite structure is greater than the variability of current metallic structures, the difference should be considered in the static strength substantiation (1) by deriving proper allowables or design values for use in the analysis, and the analysis of the results of supporting tests, or (2) by accounting for it in the static test when static proof of structure is accomplished by component test.

f. Composite structures that have high static margins of safety (e.g., some rotor blades) may be substantiated by analysis supported by subcomponent, element, and/or coupon testing.

g. It should be shown that impact damage that can be realistically expected from manufacturing and service, but not more than the established threshold of detectability for the selected inspection procedure, will not reduce the structural strength below ultimate load capability. This can be shown by analysis supported by test evidence, or by tests at the coupon, element or subcomponent level.

7. PROOF OF STRUCTURE - FATIGUE/DAMAGE TOLERANCE. The evaluation of composite structure should be based on the applicable requirements of FAR 23.571, 23.572, 25.571, 27.571, and 29.571. The nature and extent of analysis or tests on complete structures and/or portions of the primary structure will depend upon applicable previous fatigue/damage tolerant designs, construction, tests, and service experience on similar structures. In the absence of experience with similar designs, FAA-approved structural development tests of components, subcomponents, and elements should be performed. The following considerations are unique to the use of composite material systems and should be observed for the method of substantiation selected by the applicant. When selecting the damage tolerance or safe life approach, attention should be given to geometry, inspectability, good design practice, and the type of damage/degradation of the structure under consideration.

a. Damage Tolerance (Fail-Safe) Evaluation.

(1) Structural details, elements, and subcomponents of critical structural areas should be tested under repeated loads to define the sensitivity of the structure to damage growth. This testing can form the basis for validating a no-growth approach to the damage tolerance requirements. The testing should assess the effect of the environment on the flaw growth characteristics and the no-growth validation. The environment used should be appropriate to the expected service usage. The repeated loading should be representative of anticipated service usage. The repeated load testing should include damage levels (including impact damage) typical of those that may occur during fabrication, assembly, and in-service, consistent with the inspection techniques employed. The damage tolerance test articles should be fabricated and

assembled in accordance with production specifications and processes so that the test articles are representative of production structure.

(2) The extent of initially detectable damage should be established and be consistent with the inspection techniques employed during manufacture and in service. Flaw/damage growth data should be obtained by repeated load cycling of intrinsic flaws or mechanically introduced damage. The number of cycles applied to validate a no-growth concept should be statistically significant, and may be determined by load and/or life considerations. The growth or no growth evaluation should be performed by analysis supported by test evidence or by tests at the coupon, element, or subcomponent level.

(3) The extent of damage for residual strength assessments should be established. Residual strength evaluation by component or subcomponent testing or by analysis supported by test evidence should be performed considering that damage. The evaluation should demonstrate that the residual strength of the structure is equal to or greater than the strength required for the specified design loads (considered as ultimate). It should be shown that stiffness properties have not changed beyond acceptable levels. For the no-growth concept residual strength testing should be performed after repeated load cycling.

(4) An inspection program should be developed consisting of frequency, extent, and methods of inspection for inclusion in the maintenance plan. Inspection intervals should be established such that the damage will be detected between the time it initially becomes detectable and the time at which the extent of damage reaches the limits for required residual strength capability. For the case of no-growth design concept, inspection intervals should be established as part of the maintenance program. In selecting such intervals the residual strength level associated with the assumed damages should be considered.

(5) The structure should be able to withstand static loads (considered as ultimate loads) which are reasonably expected during a completion of the flight on which damage resulting from obvious discrete sources occur (i.e., uncontained engine failures, etc.). The extent of damage should be based on a rational assessment of service mission and potential damage relating to each discrete source.

(6) The effects of temperature, humidity, and other environmental factors which may result in material property degradation should be addressed in the damage tolerance evaluation.

b. Fatigue (Safe-Life) Evaluation. Fatigue substantiation should be accomplished by component fatigue tests or by analysis supported by test evidence, accounting for the effects of the appropriate environment. The test articles should be fabricated and assembled in accordance with production specifications and processes so that the test articles are representative of production structure. Sufficient component, subcomponent, element or coupon tests should be performed to establish the fatigue scatter and the environmental effects. Component, subcomponent, and/or element tests may be used to evaluate the fatigue response of structure with impact damage levels typical of those that may occur during fabrication, assembly, and in service, consistent with the inspection procedures employed. The component fatigue test may be performed with an as-manufactured test article if the effects of impact damage are reliably predicted by subcomponent and/or element tests and are accounted for in the fatigue test or in analysis of the results of the fatigue test. It should be demonstrated during the fatigue tests that the stiffness properties have not changed beyond acceptable levels. Replacement lives should be established based on the test results. An appropriate inspection program should be provided.

8. PROOF OF STRUCTURE - FLUTTER. The effects of repeated loading and environmental exposure on stiffness, mass and damping properties should be considered in the verification of integrity against flutter and other aeroelastic mechanisms. These effects may be determined by analysis supported by test evidence, or by tests at the coupon, element or subcomponent level.

9. ADDITIONAL CONSIDERATIONS.

a. Impact Dynamics. The present approach in airframe design is to assure that occupants have every reasonable chance of escaping serious injury under realistic and survivable impact conditions. Evaluation may be by test or by analysis supported by test evidence. Test evidence includes but is not limited to element or subcomponent tests and service experience. Analytical comparison to conventional structure may be used where shown to be applicable.

b. Flammability.

(1) The existing requirements for flammability and fire protection of aircraft structure attempt to minimize the hazard to the occupants in the event ignition of flammable fluids or vapors occur. In addition, components exposed to heat, flames or sparks should withstand these effects. The use of composite structure should not decrease this existing level of safety. Compliance may be shown by analysis supported by test evidence that aircraft interior material subjected to these hazards can withstand fire and heat as required in FAR 25.

(2) Certain aircraft structure is required to be fire resistant. The following test is considered acceptable for demonstrating compliance for aircraft exterior structure and engine compartment materials that are to be fire resistant. A comparison test should be made between the specimen and an aluminum alloy sheet of the thickness normally used for the intended installation. The structure and materials should be tested by subjecting a specimen sheet 24 inches by 24 inches positioned perpendicular to a 2000 ° F plus or minus 150 ° F flame produced by a modified oil burner consuming two gallons of kerosene per hour. The burner should be positioned so that the time required for the flame to penetrate the aluminum alloy sample would be approximately five minutes. The test specimen should be positioned at the same distance from the burner flame as the aluminum alloy sheet. The specimen will be considered satisfactory if it resists flame penetration for a time period equal to or greater than the aluminum alloy sheet.

c. Lightning Protection.

(1) Some composites are susceptible to lightning damage, and do not dissipate P-static electrical charges or provide electromagnetic shielding. Therefore it should be demonstrated by analysis support by test evidence that the structure can dissipate P-static electrical charges, provides electromagnetic protection where required and provides an

acceptable means of diverting the resulting electrical current (as a result of a lightning strike) so as not to endanger the aircraft.

(2) Consideration should be given possible deterioration and undetected damage to the lightning protection system.

d. Protection of Structure. Weathering, abrasion, erosion, ultraviolet radiation, and chemical environment (glycol, hydraulic fluid, fuel, cleaning agents, etc.) may cause deterioration in a composite structure. Suitable protection against and/or consideration of degradation in material properties should be provided for and demonstrated by test.

e. Quality Control. The overall plan required by the certifying agency should involve all relevant disciplines, i.e., engineering, manufacturing and quality control. This quality control plan should be responsive to special engineering requirements that arise in individual parts or areas as a result of potential failure modes, damage tolerance and flaw growth requirements, loadings, inspectability, and local sensitivities to manufacture and assembly.

f. Production Specifications. Specifications covering material, material processing, and fabrication procedures should be developed to ensure a basis for fabricating reproducible and reliable structure. The discrepancies permitted by the specifications should be substantiated by analysis supported by test evidence, or tests at the coupon, element or subcomponent level.

g. Inspection and Maintenance. Maintenance manuals developed by manufacturers should include appropriate inspection, maintenance and repair procedures for composite structures.

h. Substantiation of Repair. When repair procedures are provided in FAA approved documents or the maintenance manual, it should be demonstrated by analysis and/or test that methods and techniques of repair will restore the structure to an airworthy condition.

10. CHANGE OF COMPOSITE MATERIAL – Part 25 (See also Appendix 3).

a. For composite structures a change of material is defined as any of the following situations (even though the structural design remains unchanged).

(1) Any change in the basic constituents.
(2) The same basic constituents but any change of the impregnation method.
(3) The same material, but modification of the processing route.

b. For any material change the showing of compliance with FAR 25.603 should cover paragraphs b(1) to b(5) in detail.

(1) The nature and extent of the material change should be clearly defined.

(2) Substantiation should be based on a comparability study between the structural performances of the material accepted for type certification and the replacement

material. An acceptable approach would be to select from the original substantiating testing those tests that are to be repeated and to justify the omission of others. The extent of testing required will depend on the airworthiness significance of the part and the nature of the material change.

(3) Pass /fail targets should be established as part of the agreement to the test program. Any properties that show a significant change in the replacement material should be given special consideration.

(4) The test substantiation selected should interrogate the critical failure modes of the component.

(5) Design allowables should be established to the same level of statistical confidence for the replacement material.

M.C. Beard
Director of Airworthiness

APPENDIX 1. APPLICABLE FARs AND RELATED ADVISORY CIRCULARS

Text Paragraphs	FAR 23	FAR 25	FAR 27	FAR 29
1. PURPOSE		Not Applicable		
2. CANCELLATION		Not Applicable		
3. REGULATIONS AFFECTED		Not Applicable		
4. GENERAL		Not Applicable		
5. MATERIAL AND FABRICATION DEVELOPMENT				
	.603	.603	.603	.603
	.613	.613	.613	.613
	.615	.615		
6. PROOF OF STRUCTURE - STATIC	.305	.305	.305	.305
	.307(a)	.307(a)	.307(a)	.307(a)
7. PROOF OF STRUCTURE - FATIGUE/DAMAGE TOLERANCE				
	.571	.571	.571	.571
	.572		AC 20-95	AC 20-95
8. PROOF OF STRUCTURE - FLUTTER	.629	.629	.629	.629
9. ADDITIONAL CONSIDERATIONS				
a. Impact Dynamics	.561	.561	.561	.561
	.601	.601		
	.785	.721	.601	.601
		.783(c)(g)	.785	.783(d)
	.787(e)	.785	.787(c)	.785
	.807(b)(4)	.787(a)(b)	.801	.787(c)
	.967(e)	.789	.807(b)(4)	
		.801	.965	.801
		.809		.803(c)(1)
		.963(d)		

APPENDIX 1. APPLICABLE FARs AND RELATED ADVISORY CIRCULARS

Text Paragraphs	FAR 23	FAR 25	FAR 27	FAR 29
ADDITIONAL CONSIDERATIONS				
a. Impact Dynamics (cont'd)				
		*	.1413	.809 .963(b) .967(f)
b. Flammability	.609(a)	.609(a)	.609(a)	.609(a)
	.787(d)	.853	.853	.853
	.853	.855	.855	.855
	.859	.859	.859	.859
	.865	.863	.861	.861
	.1121(c)	.865	.1183	.863
	.1182	.867	.1185	.903(c)
	.1183	.903(c)	.1191	.967(e)
	.1189(b)(2)	.967(e)	.1193(d)(e)	
	.1191	.1121(c)	.1194	.1013(e)
	.1193(c)(d)(e)	.1181		.1121(c)
		.1182		.1183
		.1183		.1185
		.1185		.1189(a)(2)
		.1189(a)(2)		.1191
		.1191		.1193(c)(d)(e)
		.1193(c)(d)(e)		.1194

* Special Conditions have been issued in the past on wide body airplanes concerning emergency wheels up landing.

APPENDIX 1. APPLICABLE FARs AND RELATED ADVISORY CIRCULARS

Text Paragraphs	FAR 23	FAR 25	FAR 27	FAR 29
ADDITIONAL CONSIDERATIONS				
c. Lightning Protection	.609 .867	.581 .609	.609	.609
d. Protection of Structure	.609	.609	.609	.609
e. Quality Control	**	**	**	**
f. Production Specifications	.603 .605	.603 .605	.603 .605	.603 .605
10. CHANGE OF COMPOSITE MATERIAL		.603		

** A new Advisory Circular on Quality Control for Composites is under development.

APPENDIX 2. DEFINITIONS

Design values - material, structural element, and structural detail properties that have been determined from test data and chosen to assure a high degree of confidence in the integrity of the completed structure [reference FAR 25.613(b)].

Allowables - material values that are determined from test data at the laminate or lamina level on a probability basis, e.g., A or B base values [reference FAR 25.615(a)].

Laminate level design values or allowables - established from multi-ply laminate test data and/or from test data at the lamina level and then established at the laminate level by test validated analytical methods.

Lamina level material properties - established from test data for a single ply or multi-ply single direction oriented lamina layup.

Point design - an element or detail of a specific design which is not considered generically applicable to other structure for the purpose of substantiation, e.g., lugs and major joints. Such a design element or detail can be qualified by test or by a combination of test and analysis.

Environment - external, non-accidental conditions (excluding mechanical leading), separately or in combination, that can be expected in service and which may affect the structure (e.g., temperature, moisture, UV radiation, and fuel).

Degradation - the alteration of material properties (e.g., strength, modulus, coefficient of expansion) which may result from deviations in manufacturing or from repeated loading and/or environmental exposure.

Discrepancy - a manufacturing anomaly allowed and detected by the planned inspection procedure. They can be created by processing, fabrication or assembly procedures.

Flaw - a manufacturing anomaly created by processing, fabrication or assembly procedures.

Damage - a structural anomaly caused by manufacturing (processing, fabrication, assembly or handling) or service usage. Usually caused by trimming, fastener installation or foreign object contact.

Impact damage - a structural anomaly created by foreign object impact.

Coupon - a small test specimen (e.g., usually a flat laminate) for evaluation of basic lamina or laminate properties or properties of generic structural features (e.g., bonded or mechanically fastened joints).

APPENDIX 2. DEFINITIONS

Element - a generic element of a more complex structural member (e.g., skin, stringers, shear panels, sandwich panels, joints, or splices).

Detail - a non-generic structural element of a more complex structural member (e.g. specific design configurated joints, splices, stringers, stringer runouts, or major access holes).

Subcomponent - a major three-dimensional structure which can provide complete structural representation of a section of the full structure (e.g. stub-box, section of a spar, wing panel, wing rib, body panel, or frames).

Component - a major section of the airframe structure (e.g., wing, body, fin, horizontal stabilizer) which can be tested as a complete unit to qualify the structure.

APPENDIX 3 CHANGE OF COMPOSITE MATERIALS

Purpose

This Appendix provides guidance for the re-certification of composite structures that, in production, use a different material from that proposed and substantiated at the time of certification of the original structure. It is issued to provide guidance and to outline an acceptable method of showing compliance with FAR 25 certification requirements.

Scope

This Appendix only addresses already certificated composite structures where there is no change to the design and use other than the material change. Components that have a change in geometry or design loading may need to be addressed in a different way.

1. *Background*

The showing of compliance of a new material with FAR 25 requirements, as an alternative to the previously selected material, should normally involve the following steps:

- identify the key material parameters governing performances,
- define the appropriate tests able to measure these parameters,
- define pass/fail criteria for these tests.

The problem with composites is much more complex than with metallic materials, because their performance is much more process dependent. So, until we are capable of accurately identifying the key material parameters governing processability, there will be a need for tests directly interrogating material performance through specimens representative of the actual design details of the composite structure.

Today, showing the suitability of a composite material for its anticipated use, requires a large amount of test data ranging from the coupon level to specimens representative of the most complex features of the structure design. The time needed to perform all these tests and the associated costs are the reasons why, in most cases, only one material can be proposed for type certification.

Such diversity of testing is required with composites because these materials develop their mechanical properties only when the component is processed (or at least, the resin cured) i.e. that the design of the structure and the associated production processes govern these properties.

To give a more technical interpretation of this specific character of composites, it is necessary to go back to the general principles for dimensioning a structure. Theoretically the strength of a structure could be calculated with analytical models capable, from the knowledge of relevant material properties, of anticipating the mechanical behavior of complex design details. Unfortunately with composites these analytical models are still insufficiently precise at the level of failure prediction and require a step-by-step testing verification with more and more complex specimens (the "pyramid" approach).

Moreover, as the design and the associated manufacturing process can affect the eventual properties, the failure modes along with composite failure prediction models may vary from one material to another. Consequently, they both need to be examined for any material change.

"In house" composite material "qualification" procedures developed by every manufacturer involve specifications covering:

- physical plus, in some cases, chemical properties,
- mechanical properties measured at the coupon level,
- reproducibility (checked by testing several batches).

But interchangeability for a structural application is not guaranteed between two materials meeting the same manufacture specification (as it could be for materials that are much less process dependant, metallic materials for instance). Under these circumstances, a material that meets the "qualification" required by a specification does not necessarily produce satisfactory components.

2. *Definition of Material Change*

There is a material change in any of the following situations:

A- A change in one or both of the basic constituents
  - resin
  - fiber (including sizing or surface treatment alone).

B- Same basic constituents but any change of the impregnation method
  - prepregging process (e.g. solvent bath to hot melt coating),
  - tow size (3k, 6k, 12k) with the same fiber areal weight,
  - prepregging machine at the same suppliers,
  - supplier change for a same material (licensed supplier),
  - etc.,

C- Same material but modification of the processing route (if the modification to the processing route governs eventual composite mechanical properties):
  - curing cycle,
  - tooling,
  - lay-up method,
  - environmental parameters of the laying room.

A classification is to be made between a new material which is intended to be a replica of the former one (cases 'B' or 'C') and a 'truly new material' (case 'A'). So, two classes are proposed:

  - 'Identical materials' in case of a replica.

- ‘Alternative materials’ for truly new materials.

Within the ‘identical materials’ class, a sub-classification can be made between a change of the prepregging machine alone at the supplier and licensed production elsewhere. For the time being, a change to a new fiber produced under a licensed process and reputed to be a replica of the former one, will be dealt with as an ‘alternate material’.

Some changes within this class may not interact with structural performances (e.g. prepreg release papers, some bagging materials, etc.) and should not be submitted to an agency approval. However the manufacturers (or the supplier) should develop a proper system for screening those changes, with adequate proficiency at all relevant decision levels.

Case ‘A’ (alternative material) should always be considered as an important change. It is not recommended to try a sub-classification according to the basic constituents being changed, as material behavior (e.g. sensitivity to stress concentrations) may be governed by interfacial properties which may be affected either by a fiber or a resin change.

3. *Substantiation Method*

Only the technical aspects of substantiation are addressed here.

a. *Compliance philosophy*

Substantiation should be based on a comparability study between the structural performances of the material accepted for type certification, and the second material.

Whatever the modification proposed for a certificated item, the revised margins of safety should remain adequate. Any reduction in the previously demonstrated margin should be investigated in detail.

Identical material (case “B” and “C”):

- allowables and design values, whatever the level of investigation; material or design, should remain valid,
- calculation models – including failure prediction should remain the same,
- the technical content of the procurement specification (case “B”) should not be changed.

Alternative material (case “A”):

- new allowables and design values for all relevant properties should be determined,
- analytical models, including failure prediction models, should be reviewed and, if necessary, substantiated by tests,

- the procurement specification should be evaluated (or a new specification suited to the newly selected material should be defined) to adequately control quality variations.
- example changing from 1st to 2nd generation of carbon fibers may improve tensile strength properties by more than 20%: so keeping the same acceptability threshold in the process specification would not allow the detection of quality variations.

b. *Tests to be performed*

The pyramid of tests (building block approach) illustrated in Figure 1 is a consistent way to prepare and present structural substantiation for approval. Each stage of this pyramid refers to an investigation level in terms of specimen category (coupon, element, detail, sub-component and component) as they are defined in Appendix 2. Coupons and elements are generic specimens which form the database and can be common to several pyramids. The non-generic specimens (details, sub-component, component) are specific to each composite item.

Under these circumstances substantiation to be provided for a changed material cannot be independent from the structural item concerned and a universal list of tests cannot be established. The approach would then consist in selecting, within each pyramid, those tests that are to be duplicated with the second material for the component under examination and the justification of the omission of others.

As a first approach, the investigation level might be restricted to the generic specimens for an identical material, but for an alternative material non-generic ones should be included.

Typically, substantiation should always cover the inherent structural behavior of composites. The program should be established considering the material change proposed and the airworthiness significance of the part. An example list of tests is given in table 1.

This table applies also for a change in the process route Case C. In some instances (e.g. a cure cycle change) possible consequences can be assessed by tests on generic specimens only. For other changes like those involving tooling (e.g. from a full bag process to thermo-expansive cores) the assessment should include an evaluation of the component itself (sometimes called the 'tool proof test'). In this case, an expanded non-destructive procedure should be required for the first items to be produced. This should be supplemented – if deemed necessary – by 'cut up' specimens from a representative component, for physical or mechanical investigations.

c. *Number of batches*

The purpose for testing a number of batches is the demonstration of an acceptable reproducibility of material characteristics. The number of batches required should take into account:
- material classification (identical or alternative),
- the investigation level (non-generic or generic specimen),
- the source of supply,
- the property under investigation.

d. Pass/Fail Criteria

Target pass/fail criteria should be established as part of the test program. As regards strength considerations for instance, a statistical analysis of test data should demonstrate that new allowables derived for the second material provide an adequate margin of safety. Therefore, provision should be made for a sufficient number of test specimens to allow for such analysis. At the non-generic level, when only one test article is used to assess a structural feature, the pass criteria should be a result acceptable with respect to design ultimate loads. In the cases where test results show lower margins certification documentation will need to be revised.

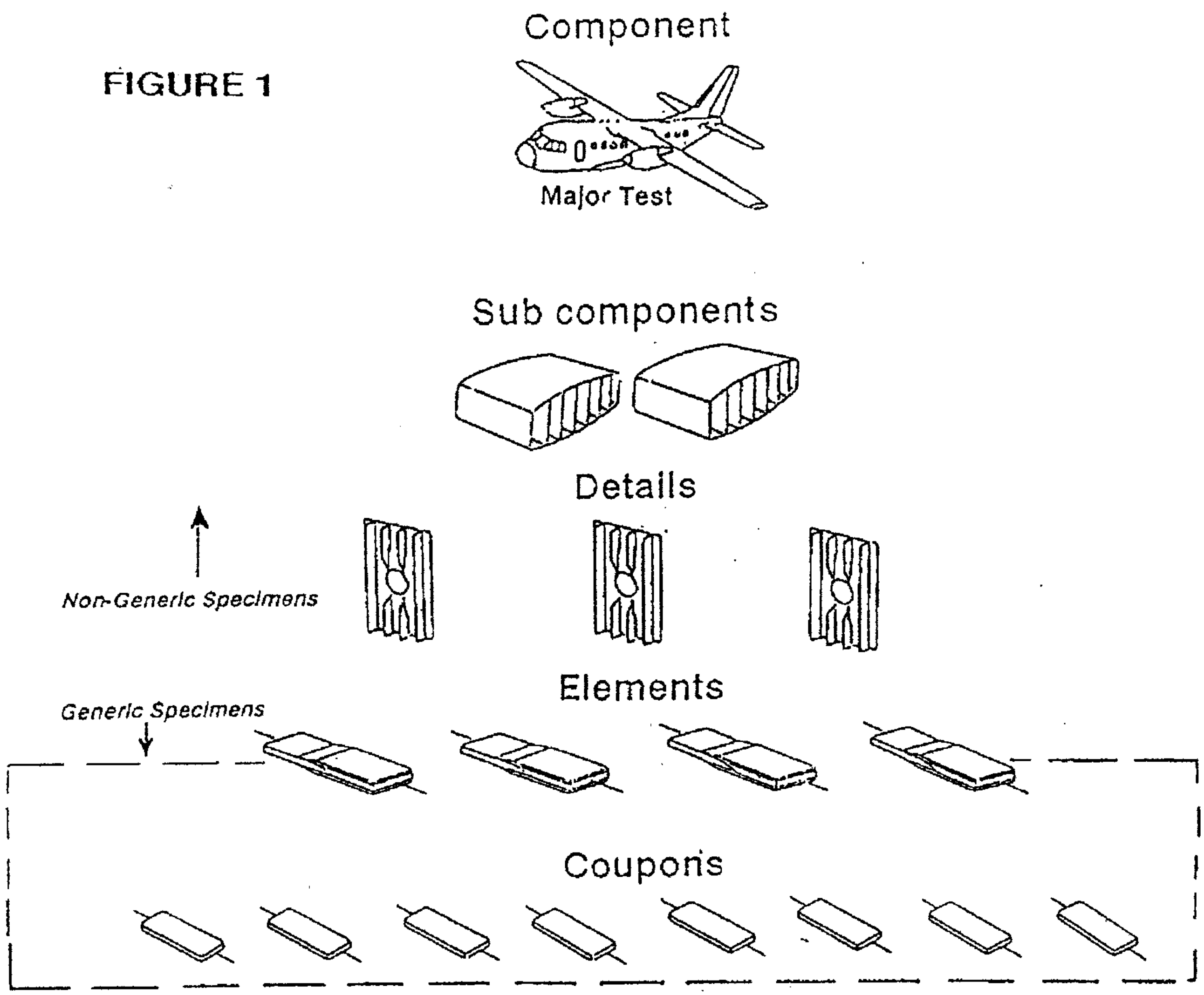
e. Other considerations

For characteristics other than strength (all those listed in paragraphs 8 and 9) the substantiation should also ensure an equivalent level of safety.

Table 1
EXAMPLES OF TESTS THAT MAY NEED TO BE CARRIED OUT

				Number of Batches		
				Alternative Material “A”	Identical B”	Material C”
Generic Tests	On the material	Material Identity	**- Physical tests (aerial weight, resin content, volatile content).** **- Thermomechanical tests** **- Physio-chemical characterization of the resin (IR, HPLC, DSC, etc.)** **- Fiber Characterization, etc.**	up to 3	1 min	0
Generic Tests	On the Laminate	Structural Properties	- Physical tests (cured ply thickness, fiber content, porosity, etc.) - Mechanical test: - on unidirectional lay-up, - on standardized stacking sequences, taking into account: - stress raiser effects in static - temperature/environmental sensitivity - bearing effects - tolerance to manufacturing defects, etc.	up to 5	up to 3	1
Non-generic tests		Structural Properties	- Tests on stacking sequences representative of the actual ones on the design - Damage tolerance tests - Detailed tests (e.g.: stringer runouts, access holes, sandwich panels if relevant, etc.) To be selected, from engineering judgment, within the pyramid of tests provided for the first material.	1	0	0
Non-generic tests		Processability	Tool proof tests	1	1	1
Non-generic tests		Other Considerations	Impact dynamics, flammability, lightning protection, flutter, protection of structure, substantiation of repairs.	1	0	0

FIGURE 1


Component
Major Test
Sub components
Details
Non-Generic Specimens
Elements
Generic Specimens
Coupons

June 30, 2003
L350-03-114

Mr. Craig R. Bolt
Assistant Chair, TAEIG
Pratt & Whitney
400 Main Street
East Hartford, Ct 06108

Dear Craig,

Subject: Submittal of Results of Harmonization Effort on FAR/JAR §25.631, Birdstrike

This submittal is a follow-up to earlier submittals in July of 1995 and June of 1999 on the same subject. The General Structures Harmonization Working Group, having spent ten years of meetings and discussions on this subject, cannot reach consensus on a harmonized set of criteria for birdstrike. Two issues continue to divide the group: 1) bird weight and 2) cutback speed. The group therefore has agreed to disagree and has provided white papers attached to this working group report outlining the individual positions.

Summary

The GHWG proceeded in good faith to harmonize the material related to birdstrike and did reach agreement within the GSHWG in May 1995 on changes to the rule(s) and the advisory material, with one documented dissenting opinion. A draft NPRM and AC were submitted to TAEIG in July of 1995 for review and submittal to the FAA for legal and economic evaluation. The dissenting opinion, held by the FAA, was noted and the GSHWG resolution of the dissenting opinion was enclosed with the submittal package. TAEIG voted to accept the package and to forward it to the FAA. The package was submitted to the FAA by the TAEIG for legal and economic review in May of 1996.

In January of 1999, the GSHWG chairperson received a memorandum from the economist assigned to the project providing a “rough estimate” of the evaluation of the NPRM and advisory material package that had been submitted. The economist had determined that the safety level had been reduced and that the expected decrease in cost to the industry was so small that it did not appear to justify the proposal. Based on this preliminary result, the FAA indicated they did not wish to invest any more time in completing the evaluation, since it would not be accepted. The GSHWG chairperson relayed this information to the TAEIG in March of 1999. In August of 1999 the TAEIG Assistant Chairperson requested formal technical positions regarding bird weight from the FAA and JAA so that it could be determined if harmonization was possible.

In April of 2000 the FAA provided to the JAA its justification for the FAA position on the eight-pound bird requirement. In August of 2000 the FAA requested the TAEIG opinion on whether or not to close the birdstrike issue. In addition, an FAA sponsored research project, “Assessment of Wildlife Strike Risk to Airframes”, was initiated by the University of Illinois Airport Technology Center of Excellence. In October of 2000, the GSHWG made a recommendation to the TAEIG not to close the birdstrike tasking. The group agreed to review the outcome from FAA sponsored study.

In January of 2001 the SSG issued draft Temporary Guidance Material (TGM) on birdstrike cutback speeds. In August of 2001 the JAA withdrew its support of the GSHWG agreed position on birdstrike, indicating that the issue of "cutback" speeds must be addressed, i.e. "cutback" speeds could no longer be allowed. At the thirty-fourth meeting of the GSHWG in October of 2002, the results of the University of Illinois research (formally documented in a University of Illinois report dated December 2002) were reviewed and several attempts were made to reach group consensus on a harmonized position. The group finally agreed to disagree and submit separate white papers to the TAEIG along with a statement that harmonization cannot be achieved within the group.

The working group report being submitted reflects the lack of harmonization achieved on this subject and provides documentation of each of the major group member positions. The GSHWG deeply regrets that harmonization could not be attained but feels that further efforts at harmonization on this subject by the group would continue to be non-productive.

Sincerely,

Andrew H. Kasowski
General Structures HWG Chairperson
316-517-6008
315-517-1820 FAX
akasowski@cessna.textron.com

Attachment A

General Structures Harmonization Working Group Report

Birdstrike FAR/JAR §25.571(e)(1), 25.631, 25.775(b)(c)

Transport Airplane Directorate
<u>WG Report Format</u>
Harmonization and New Projects

1 - BACKGROUND:

- *This section "tells the story."*
- *It should include all the information necessary to provide context for the planned action. Only include information that is helpful in understanding the proposal -- no extraneous information (e.g., no "day-by-day" description of Working Group's activities).*
- *It should provide an answer for all of the following questions:*

a. <u>SAFETY ISSUE ADDRESSED/STATEMENT OF THE PROBLEM</u>

(1) What prompted this rulemaking activity (e.g., accident, accident investigation, NTSB recommendation, new technology, service history, etc.)? What focused our attention on the issue?

Part 25 bird strike requirements

Prior to 1970, the only U.S. airworthiness regulation concerning bird strikes on transport category airplanes was Civil Air Regulations (CAR) 4b, which requires no penetration of the windshield by a four pound bird impact at cruise speed. The requirement preceded the jet transport era, and was adopted after a number of crew injuries due to bird penetrations of windshields.

In 1970, the regulations were changed as a result of an accident that occurred in 1962, in which a Vickers Viscount turboprop airplane operated by a U.S. airline experienced loss of control and crashed with no survivors near Chesapeake, Maryland. The accident was caused by impact with a swan, estimated to weigh between 12 and 17 pounds, which damaged the horizontal stabilizer and elevator while the airplane was in cruise flight at 6,000 feet altitude. That resulted in an FAA review of existing statistical bird strike data. As a result of that review, the FAA concluded that transport airplanes should be capable of continued safe flight and landing after impact with birds weighing up to eight pounds. This was formalized as an FAA proposal for the 1966 Airworthiness Review Conference.

The FAA reviewed statistical data collected from actual air carrier operations and noted that the fail-safe design principles used for structure and control systems had provided a high degree of protection against catastrophic damage due to the impact of large birds such as geese even when multiple strikes had occurred. The FAA also conducted bird strike testing on several types of jet transport airplanes, which served to reinforce the service data. The FAA concluded that most existing transport airplanes were inherently bird resistant, although a few types, such as the one noted above which crashed, were not sufficiently resistant in the empennage area.

The FAA anticipated that jet transports would displace propeller-driven airplanes in the 1970's and 1980's. After considering the above factors, the FAA determined that a specific rule applying to the entire airplane would only add to the substantiation effort without providing any significant design changes. Therefore, Notice of Proposed Rulemaking 68-18 (33 FR 11913, August 22, 1968) proposed the addition of § 25.631 which would require airplanes to be capable of continued safe flight and landing after impact on the empennage by an eight pound bird at design cruise speed.

There were a number of comments received on the above FAA proposal. One European airworthiness authority commented that having a requirement only on the tail was illogical, and that smaller airplanes in the weight range of 13,000 to 40,000 lbs. would be vulnerable from wing impacts. Also noted by that commenter was the fact that the proposed eight-pound requirement would not have prevented the one accident (noted above), and that the size of the bird should be based on probability considerations. The US Aerospace Industries Association commented that four pounds would be sufficient, since it had proven satisfactory for windshields. There were several comments that the eight-pound bird was not realistic and that larger birds should be considered (one commenter proposed 12 pounds, another 20 pounds), and that any requirement should also be applied to the wings and the windshield as well as the tail.

The FAA responded to the comments that service experience did not indicate an inadequacy in the resistance to the impact of large birds on structures other than the empennage, and that impacts with birds weighing more than eight pounds were rare enough that they need not be considered.

As a result of Notice 68-18 and subsequent comments, part 25 was amended in 1970 (Amendment 25-23; 35 FR 5665, April 8, 1970) to add a new § 25.631 that required the empennage structure to be designed to assure the capability of continued safe flight and landing after impact with an eight pound bird at speeds up to the design cruise speed at sea level.

Other rule changes regarding bird strikes have been introduced since § 25.631 was adopted.

On August 15, 1977, the FAA published Notice 77-15 (41 FR 41236, August 15,1977) proposing new damage tolerance requirements to be added to § 25.571, "Fatigue Evaluation of Flight Structure", including requirements for discrete damage caused by bird impact. Only a few comments were received regarding bird strike damage. Two stated that the proposed bird strike requirement (continued safe flight following impact with a four pound bird at likely operational speeds) was inconsistent with §§ 25.631 and 25.775 (the windshield requirement). A major European airplane manufacturer commented that §§ 25.631 and 25.775 were completely adequate to ensure safety and that there was no justification for the proposed additional bird requirement. On December 1, 1978, § 25.571 was amended (Amendment 25-45; 45 FR 46242, October 5, 1978) as proposed, although the FAA did note in the preamble that there was some merit to having consistent requirements. It is unclear why the FAA originally proposed an inconsistent weight requirement, or why it failed to fully address the comment concerning justification of the proposal. There has been no reported incident where impact by a bird weighing four pounds or less has resulted in a serious non-engine related safety hazard to any transport category airplane.

The bird strike requirement of § 25.571(e) was amended further by Amendment 25-72 (55 FR 29776, July 20, 1990), which changed the speed requirement from "likely operational speed" to "design cruise speed." That was accomplished in part to harmonize the requirement with the existing JAR, and to prevent possible ambiguous interpretations of likely operational speeds. There is a current FAA proposal to correct an unintentional error in that amendment; it would specify a speed of Vc at sea level or 0.85Vc at 8,000 feet, whichever is the more critical. That is also the current JAA requirement.

In some cases, special interpretations, equivalent safety findings and special conditions have been issued for bird strikes. Since § 25.631 does not apply to wings, the FAA has requested, and several manufacturers have agreed, to establish an acceptable level of safety for airplanes equipped with winglets, with one winglet missing to account for impact with a large bird. Special interpretations have also been necessary in the application of other rules, such as § 25.365 which applies to the structural design loads arising from depressurization events. The FAA has interpreted that section as requiring an evaluation of the effects of depressurization resulting from the loss of a complete windshield panel from large bird impacts at altitudes up to 8000 feet (above which such impacts have been considered extremely improbable). For some airplanes having certification bases prior to Amendment 25-23, § 25.631 has been applied to design changes involving composite empennage structure.

JAR-25 bird strike requirements

In the late 1960's and early 1970's, when JAR-25 was developed in Europe as an airworthiness code, part 25 was selected as the basic code. The discussions included review of §§ 25.631 and 25.775(b).

The text of § 25.631 (Amendment 23) was not adopted in Change 1 (effective 25 July 1975) of JAR-25. Instead, JAR 25.631 at Change 1 specified that "the aeroplane must be designed to assure capability of continued safe flight and landing after impact with a four pound bird when the velocity of the aeroplane (relative to the bird along the aeroplane's flight path) is equal to Vc at sea level or 0.85 Vc at 8000 ft, whichever is the more critical."

Partially based on the British BCAR Section D, it was purposefully decided to deviate from part 25 on a number of points:

- instead of the empennage only, it was decided to address the complete airplane;
- instead of an eight pound bird, a four pound bird was appropriate;
- an additional "spot-check" at 8000 ft was required to prohibit manufacturers choosing a low Vc at sea level, with a possible rapid increase of Vc just above sea level, that would avoid the intent of the requirement.

The protection of essential systems against bird impact was also addressed in JAR 25.631 (Change 1). This was later (Change 5, effective 1 January 1979) taken out of the basic requirement and put in a separate ACJ 25.631.

It was also decided to adopt the text of § 25.775(b) (Amendment 1) in Change 1 of JAR-25 as JAR 25.775(b), but to change the last part of the sentence of this subparagraph to make reference to JAR 25.631. Section 25.775(c) at Amendment 1 was later adopted as JAR 25.775(c) in Change 8 (effective 30 November 1981).

Amendment 25-45 of part 25 introduced the damage tolerance (discrete source) evaluations in § 25.571(e), where (e)(1) addressed bird strike. This was adopted as JAR 25.571(e)(1) in Change 7 (effective 24 November 1980) of JAR-25, but instead of adopting the part 25 text a reference was made to JAR 25.631. In ACJ 25.571 text was added to require (subparagraph 2.7.2.) the remaining structure (after bird impact) to be able to carry specific loads, and to be free from flutter.

In the latest version of JAR-25 (Change 15, effective 1 June 2000), JAR 25.631, 25.775(b)(c) and 25.571(e)(1) are still contained as described above.

FAA Reassessment of Bird Strike Requirements

In 1987 the FAA initiated a reassessment of the current bird strike regulations due to concerns with new technology. The new technology increased the use of critical systems and composite materials, which were believed to be more sensitive to bird impact. These concepts were not considered when the original empennage requirement was enacted. A draft NPRM was prepared proposing the following new requirements: (1) Continued safe flight and landing after impact, at any location on the airplane, with an eight pound bird at design cruise speed. This would include effects of bird strike on structure as well as systems. (2) No penetration of the fuselage after impact with a four pound bird at design cruise speed.

The draft NPRM received significant negative comments from industry and the regulatory evaluation was revised after consideration of those comments. It then received its regulatory economic and legal evaluations, and in the latter part of 1992 was in final coordination prior to publication, even though substantial industry opposition still existed. At that point, the FAA decided to complete the rulemaking process through ARAC.

In 1989, a bird strike on a twin engine jet transport caused loss of information on four Cathode Ray Tube displays, and tripped a fuel shutoff valve, causing one engine to shut down. The bird, a vulture, approximately 10 pounds, struck (but did not penetrate) the top of the captain's panel of the windshield, while the airplane was flying at 250 KIAS at an altitude of 2500 ft. This incident is an example of what may happen to an airplane equipped with modern electronic flight control systems, where, although the bird does not penetrate the structure, the shock loading resulting from the impact still may have an effect on the functioning of essential systems. This issue is not clearly addressed in the current part 25 regulations, and partially addressed in ACJ 25.631 of JAR-25.

(2) What is the underlying safety issue to be addressed in this proposal?

See Item 1 above.

(3) What is the underlying safety rationale for the requirement?

See Item 1 above.

(4) Why should the requirement exist?

See Item 1 above.

b. Current Standards or Means to Address

(1) If regulations currently exist:

(a) What are the current regulations relative to this subject? (Include both the FAR's and JAR's.)

Current CFR 14 Part 25 text:

§ 25.631 Bird strike damage.
The empennage structure must be designed to assure capability of continued safe flight and landing of the airplane after impact with an 8-pound bird when the velocity of the airplane

(relative to the bird along the airplane's flight path) is equal to V_C at sea level, selected under § 25.335(a). Compliance with this section by provision of redundant structure and protected location of control system elements or protective devices such as splitter plates or energy absorbing material is acceptable. Where compliance is shown by analysis, tests, or both, use of data on airplanes having similar structural design is acceptable.
[Amdt. 25-23, 35 FR 5674, Apr. 8, 1970]

§ 25.571 Damage -- tolerance and fatigue evaluation of structure.

(e) *Damage-tolerance (discrete source) evaluation.* The airplane must be capable of successfully completing a flight during which likely structural damage occurs as a result of –

(1) Impact with a 4-pound bird when the velocity of the airplane relative to the bird along the airplane's flight path is equal to Vc at sea level or 0.85Vc at 8,000 feet, whichever is more critical;
(2) …;
(3) …; or
(4) …..
[Amdt. 25-45, 43 FR 46242, Oct. 5, 1978, as amended by Amdt. 25-54, 45 FR 60173, Sept. 11, 1980; Amdt. 25-72, 55 FR 29776, July 20, 1990; Amdt. 25-86, 61 FR 5222, Feb. 9, 1996; Amdt. 25-96, 63 FR 15714, Mar. 31, 1998; 63 FR 23338, Apr. 28, 1998]

§ 25.775 Windshields and windows.
(a) ….
(b) Windshield panes directly in front of the pilots in the normal conduct of their duties, and the supporting structures for these panes, must withstand, without penetration, the impact of a four-pound bird when the velocity of the airplane (relative to the bird along the airplane's flight path) is equal to the value of V_C, at sea level, selected under § 25.335(a).
(c) Unless it can be shown by analysis or tests that the probability of occurrence of a critical windshield fragmentation condition is of a low order, the airplane must have a means to minimize the danger to the pilots from flying windshield fragments due to bird impact. This must be shown for each transparent pane in the cockpit that --
(1) Appears in the front view of the airplane;
(2) Is inclined 15 degrees or more to the longitudinal axis of the airplane; and
(3) Has any part of the pane located where its fragmentation will constitute a hazard to the pilots.
(d) ….
(e) ….
[Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25-23, 35 FR 5676, Apr. 8, 1970; Amdt. 25-38, 41 FR 55466, Dec. 20, 1976]

***Current JAR text*:**

JAR 25.631 Bird strike damage
The aeroplane must be designed to assure capability of continued safe flight and landing of the aeroplane after impact with a 4 lb bird when the velocity of the aeroplane (relative to the bird along the aeroplane's flight path) is equal to V_C at sea-level or 0·85 V_C at 2438 m (8000

ft), whichever is the more critical. Compliance may be shown by analysis only when based on tests carried out on sufficiently representative structures of similar design. (See ACJ 25.631.)

JAR 25.571 Damage -- tolerance and fatigue evaluation of structure.

(e) *Damage-tolerance (discrete source) evaluation.* The aeroplane must be capable of successfully completing a flight during which likely structural damage occurs as a result of –
(1) Bird impact as specified in JAR 25.631;
(2) …
(3) …
(4) …

JAR 25.775 Windshields and windows
(a) ….
(b) Windshield panes directly in front of the pilots in the normal conduct of their duties, and the supporting structures for these panes, must withstand, without penetration, the bird impact conditions specified in JAR 25.631.
(c) Unless it can be shown by analysis or tests that the probability of occurrence of a critical windshield fragmentation condition is of a low order, the aeroplane must have a means to minimise the danger to the pilots from flying windshield fragments due to bird impact. This must be shown for each transparent pane in the cockpit that –
(1) Appears in the front view of the aeroplane;
(2) Is inclined 15° or more to the longitudinal axis of the aeroplane; and
(3) Has any part of the pane located where its fragmentation will constitute a hazard to the pilots.
(d) …..
(e)…...

(b) How have the regulations been applied? (What are the current means of compliance?) If there are differences between the FAR and JAR, what are they and how has each been applied? (Include a discussion of any advisory material that currently exists.)

See Item a.(1) above.

(c) What has occurred since those regulations were adopted that has caused us to conclude that additional or revised regulations are necessary? Why are those regulations now inadequate?

See Item a.(1) above.

2. If no regulations currently exist:

(a) What means, if any, have been used in the past to ensure that this safety issue is addressed? Has the FAA relied on issue papers? Special Conditions? Policy statements? Certification action items? Has the JAA relied on Certification Review Items? Interim Policy? If so, reproduce the applicable text from these items that is relative to this issue.

Not applicable, current rules exist.

(b) Why are those means inadequate? Why is rulemaking considered necessary (i.e., do we need a general standard instead of addressing the issue on a case-by-case basis?)?

Not applicable, current rules exist.

2. DISCUSSION of PROPOSAL

- *This section explains:*

→ *what the proposal would require,*

→ *what effect we intend the requirement to have, and*

→ *how the proposal addresses the problems identified in Background.*

- *Discuss each requirement separately. Where two or more requirements are very closely related, discuss them together.*
- *This section also should discuss alternatives considered and why each was rejected.*

a. SECTION-BY-SECTION DESCRIPTION OF PROPOSED ACTION

(1) What is the proposed action? Is the proposed action to introduce a new regulation, revise the existing regulation, or to take some other action?

After 10 years of meetings and discussions the group could not reach consensus on a harmonized set of criteria. Two issues continue to divide the group: 1) Bird Weight and 2) Cutback Speed. The group therefore agrees to disagree and has provided white papers attached to this working group report outlining the individual positions.

(2) If regulatory action is proposed, what is the text of the proposed regulation?

Not applicable, no rule changes are proposed.

(3) If this text changes current regulations, what change does it make? For each change:

- What is the reason for the change?
- What is the effect of the change?

Not applicable, no rule changes are proposed.

(4) If not answered already, how will the proposed action address (i.e., correct, eliminate) the underlying safety issue (identified previously)?

Not applicable, no rule changes are proposed.

(5) Why is the proposed action superior to the current regulations?

Not applicable, no rule changes are proposed.

b. Alternatives Considered

(1) What actions did the working group consider other than the action proposed? Explain alternative ideas and dissenting opinions.

Initial discussions of the General Structures Harmonization Working Group focused on the issue of bird weight (eight pounds vs. four pounds, or some other weight). Much time was spent on finding a statistically sound basis for a requirement. Statistical analyses showed the probability of exceeding the energy level associated with the four pound/Vc requirement of JAR-25 to be approximately 10^{-7} per flight (for the complete airframe). The probability of exceeding the energy level associated with an eight pound/Vc requirement was established at approximately 10^{-8} per flight. These numbers, however, are not absolute, since bird strike data are subject to considerable scatter and uncertainty, and further, not every exceedance of these energy levels would result in a catastrophic event. According to European bird strike data bases, in 1.2 % of all bird strikes the weight of the bird is above four pounds, whereas American data bases indicate this number to be 7.2%. For bird weights above eight pounds the numbers are 0.3% and 3.6% respectively. There is also scatter in bird strike rate per flight: European data indicate this rate to be approximately 10^{-3} per flight, whereas American data indicate this rate to be approximately 5 x 10^{-4} per flight. Although there have been numerous bird strikes on airplanes, it is very difficult to establish the bird weight involved. In addition, the reporting of bird strike events varies widely. These situations make it difficult to conclusively develop a statistical based requirement.

It was suggested that the overall exceedance rate should be 10^{-9} per hour (extremely improbable) or better for catastrophic events, and that therefore the eight pound/Vc requirement was the more appropriate one.

It was noted that the number 10^{-9} comes from the system safety assessment of FAR/JAR 25.1309, and is applicable to systems, but not necessarily to structures. The reliability and failure rate of systems can be calculated quite accurately, in contrast to the relatively unreliable bird strike data available, and all the uncertainties attached to bird strike exceedance evaluations based on statistical/probabilistic analyses.

Traditionally, for the definition of load cases the deterministic approach has always been taken rather than a probabilistic one, with the exception of gust loads (that are expressed in limit load only). Therefore, there is no direct comparison possible with the exceedance rate of other structural requirements.

Since bird strike considerations are not taken into consideration in the design of the major components of the airframe, there is an inherent residual strength capability present after bird impact. This is also addressed in the current regulations: continued safe flight and landing is required after a bird impact, with the emphasis on freedom from flutter and residual strength capability. ACJ 25.571 defines very specifically the residual strength capability of the airframe to be considered. These loads in themselves have a probability of exceedance attached to them, although the GSHWG could not define this probability. Defining this probability of exceedance would be even more difficult for flutter. The exceedance rate for a catastrophic event would be less than the probability of exceeding a specific bird impact energy level.

The issue of whether the bird weight should be the same for both airframe and engines was debated at length. A subgroup of the GSHWG and the ARAC Engine Installation Harmonization Working Group met to discuss this matter. Their conclusions are as follows:

There are sound technical reasons for having different bird strike requirements between engines (part 33/JAR-E) and airframes (part 25/JAR-25). Differences in bird strike requirements can be linked to the differences in approach between engine and airframe designers. The airframe structural justification is done at Vc, which at the lower altitudes where most bird strikes occur, is a speed that is rarely used. At the more typical lower operational speeds, the structure would be good for much heavier birds than four pounds, as supported by service experience. Hence, this concept provides an envelope design case for structural impact energy. With engines, forward speed is not the critical parameter, but is allied with the even more important parameters of fan speed, local inlet airflow and multiple birds. Hence protection against large birds may not be covered by an "envelope" case but will need to address the large bird impact directly. Another difference is the effects of the failure. For engines, gross damage may result in loss of all thrust (i.e. loss of function). For airframes, gross damage will rarely result in complete loss of load bearing capability. Current airplane designs for damage tolerance require a significant level of design load capability to be maintained after a four pound bird strike, implying that heavier birds could be tolerated. Effects of bird impact on systems is currently addressed by § 25.1309, where the bird weight is unspecified, and by § 25.631 of the FAR for flight control systems, where eight pounds is specified. There was no consideration by the subgroup of bird impact to systems.

As it is, both the part 25/JAR-25 airframe and part 33/JAR-E engine (proposed) bird strike requirements are actually very similar in approach. For engines, the "safe shutdown" criteria defined under § 33.77 of the FAR was used for large birds. The conclusion was that the historical large bird (eight pounds) engine ingestion rate was approximately linear with the engine inlet area and varied from $1.3x10^{-7}$ to $4.0x10^{-7}$ per engine cycle (for 2000 and 6000 sq. in. engine inlet areas respectively). It has therefore been recommended to design and test to a graduated bird size starting from four pounds for the 2000 sq. in. engine inlet area up to eight pounds for a 6000 (and larger) sq. in. engine inlet area in order to comply with the target of 10^{-7} per engine cycle occurrence rates for large birds. For airframes, the level of energy associated with the current (4 lb/Vc) JAR-25 requirement is exceeded approximately 10^{-7} per flight.

As for the engines an eight pound bird ingestion rate of 10^{-7} per engine cycle has been agreed and considered as safe, it can be concluded that, by imposing the current JAR-25 bird strike requirement where the same exceedance rate of 10^{-7} per flight for the airframe is achieved, both requirements are in line with each other.

The GSHWG also discussed the safety record of those airplanes with a Maximum Take-Off Weight of 5700 kg or more (including business jets) in relation to bird strike. The following points were addressed.

(a) The only airplane that was destroyed after bird impact on the airframe (strikes on engines excluded) was a Vickers Viscount, in 1962, where a Whistling Swan (12-17 pounds) struck the tailplane, at an altitude of 6000 ft. This resulted in the eight pound bird requirement for the empennage of § 25.631 (Amendment 25-23). It was argued that the safe-life design and construction of the Viscount is not comparable to the current designs because safe life construction is not normally used, and more recent designs comply with the damage tolerance requirements of Amendment 25-45 (including multiple load paths). It was pointed out that multiple load path design is not a requirement that significant structural damage occurs occasionally on current design type of airplanes because of bird impacts. There have been more than 60 reported strikes resulting in major structural damage (including windshield penetrations), and there have been at least seven reported strikes resulting in major damage to electrical, flight control or fuel systems. Bird strikes have resulted in fuel leakage as well as total electrical failures and failure of flight instrument computers. As an example, in 1989, a twin turboprop commuter airplane impacted seven geese during a 230 knot descent at 4,500 feet altitude. Structural strength was significantly reduced as the front wing spar was heavily damaged and a number of adhesively bonded stringers were disbonded; nevertheless, the pilot was able to safely land the airplane. A large proportion of major incidents were verified as being caused by heavy birds such as geese or vultures. Approximately 80% of encounters with geese have involved multiple impacts. Except for engine ingestions, as of this date there has not been a catastrophic bird-caused accident on any jet transport. That fact supports the view that such airplanes were resistant to bird strikes because of their structural strength and redundancy, the design of their control systems, and the two-pilot requirement. It was also noted by several members of the GSHWG that one catastrophe in the last 32 years seemed to be a reasonable safety record, bearing in mind that since 1959 the commercial jet transport fleet (currently 85% of the total fleet) have accumulated approximately 400 million flight hours, with approximately 260 million flights. This would bring the safety record close to 10^{-9} catastrophic events per flight hour. Another observation was that this safety record was achieved with approximately **[80%]** of the current commercial jet transport fleet certified to part 25 pre-Amendment 25-23 requirements, i.e. four pound bird at Vc on the windshield only, with no requirement on the rest of the airplane.

(b) A survey was made to identify the number of injuries and fatalities as a result of non-engine related bird strikes. From 1970 on, 31 incidents could be identified where the flight deck area was penetrated. This resulted in 19 injuries and one fatality. There was consensus in the GSHWG that this is an acceptable level of safety.

Some time was spent on discussing the need for differentiation between turboprops and turbofans. In most countries, due to operational rules, a speed limitation of 250 KIAS below 10,000 ft is required. Since the cruise speed, V_C of most turbofans is in the 340-360 KIAS range, this provides a higher level of safety for turbofans: turboprops normally have a V_C in the 230-250 KIAS range, and operate closer to Vc (Vmo) than turbofans (below 10,000 ft). Therefore, by imposing a bird strike requirement related to Vc, the safety level will be less for turboprops than for turbofans. The operational difference results in a higher operational bird strike speed difference for jet airplanes, on the order of 40%. Propeller-driven airplanes have virtually no operational speed margin except at very low altitudes. In terms of impact energy, the 40% difference is approximately equivalent to doubling the bird weight. In other words, jet airplane structure designed for a four pound bird impact at Vc would be good for an eight pound bird when operated at normal speeds below 10,000 feet altitude. Somewhat compensating for the above disparity is the fact that current turboprops have a lower bird strike rate than larger jet airplanes.

The GSHWG discussed the turboprop/turbofan concern with several members suggesting that service experience seemed to indicate there is no need to change the regulations in that respect. There were two members of the group who believed that this was a significant problem that should be assessed and if necessary addressed by the NPRM. The GSHWG, while deciding not to further address this issue, agreed to express the concern in the published notice, which is hereby accomplished.

In attempting to reach consensus on the bird strike threat, several alternate proposals were presented and are discussed below.

(Note: these proposals were made in an attempt to reach agreement on the four pound vs. eight pound issue, and may therefore not be addressing all issues. They should not be regarded as complete proposals, but as working drafts.)

1. A proposal was made to require the airplane be designed for continued safe flight and landing after a bird impact at a minimum speed, V', which is the greater of Vc at sea level or 0.85 Vc at 8000 ft altitude, where the bird weight is 8 lb. for values of V' up to 260 knots, and is linearly reduced to 4 lb. at V' at 350 knots. This proposal would lead to a situation where the current four pound/Vc requirement would be maintained for most of the turbofan transport airplanes, but would be upgraded to eight pound/Vc for the turboprop transport airplanes and some of the executive jets. The proposal was rejected, because part of the part 25 fleet would be faced with more stringent (eight pound) bird strike requirements (apart from the empennage), which were deemed unnecessary by the majority of the GSHWG.

2. A proposal was made to require limit load capability after bird impact (instead of the ACJ 25.571.2.7.2 discrete damage loads), and maintain the JAR-25 four pound/Vc requirement. It was recognized that this also would mean an upgrade of the existing bird strike requirements, but one that may be easier to accept. This proposal was initiated by the fact that some part 25 airplanes are already certified with these higher discrete source damage loads, and that it would be possible to show that this proposal would satisfy the 10^{-9} probability of catastrophe required by the FAA. The proposal was rejected. The manufacturers of smaller Part 25 airplanes could not accept such an increase in loads.

3. A completely new rule was proposed, based on the engine non-containment requirement of FAR/JAR 25.903(d). This would assume a bird model and an associated amount of damage to the airplane, without the need for defining a bird weight/airplane velocity criterion. With that amount of damage, a certain load carrying capability would have to be demonstrated, together with freedom from flutter. Based for instance on the ratio of the critical area to the frontal area of the airplane, one could accept a certain probability of catastrophe, similar to the engine non-containment requirement. This proposal would solve many problems associated with the current regulatory approach in that the criteria would no longer be linked to a specific airplane design speed (e.g. Vc which may vary for each airplane type). The GSHWG foresaw great difficulties implementing a completely new bird strike regulatory approach, and rejected the idea in favor of the current approach.

4. A proposal was made to require the airplane be designed to assure capability of continued safe flight and landing, after impact with an eight pound bird when the velocity of the airplane (relative to the bird along the airplane's flight path) is equal to 250 KIAS at sea level to 8000 ft, whichever is most critical. If the airplane's frontal area is less than some value, yet to be specified, a four pound bird may be used. This proposal was withdrawn, mainly because an equivalent level of safety based upon variations in frontal area could not be substantiated.

5. A proposal was made to increase the level of safety by requiring (in combination with a four pound/Vc requirement) no penetration of the flight deck. The proposal was based on the argument that although the overall safety record was satisfactory, there could be improvement regarding flight deck crew protection. Thirty-one penetrations in the flight deck area had been identified over the last twenty-four years. This resulted in nineteen injuries and one fatality. Objections were raised to the above proposal, arguing that the current level of safety with regard

to flight deck crew protection is satisfactory, and penetration of the flight deck does not necessarily preclude safe flight and landing. The GSHWG rejected the proposal.

6. A proposal was made to prohibit manufacturers to cut back the Vc of their airplane below 8000 ft, combined with a rapid increase in Vc above this altitude. This would literally satisfy the requirement, but a reduction in energy level could lead to a reduction in safety. One of the members objected, stating that service experience gave no reason to assume this practice to be unacceptable. Therefore, the GSHWG rejected the proposal.

7. A proposal was made that there was a need for defining more clearly what the pass/fail criteria in relation to bird strike substantiation should be. The resulting discussion resulted in expansion of the already accepted wording in the advisory material. Specifically addressed were bird penetration in the flight deck area and bird penetration of wing and stabilizer leading edges and spars. Proposals to add in the advisory material considerations on bird strikes on tailplane tips and strikes on extended flaps were rejected by the GSHWG, because this is covered by the base requirement and not every conceivable type of bird strike could be included in the advisory material.

8. A proposal was made to add a § 25.631(b), in order to more clearly distinguish the airframe requirements of § 25.631 from the windshield requirements of § 25.775. This was supported and agreed by the GSHWG. Also the last sentence of § 25.631(a) was reworded for clarification.

Having reviewed the existing bird strike requirements in part 25/JAR- 25, the proposed FAA reassessment in 1987, the existing engine requirements JAR-E/part 33, all of the key issues and the above proposals, the GSHWG decided in 1995 that the current JAR-25 texts (§§ 25.631, 25.571(e) and 25.775(b)) would assure an acceptable level of safety. However one member specifically disagreed with this conclusion, believing the bird weight should be eight pounds instead of four pounds.

In 1998 the FAA contracted with the University of Illinois to conduct research in regard to three tasks: 1) a comprehensive analysis of wildlife strike data to determine the relationship between wildlife collisions and structural damage to aircraft, 2) a review of risk assessments and risk assessment approaches applied to wildlife/aircraft collisions, and 3) application of wildlife strike data and risk assessment procedures to support FAA rulemaking to airframes of wildlife strikes, with an emphasis on bird strikes (reference Contract # DOT 95-C-001-11). This research was concluded in 2002 with the release of the final report, “Assessment of Wildlife Strike Risk to Airframes”, dated December 2002. The research concluded: 1) that it is possible to consider the physics of bird/aircraft collisions and use kinetic energy as a measure of the forces involved in the collision, 2) that to fully support risk assessment goals for Part 25 aircraft both the quality of the wildlife strike databases must be improved with better data on altitude, speed, species struck, actual mass of the species, and better information on damage or consequence, and that additional experimental data on damage and damage mechanisms in wildlife/aircraft collisions, and 3) that the risk assessment completed as part of this research is limited by basic data resources, including adequacy and accuracy of strike reporting, and the absence of fundamental data needed to determine actual forces in wildlife/aircraft collisions, the risk analysis performed does provide an initial result that has fully utilized existing strike database records, and specifically considers the kinetic energy of the wildlife/aircraft collision.

The results of the FAA sponsored research proved to be inconclusive in defining and/or supporting any specific bird strike requirements for rulemaking. Following additional discussions, two more proposals were considered. The first proposal developed to promote harmonization was to envelope the existing FAR/JAR requirements, including the FAA requirement for an eight pound bird on the empennage structure, and include a prohibition on the use of cutback speeds. This proposal was rejected by a JAA representative based on the lack of technical justification for an eight pound bird weight on the empennage. The second proposal was to impose a prohibition on cutback speeds but maintain the disharmony between FAR and JAR bird weight requirements. This proposal was rejected because it results in an increase in the bird strike regulatory requirements without harmonization.

Position papers for the FAA, JAA, TC, and OEM's are attached supporting the position of each of these groups.

(2) Why was each action rejected (e.g., cost/benefit? unacceptable decrease in the level of safety? lack of consensus? etc.)? Include the pros and cons associated with each alternative.

See discussion in b.(1) above.

c. HARMONIZATION STATUS

(1) Is the proposed action the same for the FAA and the JAA?

Not applicable, no rule changes are proposed. FAR and JAR will remain unharmonized.

(2) If the proposed action differs for the JAA, explain the proposed JAA action.

Not applicable, no rule changes are proposed. FAR and JAR will remain unharmonized.

(3) If the proposed action differs for the JAA, explain why there is a difference between FAA and JAA proposed action (e.g., administrative differences in applicability between authorities).

Not applicable, no rule changes are proposed. FAR and JAR will remain unharmonized.

3. COSTS AND OTHER ISSUES THAT MUST BE CONSIDERED

The Working Group should answer these questions to the greatest extent possible. What information is supplied can be used in the economic evaluation that the FAA must accomplish for each regulation. The more quality information that is supplied, the quicker the evaluation can be completed.

a. COSTS ASSOCIATED WITH THE PROPOSAL

(1) Who would be affected by the proposed change? How? (Identify the parties that would be materially affected by the rule change – airplane manufacturers, airplane operators, etc.)

Not applicable, no rule changes are proposed.

(2) What is the cost impact of complying with the proposed regulation? Provide any information that will assist in estimating the costs (either positive or negative) of the proposed rule.

Not applicable, no rule changes are proposed.

b. OTHER ISSUES

(1) Will small businesses be affected? *(In general terms, "small businesses" are those employing 1,500 people or less. This question relates to the Regulatory Flexibility Act of 1980 and the Small Business Regulatory Enforcement Fairness Act of 1996.]*

Not applicable, no rule changes are proposed.

(2) Will the proposed rule require affected parties to do any new or additional record keeping? If so, explain. *[This question relates to the Paperwork Reduction Act of 1995.]*

Not applicable, no rule changes are proposed.

(3) Will the proposed rule create any unnecessary obstacles to the foreign commerce of the United States -- i.e., create barriers to international trade? *[This question relates to the Trade Agreement Act of 1979.]*

Not applicable, no rule changes are proposed.

(4) Will the proposed rule result in spending by State, local, or tribal governments, or by the private sector, that will be $100 million or more in one year? *[This question relates to the Unfunded Mandates Reform Act of 1995.]*

Not applicable, no rule changes are proposed.

4. ADVISORY MATERIAL

a. Is existing FAA or JAA advisory material adequate? Is the existing FAA and JAA advisory material harmonized?

There is no specific FAA advisory material for bird strike. However, ACJ 25.631 exists in the JAR.

b. If not, what advisory material should be adopted? Should the existing material be revised, or should new material be provided?

Not applicable, no rule or advisory material changes are proposed.

c. Insert the text of the proposed advisory material here (or attach), or summarize the information it will contain, and indicate what form it will be in (e.g., Advisory Circular, Advisory Circular – Joint, policy statement, FAA Order, etc.)

Not applicable, no rule or advisory material changes are proposed.

ATTACHMENT A

FAA BIRDSTRIKE POSITION PAPER

FAA Bird Strike Position
June 27, 2003

The FAA remains opposed to the existing General Structures Harmonization Working Group proposal to adopt a common weight bird for FAR §§ 25.571/25.775/25.631 of four pounds and a strike speed of Vc at sea level (or 0.85 V_c at 8,000 feet, whichever is more critical), because the net effect of the proposal for the FAR is to reduce the current empennage bird strike impact energy requirement of § 25.631 by approximately a factor of two.

Discussion:

The basic arguments of the FAA April 24, 2000 position still apply (copy attached). Between April 24, 2000 and January 1, 2003, FAA sponsored research to try to ascertain a bird strike energy criterion grounded in a risk assessment approach. This research, summarized in "Assessment of Wildlife Strike Risk to Airframes", December 2002, by Edwin E. Herricks, Phil Mankin, and David J. Shaeffer, did not produce a definitive result; nevertheless, it did reveal some new information, which further reinforces the FAA's reason for concern:

1. The Canada Goose represents a unique hazard to airplanes operating in North America because of it size, abundance, tendency to flock, and at times to fly at higher altitude.
    a. The Canada Goose is the fourth most likely bird species to be reported struck by airframes in North America. The US Birdstrike data base contained 205 reports of Canada Geese being struck by the airframe.
    b. The Canada Goose is a very large bird having a mean weight of about 8.5 pounds and a maximum weight up to 10.4 pounds for the most common subspecies.
    c. Waterfowl are observed to fly at high altitudes at times, particularly during migration seasons. Although number of airplane impacts with all birds decline dramatically with altitude, impacts at high altitude are not unheard of. Impacts with waterfowl, including the Canada Goose, can be expected to occur at high altitude, albeit very infrequently. Impacts at high altitude can be expected to be at a high speed, because the speed of an airplane is increased as the airplane leaves the airport area and gains altitude. For example, the FAA notes that an impact of a large transport airplane with a flock of Northern Shovelers, a waterfowl significantly smaller than 4 pounds (0.69 – 2.43 pounds; avg 1.31 pounds), occurred in April 2001 during climbout at a 14,000 foot altitude and at an airplane airspeed of 330 knots IAS. Although the airplane returned to its point of origin safely, the event resulted in extensive airframe damage, including a cabin decompression. This event illustrates, however, that impacts with waterfowl, like the Canada Goose, can be expected to occur at high altitude with correspondingly high airplane speed.
    d. US Geological Survey data indicate that the population of the Canada Goose in the US has increased dramatically (twenty fold) since 1967, and the trend is still upward. This suggests that impacts with Canada Geese are much more likely today than in the past.
    e. The behavior of the Canada Goose, and other waterfowl, is to flock, so that an impact event is likely to involve more than one bird. Therefore, the 205 reports of Canada Goose strikes are probably reflective of around 500 individual airframe impacts.

2. The populations of other bird species in North America having high mass and that can be encountered at high altitude have also increased over time, and in many cases the trend is still upward (e.g. Bald Eagle, Golden Eagle, Snow Goose)

Because of this, the FAA remains concerned with adequacy of the current FAR part 25 bird strike regulations. Therefore:

1. In the absence of a definitive risk assessment showing that an 8 pound bird strike to the empennage, occurring at V_c, at sea level, is an unrealistic energy criterion, the FAA sees no justification for diminishing the current § 25.631 requirement.
2. The FAR § 25.571 requirement for the remainder of the airframe structure, of continued safe flight and landing after impact with a 4 pound bird at V_c, (or 0.85 V_c at 8,000 feet, whichever is more critical) is probably inadequate as a structural criterion, although it is likely that most airframe structure has acceptable capability due to structural redundancy typical of modern airplane construction. One area of concern, however, is the structure protecting the pilots or passengers from the direct effects of an impact, where the FAA believes that increased protection is necessary.
3. The § 25.775 four pound bird strike, at V_c, at sea level, with no penetration of the windshield, is not considered adequate. There have been, and continue to be, flight deck penetrations and injuries to the pilots. The FAA believes that the area of no penetration should be expanded beyond the windshield, and further, the bird mass should be increased to reduce the number of windshield failures and flight deck penetrations (although data have not developed to show how much the mass should be increased). The FAA is particularly concerned about the possibility of an injurious flight deck penetration occurring in conjunction with other severe airframe, systems, or engine damage due to an encounter with a flock of large waterfowl, such as the Canada Goose.

In conclusion, at this time, the FAA sees no reason to diminish any of the existing bird strike requirements of the FAR. The FAA would accept enveloping the FAR and JAR regulations for the sake of harmonization. Although the FAA is sympathetic with the elimination of the possibility of speed cutbacks at altitudes under 8000 feet, as proposed by the RLD, the FAA currently considers a rule change necessary to accomplish this.

FAA Bird Strike Position
April 24, 2000

Text of an April 24, 2000 e-mail message to Thaddee:

Subject: Harmonization of 25.631
Author: Dorenda Baker at ANM100
Date: 4/24/2000 6:49 PM

Hi Thaddee,

I coordinated the General Structures Harmonization Working Group (GSHWG) issue related to bird strike and FAR/JAR 25.631 with John Hickey, Manager of the Transport Airplane Directorate. The FAA position is that the current 8 pound bird strike impact weight requirement of § 25.631 remain unchanged.

The following is justification of the FAA position on this issue.

The Transport Airplane Directorate (TAD) had initiated a rulemaking project to upgrade the part 25 structural requirements for bird strike prior to the existence of ARAC. This was based on service experience data for bird strikes, which the FAA had become aware of, particularly the high incidence of bird penetrations into the cockpit. At that time the TAD was considering proposing that the entire airplane be capable of meeting the § 25.631 bird strike requirement (8 pounds at Vc) and expanding the zone for "no-penetration" in front of the pilots for their protection. With the advent of ARAC, the FAA project was turned over to the GSHWG of the Transport Aircraft and Engine Interest Group (TAEIG).

The GSHWG harmonization activity has been to recommend harmonizing on the bird strike requirements of the Joint Aviation Regulations (JAR). Since the JAR requires consideration of a 4-pound bird in JAR 25.631, the effect of this harmonization would be to reduce the stringency of the current § 25.631 requirement for the empennage. This proposal did nothing to alleviate the FAA's concern about obviating or at least reducing the frequency of bird penetrations into the flight deck.

The GSHWG contends that the service experience on airplanes since 1970 is mainly with airplanes that do not meet the 8-pound requirement because this requirement first came into effect in 1970. The requirements before that only required impact resistance of a 4 pound strike to the windshield, not the rest of the airplane. The GSHWG rationalized that service experience for the existing fleet of airplanes justifies the adequacy of a 4-pound strike at Vc and that the 4-pound criterion be applied to all structure including the empennage.

The FAA disagrees with the GSHWG position. The FAA does not concur that 1) the service experience with bird strikes, including 31 cockpit penetrations, with 19 injuries and 1 fatality, is indicative of an acceptable level of safety, and 2) that the service experience with bird strikes (which includes a catastrophic accident after a bird impacted the empennage of an airplane) supports alleviating the current

8 pound bird at Vc requirement to the JAR value of 4 pounds at Vc. The FAA believes that service experience demonstrates that bird strikes pose a real threat to safety and that there is considerable room for improving the bird strike capability of modern aircraft.

Furthermore, the preliminary economic evaluation of the proposed rulemaking concluded that economics do not appear to justify the proposal either.

Per the GSHWG request, the FAA completed a rough estimate of the costs and benefits resulting from their proposal. This analysis indicated that "bird strikes occur regularly, they are not decreasing over time, and they do cause damage to the airplanes- all of which suggests that safety concerns should be carefully considered." The analysis also indicated that "bird strikes have had a 'negative impact' on a wide range of aircraft." The FAA economist determined that since the proposed regulatory change does not improve safety of air transportation, the benefits from the proposed rule would have to come from a reduction in costs to the aviation industry. According to the data provided by the GSHWG, the expected decrease in manufacturing and operating costs is relatively small. The FAA economist concluded:

.. data on accidents/incidents indicate an increasing number of bird strikes to the tail of airplanes - with accompanying damage to airplanes in a substantial number of cases. Thus, the risk of an accident has not decreased over time. The proposed rule would probably increase this risk and the severity of damage. On the other hand, the expected decrease in cost to the industry from the proposed rule is quite small. Consequently, the economics do not appear likely to justify the proposal.

If you need additional information please let us know.

Thanks

Dorenda

ATTACHMENT B

JAA BIRDSTRIKE POSITION PAPER

JAA Position on Bird Strike

(Hoofddorp, 14 November 2002)

The JAA was requested to submit its position on harmonisation of the bird strike requirements of JAR-25 and FAR 25 (ref. GSHWG Action Item 33-12).

(a) Bird weight

The current JAR-25 and FAR 25 bird strike requirements are harmonised, except for FAR 25.631 that requires the empennage structure to be designed for impact with an 8-pound bird (JAR-25 requires a 4-pound bird) at Vc (sea-level).

The JAA is of the opinion that adoption of the FAR 25.631 8-pound bird (empennage) requirement in JAR-25 cannot be substantiated from a technical point of view. The rationale for this position is explained in more detail in Appendix 1 to this document.

It should be noted that this JAA position reflects the majority position of the GSHWG.

(b) Cut-back in Vc

More and more OEM's are reducing Vc below 8000 ft, with a sudden increase in Vc at that altitude, for bird strike reasons. There is a serious safety concern regarding reduction of Vc below 8000 ft. Although accepted by the JAA and FAA in the past on a case-by-case basis, this reduction, if generally applied, could reduce safety below a level acceptable to the JAA.

The JAA is of the opinion that JAR 25.631 should be amended to address this safety concern.

The JAA position on this issue is explained in more detail in Appendix 2 to this document.

It should be noted that the FAA has stated to be in agreement with this JAA position. Even the Industry representatives of the GSHWG could, for the sake of harmonisation, agree on this position (provided that harmonisation was also achieved on the bird weight as discussed under (a) above).

* * *

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Appendix 1 to JAA Position on Bird Strike

BIRD STRIKE

General Structures Harmonisation Working Group

(Issue 3)

= Hoofddorp, December 1995 =

General Structures Harmonization Working Group Report

Birdstrike FAR/JAR §25.571(e)(1), 25.631, 25.775(b)(c)

Note: The content of this Discussion Paper is the same as the Final Draft NPRM, as agreed and signed by the GSHWG on the 12th of May, 1995.

Contents

General Structures Harmonization Working Group Report

Birdstrike FAR/JAR §25.571(e)(1), 25.631, 25.775(b)(c)

1. Background

In 1992, the Aviation Regulatory Advisory Committee (ARAC) chartered by notice in the Federal Register a General Structures Harmonisation Working Group (GSHWG) of industry and government structural specialists of Europe, the United States and Canada, to work on a number of issues to harmonise Part 25 of the Federal Aviation Regulations (FAR 25) and the European Joint Airworthiness Requirements, JAR-25. This notice is the recommendation of GSHWG of the Aviation Regulatory Advisory Committee (ARAC), which had been chartered by the FAA for this purpose. The GSHWG was comprised of representatives from the European Joint Aviation Authorities (JAA), Transport Canada, the FAA, and several European and U.S. aeroplane manufacturers.

At the start of this harmonisation effort, bird strike requirements existed in both FAR 25 and JAR-25. The development of the bird strike regulations for the U.S. and Europe is summarised below.

a) FAR 25 bird strike requirements

Prior to 1970, the only U.S. airworthiness regulation concerning bird strikes on transport category aeroplanes was CAR 4b., which requires no penetration of the windshield by a 4 lb. bird impact at cruise speed. The requirement preceded the jet transport era, and was adopted after a number of crew injuries due to bird penetrations of windshields.

In 1970, the regulations were changed as a result of an accident that occurred in 1962, in which a Vickers Viscount turboprop aeroplane operated by a U.S. airline experienced loss of control and crashed with no survivors near Chesapeake, Maryland. The accident was caused by impact with a swan, estimated to weigh between 12 and 17 lb., which damaged the horizontal stabiliser and elevator while the aeroplane was in cruise flight at 6,000 feet altitude. That resulted in a FAA review of existing statistical bird strike data. As a result of that review, the FAA concluded that transport aeroplanes should be capable of continued safe flight and landing after impact with birds weighing up to 8 lb. This was formalised as an FAA proposal for the 1966 Airworthiness Review Conference.

The FAA reviewed statistical data collected from actual air carrier operations and noted that the fail-safe design principles used for structure and control systems had provided a high degree of protection against catastrophic damage due to the impact of large birds such as geese even when multiple strikes had occurred. The FAA also conducted bird strike testing on several types of jet transport aeroplanes, which served to reinforce the service data. The FAA concluded that most existing transport aeroplanes were inherently bird resistant, although a few types, such as the one noted above which crashed, were not sufficiently resistant in the empennage area.

The FAA anticipated that jet transports would displace propeller-driven aeroplanes in the 1970's and 1980's. After considering the above factors, the FAA determined that a specific rule applying to the entire aeroplane would only add to the substantiation effort without providing any significant design changes. Therefore, Notice of Proposed Rulemaking 68-18 (33 FR 11913) published on August 22, 1968, proposed the addition of § 25.631 which would require aircraft to be capable of continued safe flight and landing after impact on the empennage by an 8 lb. pound bird at design cruise speed.

There were a number of comments received on the above FAA proposal. One European airworthiness authority commented that having a requirement only on the tail was illogical, and that smaller aeroplanes in the weight range of 13,000 to 40,000 lb. would be vulnerable from wing impacts. Also noted by that commenter was the fact that the proposed 8 lb. requirement would not have prevented the one accident (noted above), and that the size of the bird should be based on probability considerations. The US Aerospace Industries Association commented that 4 lb. would be sufficient, since it had proven satisfactory for windshields. There were several comments that the 8 lb. bird was not realistic and that larger birds should be considered (one commenter proposed 12 lb., another 20 lb.), and that any requirement should also be applied to the wings and the windshield as well as the tail.

The FAA responded to the comments that service experience did not indicate an inadequacy in the resistance to the impact of large birds on structures other than the empennage, and that impacts with birds weighing more than 8 lb. were rare enough that they need not be considered.

As a result of Notice 68-18 and subsequent comments, Part 25 was amended in 1970 (Amendment 25-23; 35 FR 5665, April 8, 1970) to add a new § 25.631 that required the empennage structure to be designed to assure the capability of continued safe flight and landing after impact with an 8 lb. bird at speeds up to the design cruise speed at sea level.

Other rule changes regarding bird strikes have been introduced since § 25.631 was adopted.

On August 15, 1977, the FAA published Notice 77-15, 41 FR 41236, proposing new damage tolerance requirements, including requirements for discrete damage caused by bird impact. Only a few comments were received regarding bird strike damage. Two stated that the proposed bird strike requirement (continued safe flight following impact with a 4 lb. bird at likely operational speeds) was inconsistent with § 25.631 and § 25.775. A major European aeroplane manufacturer commented that § 25.631 and § 25.775 were completely adequate to ensure safety and that there was no justification for the proposed additional bird requirement. On December 1, 1978, § 25.571 was amended (Amendment 25-45; 45 FR 46242, October 5, 1978) as proposed, although the FAA did note in the preamble that there was some merit to having consistent requirements. It is unclear why the FAA originally proposed an inconsistent weight requirement, or why it failed to fully address the comment concerning justification of the proposal. There has been no reported incident where impact by a bird weighing 4 lb. or less has resulted in a serious non-engine related safety hazard to any transport category aeroplane.

The bird strike requirement of § 25.571(e) was amended further by Amendment 25-72, 55 FR 29776, July 20, 1990, which changed the speed requirement from "likely operational speed" to "design cruise speed." That was accomplished in part to harmonise the requirement with the existing JAR, and to prevent possible ambiguous interpretations of likely operational speeds. There is a current FAA proposal to correct an unintentional error in that amendment; it would specify a speed of Vc at sea level or 0.85Vc at 8,000 feet, whichever is the more critical. That is also the current JAA requirement.

In some cases, special interpretations, equivalent safety findings and special conditions have been issued for bird strikes. Since § 25.631 does not apply to wings, the FAA has requested, and several manufacturers have agreed, to establish an acceptable level of safety for aeroplanes equipped with winglets, with one winglet missing to account for impact with a large bird. Special interpretations have also been necessary in the application of other rules, such as § 25.365 which applies to the structural design loads arising from depressurization events. The FAA has interpreted that section as requiring an evaluation of the effects of depressurization resulting from the loss of a complete windshield panel from large bird impacts at altitudes up to 8000 feet (above which such impacts have been considered extremely improbable). For some aeroplanes having certification bases prior to Amendment 25-23, § 25.631 has been applied to design changes involving composite empennage structure.

b) JAR-25 bird strike requirements

In the late 60's and early 70's, when JAR-25 was developed in Europe as an airworthiness code, FAR 25 was selected as the basic code. The discussions included review of the FAR Sections 25.631 and 25.775(b).

The text of FAR 25.631 (Amendment 23) was not adopted in Change 1 (effective 25 July 1975) of JAR-25. Instead, JAR 25.631 at Change 1 specified that "the aeroplane must be designed to assure capability of continued safe flight and landing after impact with a 4 lb bird when the velocity of the aeroplane (relative to the bird along the aeroplane's flight path) is equal to Vc at sea level or 0.85 Vc at 8000 ft, whichever is the more critical."

Partially based on the British BCAR Section D, it was purposefully decided to deviate from FAR 25 on an number of points:

- instead of the empennage only, it was decided to address the complete aeroplane;
- instead of an eight-pound bird, a four-pound bird was appropriate;

- an additional "spot-check" at 8000 ft was required to prohibit manufacturers choosing a low Vc at sea level, with a possible rapid increase of Vc just above sea level, that would avoid the intent of the requirement.

The protection of essential systems against bird impact was also addressed in JAR 25.631 (Change 1). This was later (Change 5, effective 1 January 1979) taken out of the basic requirement and put in a separate ACJ 25.631.

It was also decided to adopt the text of FAR 25.775(b) (Amendment 1) in Change 1 of JAR-25 as JAR 25.775(b), but to change the last part of the sentence of this subparagraph to make reference to JAR 25.631. FAR 25.775(c) at Amendment 1 was later adopted as JAR 25.775(c) in Change 8 (effective 30 November 1981).

Amendment 45 of FAR 25 introduced the damage tolerance (discrete source) evaluations in FAR 25.571(e), where (e)(1) addressed bird strike. This was adopted as JAR 25.571(e)(1) in Change 7 (effective 24 November 1980) of JAR-25, but instead of adopting the FAR 25 text a reference was made to JAR 25.631. In ACJ 25.571 text was added to require (subparagraph 2.7.2.) the remaining structure (after bird impact) to be able to carry specific loads, and to be free from flutter.

In the latest version of JAR-25 (Change 14, effective 27 May 1994), JAR 25.631, 25.775(b)(c) and 25.571(e)(1) are still contained as described above.

c) <u>FAA reassessment of bird strike requirements</u>

In 1987 the FAA initiated a reassessment of the current bird strike regulations due to concerns with new technology. The new technology increased the use of critical systems and composite materials, which were believed to be more sensitive to bird impact. These concepts were not considered when the original empennage requirement was enacted. A draft NPRM was prepared proposing the following new requirements:

1. Continued safe flight and landing after impact, at any location on the aeroplane, with an 8 lb. bird at design cruise speed. This would include effects of bird strike on structure as well as systems.

2. No penetration of the fuselage after impact with a 4 lb. bird at design cruise speed.

The draft NPRM received significant negative comments from industry and the economical evaluation was revised after consideration of those comments. It then received its regulatory economic and legal evaluations, and in the latter part of 1992 was in final co-ordination prior to publication, even though substantial industry opposition still existed. At that point, the FAA decided to complete the rulemaking process through ARAC.

2. Discussion

In the Bird Strike Harmonisation effort the following key issues were identified and discussed:

1) Current regulations and advisory material
2) The basic requirements and differences between FAR and JAR
   - bird weight
   - aircraft speed and altitude
   - structure of the rules
3) Other considerations
   - Vc reduction below 8000 feet
   - flight crew protection
   - protection of essential systems
   - turboprops and turbofans
      - airframe and engine criteria
      - service experience
      - pass/fail criteria
      - safety target
      - discrete source event loads

The above issues are discussed below.

2.1. Definition of the basic requirement

Initial discussions focused on the issue of bird weight (8 lb. vs. 4 lb., or some other weight). Much time was spent on finding a statistically sound basis for a requirement. Statistical analyses showed the probability of exceeding the energy level associated with the 4 lb./Vc requirement of JAR-25 to be approximately 10^{-7} per flight (for the complete airframe). The probability of exceeding the energy level associated with an 8 lb./Vc requirement was established at approximately 10^{-8} per flight. These numbers, however, are not absolute, since bird strike data are subject to considerable scatter and uncertainty, and further, not every exceedance of these energy levels would result in a catastrophic event. According to European bird strike data bases, in 1.2 % of all bird strikes the weight of the bird is above 4 lb., whereas American data bases indicate this number to be 7.2%. For bird weights above 8 lb. the numbers are 0.3% and 3.6% respectively. There is also scatter in bird strike rate per flight: European data indicate this rate to be approximately 10^{-3} per flight, whereas American data indicate this rate to be approximately 5×10^{-4} per flight. Although there have been numerous bird strikes on aeroplanes, it is very difficult to establish the bird weight involved. In addition, the reporting of bird strike events varies widely. These situations make it difficult to conclusively develop a statistical based requirement.

It was suggested that the overall exceedance rate should be 10^{-9} per hour (extremely improbable) or better for catastrophic events, and that therefore the 8 lb./Vc requirement was the more appropriate one.

It was noted that the number 10^{-9} comes from the system safety assessment of FAR/JAR 25.1309, and is applicable to systems, but not necessarily to structures. The reliability and failure rate of systems can be calculated quite accurately, in contrast to the relatively unreliable bird strike data available, and all the uncertainties attached to bird strike exceedance evaluations based on statistical/probabilistic analyses.

Traditionally, for the definition of load cases the deterministic approach has always been taken rather than a probabilistic one, with the exception of gust loads (that are expressed in limit load only). Therefore, there is no direct comparison possible with the exceedance rate of other structural requirements.
Since bird strike considerations do not normally design the major components of the airframe, there is an inherent residual strength capability present after bird impact. This is also addressed in the current regulations: continued safe flight and landing is required after a bird impact, with the emphasis on freedom from flutter and residual strength capability. ACJ 25.571 defines very specifically the residual strength capability of the airframe to be considered. These loads in themselves have a probability of exceedance attached to them, although the GSHWG could not define this probability. Defining this probability of exceedance would be even more difficult for flutter. The exceedance rate for a catastrophic event would be less than the probability of exceeding a specific bird impact energy level.

The issue of whether the bird weight should be the same for both airframe and engines was debated at length. A subgroup of the GSHWG and the ARAC Engine Installation Harmonisation Working Group met to discuss this matter. Their conclusions are as follows:

There are sound technical reasons for having different bird strike requirements between engines (part 33/JAR-E) and airframes (part 25/JAR-25). Differences in bird strike requirements can be linked to the differences in approach between engine and airframe designers. The airframe structural justification is done at Vc, which at the lower altitudes where most bird strikes occur, is a speed that is rarely used. At the more typical lower operational speeds, the structure would be good for much heavier birds than 4 lb., as supported by service experience. Hence, this concept provides an envelope design case for structural impact energy. With engines, forward speed is not the critical parameter, but is allied with the even more important parameters of fan speed, local inlet airflow and multiple birds. Hence protection against large birds may not be covered by an "envelope" case but will need to address the large bird impact directly. Another difference is the effects of the failure. For engines, gross damage may result in loss of all thrust (i.e. loss of function). For airframes, gross damage will rarely result in complete loss of load bearing capability. Current aircraft designs for damage tolerance require a significant level of design load capability to be maintained after a 4 lb. bird strike, implying that heavier birds could be tolerated.

As it is, both the part 25/JAR-25 airframe and part 33/JAR-E engine (proposed) bird strike requirements are actually very similar in approach. For engines, the "safe shutdown" criteria defined under FAR Part 33.77 was used for large birds. The conclusion was that the historical large bird (8 lb.) engine ingestion rate was approximately linear with the engine inlet area and varied from $1.3x10^{-7}$ to $4.0x10^{-7}$ per engine cycle (for 2000 and 6000 sq. in. engine inlet areas respectively). It has therefore been recommended to design and test to a graduated bird size starting from 4 lb. for the 2000 sq. in. engine inlet area up to 8 lb. for a 6000 (and larger) sq. in. engine inlet area in order to comply with the target of 10^{-7} per engine cycle occurrence rates for large birds. For airframes, the level of energy associated with the current (4 lb/Vc) JAR-25 requirement is exceeded approximately 10^{-7} per flight.

As for the engines an 8 lb. bird ingestion rate of 10^{-7} per engine cycle has been agreed and considered as safe, it can be concluded that, by imposing the current JAR-25 bird strike requirement where the same exceedance rate of 10^{-7} per flight for the airframe is achieved, both requirements are in line with each other.

The GSHWG discussed also the safety record of those aeroplanes with a Maximum Take-Off Weight of 5700 kg or more (including business jets) in relation to bird strike. The following points were addressed.

(a) The only aircraft that was destroyed after bird impact on the airframe (strikes on engines excluded) was a Vickers Viscount, in 1962, where a Whistling Swan (12-17 lb.) struck the tailplane, at an altitude of 6000 ft. This resulted in the 8 lb. bird requirement for the empennage of § 25.631 (Amendment 23).

It was argued that the design and construction of this aeroplane is not comparable to the current designs because safe life construction is not normally used, and designs comply with the damage tolerance requirements of Amendment 45 (including multiple load paths).

It was pointed out that multiple load path design is not a requirement, that significant structural damage occurs occasionally on current design type of aeroplanes because of bird impacts. There have been more than 60 reported strikes resulting in major structural damage (including windshield penetrations), and there have been at least 7 reported strikes resulting in major damage to electrical, flight control or fuel systems. Bird strikes have resulted in fuel leakage as well as total electrical failures and failure of flight instrument computers. As an example, in 1989, a twin turboprop commuter aeroplane impacted 7 geese during a 230 knot descent at 4,500 feet altitude. Structural strength was significantly reduced as the front wing spar was heavily damaged and a number of adhesively bonded stringers were disbonded; nevertheless, the pilot was able to safely land the aeroplane. A large proportion of major incidents were verified as being caused by heavy birds such as geese or vultures. Approximately 80% of encounters with geese have involved multiple impacts. Except for engine ingestions, as of this date there has not been a catastrophic bird-caused accident on any jet transport. That fact supports the view that such aeroplanes were resistant to bird strikes because of their structural strength and redundancy, the design of their control systems, and the two-pilot requirement.

It was also noted by several members of the GSHWG that one catastrophe in the last thirty-two years seemed to be a reasonable safety record, bearing in mind that since 1959 the commercial jet transport fleet (currently 85% of the total fleet) have accumulated approximately 400 million flight hours, with approximately 260 million flights. This would bring the safety record close to 10^{-9} catastrophic events per flight hour.

Another observation was that this safety record was achieved with approximately 80% of the current commercial jet transport fleet certified to FAR 25 pre-Amendment 23 requirements, i.e. 4 lb. bird at Vc on windshield only, with no requirement on the rest of the aeroplane.

(b) A survey was made to identify the number of injuries and fatalities as a result of non-engine related bird strikes. From 1970 on, thirty-one incidents could be identified where the flight deck area was penetrated. This resulted in nineteen injuries and one fatality. There was consensus in the GSHWG that this is an acceptable level of safety.

Some time was spent on discussing the need for differentiation between turboprops and turbofans. In most countries, due to operational rules, a speed limitation of 250 KIAS below 10,000 ft is required. Since the cruise speed, V_C of most turbofans is in the 340-360 KIAS range, this provides a higher level of safety for turbofans: turboprops normally have a V_C in the 230-250 KIAS range, and operate closer to Vc (Vmo) than turbofans (below 10,000 ft). Therefore, by imposing a bird strike requirement related to Vc, the safety level will be less for turboprops than for turbofans. The operational difference results in a higher operational bird strike speed difference for jet aeroplanes, on the order of 40%. Propeller-driven aircraft have virtually no operational speed margin except at very low altitudes. In terms of impact energy, the 40% difference is approximately equivalent to doubling the bird weight. In other words, jet aircraft structure designed for a 4 lb. bird impact at Vc would be good for an 8 lb. bird when operated at normal speeds below 10,000 feet altitude. Somewhat compensating for the above disparity is the fact that current turboprops have a lower bird strike rate than larger jet aeroplanes.

The GSHWG discussed the above concern with several members suggesting that service experience seemed to indicate there is no need to change the regulations in that respect. There were two members of the group who believed that this was a significant problem which should be assessed and if necessary addressed by the NPRM. The GSHWG, while deciding not to further address this issue, agreed to express the concern in the published notice, which is hereby accomplished.

In attempting to reach consensus on the bird strike threat, several alternate proposals were presented and are discussed below.

(Note: these proposals were made in an attempt to reach agreement on the 4 lb. vs. 8 lb. issue, and may therefore not be addressing all issues. They should not be regarded as complete proposals, but as working drafts.)

1. The aeroplane must be designed for continued safe flight and landing after a bird impact at a minimum speed, V', which is the greater of Vc at sea level or 0.85 Vc at 8000 ft altitude, where the bird weight is 8 lb. for values of V' up to 260 knots, and is linearly reduced to 4 lb. at V' at 350 knots.

   This proposal would lead to a situation where the current 4 lb./Vc requirement would be maintained for most of the turbofan transport aeroplanes, but would be upgraded to 8 lb./Vc for the turboprop transport aeroplanes and some of the executive jets. The proposal was rejected, because part of the Part 25 fleet would be faced with more stringent (8 lb.) bird strike requirements (apart from the empennage), which were deemed unnecessary by the majority of the GSHWG.

2. A proposal was made to require limit load capability after bird impact (instead of the ACJ 25.571.2.7.2 discrete damage loads), and maintain the JAR-25 four pound/Vc requirement. It was recognised that this also would mean an upgrade of the existing bird strike requirements, but one that may be easier to accept. This proposal was initiated by the fact that some Part 25 aeroplanes are already certified with these higher discrete source damage loads, and that it would be possible to show that this proposal would satisfy the 10^{-9} probability of catastrophe required by the FAA.

The proposal was rejected. The manufacturers of smaller Part 25 aeroplanes could not accept such an increase in loads.

3. A completely new rule was proposed, based on the engine non-containment requirement of FAR/JAR 25.903(d). This would assume a bird model and an associated amount of damage to the aeroplane, without the need for defining a bird weight/aeroplane velocity criterion. With that amount of damage, a certain load carrying capability would have to be demonstrated, together with freedom from flutter. Based for instance on the ratio of the critical area to the frontal area of the aeroplane, one could accept a certain probability of catastrophe, similar to the engine non-containment requirement. This proposal would solve many problems associated with the current regulatory approach in that the criteria would no longer be linked to a specific aeroplane design speed (e.g. Vc which may vary for each aeroplane type).

   The GSHWG foresaw great difficulties implementing a completely new bird strike regulatory approach, and rejected the idea in favour of the current approach.

4. The aeroplane must be designed to assure capability of continued safe flight and landing, after impact with an 8 lb. bird when the velocity of the aeroplane (relative to the bird along the aeroplane's flight path) is equal to 250 KIAS at sea level to 8000 ft, whichever is most critical. If the aeroplane's frontal area is less than TBD sq. ft., a 4 lb. bird may be used.

   This proposal was withdrawn, mainly because an equivalent level of safety based upon variations in frontal area could not be substantiated.

Having reviewed the existing bird strike requirements in FAR/JAR Part 25, the proposed FAA reassessment in 1987, the existing engine requirements JAR-E/FAR Part 33, all of the key issues and the above proposals, the GSHWG decided that the current JAR-25 texts (25.631, 25.571(e) and 25.775(b)) would assure an acceptable level of safety. However one member specifically disagreed with this conclusion, believing the bird weight should be 8 lb. instead of 4 lb.

2.2. Other concerns

Several other proposals were made for improvement in the existing bird strike regulations.

a) Thirty-one penetrations in the flight deck area had been identified over the last twenty-four years. This resulted in nineteen injuries and one fatality. A proposal was made to increase the level of safety by requiring (in combination with a 4 lb./Vc requirement) no penetration of the flight deck. This was based on the argument that although the overall safety record was satisfactory, there could be improvement regarding flight deck crew protection.

Objections were raised to the above proposal, arguing that the current level of safety with regard to flight deck crew protection is satisfactory, and penetration of the flight deck does not necessarily preclude safe flight and landing. The GSHWG rejected the proposal.

b) A proposal was made to prohibit manufacturers to cut back the Vc of their aeroplane below 8000 ft, combined with a rapid increase in Vc above this altitude. This would literally satisfy the requirement, but a reduction in energy level could lead to a reduction in safety. One of the members objected, stating that service experience gave no reason to assume this practice to be unacceptable.

Therefore, the GSHWG rejected the proposal.

c) It was suggested that there was a need for defining more clearly what the pass/fail criteria in relation to bird strike substantiation should be. This discussion resulted in expansion of the already accepted wording in the advisory material. Specifically addressed were bird penetration in the flight deck area and bird penetration of wing and stabiliser leading edges and spars.

Proposals to add in the advisory material considerations on bird strikes on tailplane tips and strikes on extended flaps were rejected by the GSHWG, because this is covered by the base requirement and not every conceivable type of bird strike could be included in the advisory material.

d) It was proposed to add a subparagraph 25.631(b), in order to more clearly distinguish the airframe requirements of § 25.631 from the windshield requirements of § 25.775.

This was supported and agreed by the GSHWG. Also the last sentence of § 25.631(a) was reworded for clarification.

2.3. Protection of essential systems

In 1989, a bird strike on a twin engined jet transport caused loss of information on four Cathode Ray Tube displays, and tripped a fuel shut-off valve, causing one engine to shut down. The bird, a vulture, approximately 10 lb., struck (but did not penetrate) the top of the captain's panel of the windshield, while the aeroplane was flying at 250 KIAS at an altitude of 2500 ft. This incident is an example of what may happen to an aeroplane equipped with modern electronic flight control systems, where, although the bird does not penetrate the structure, the shock loading resulting from the impact still may have an effect on the functioning of essential systems. This issue is not specifically addressed in the current FAR 25 regulations, and partially addressed in ACJ 25.631 of JAR-25.

Birdstrike FAR/JAR §25.571(e)(1), 25.631, 25.775(b)(c)

Within the GSHWG there was consensus about the need to address this concern. It was decided to adopt in the advisory material the current text of ACJ 25.631, and add a reference to FAR/JAR 25.1309, which requires that the system safety assessment should consider the effects of a bird strike.

3. Summary of GSHWG conclusions

1. FAR 25.631 should be harmonised on the JAR requirement revised as shown in the proposed amendment.

2. FAR 25.571(e) should be revised to refer to 25.631 for the bird impact to be assessed as a discrete source of damage.

3. FAR 25.775(b) should refer to 25.631 for the bird impact for windshield design.

4. Advisory material was developed by the GSHWG to accompany the NPRM.

* * *

Appendix 2 to JAA Position on Bird Strike

Proposal to Address Vc Cut-backs in Relation to Bird Strike
(Hoofddorp, 13/08/02)

Statement of issue

JAR 25.631 (Change 15) requires that the aeroplane must be designed to assure capability of continued safe flight and landing of the aeroplane after impact with a 4 lb bird when the velocity of the aeroplane (relative to the bird along the aeroplane's flight path) is equal to Vc at sea-level or 0.85 Vc at 8000 ft, whichever is the more critical.

In the early 1970's, when JAR-25 was developed, the 0.85 Vc at 8000 ft condition was added to the Vc at sea-level condition to prevent OEM's from choosing a low Vc at sea-level, with a sudden increase in Vc just above sea-level, which would render the requirement ineffective. By no means the 8000 ft condition suggests that bird strikes above that altitude do not occur.

More and more OEM's are reducing Vc below 8000 ft, with a sudden increase in Vc at that altitude, for bird strike reasons. There is nothing in the current regulations that prevents this; Vc can be "freely" chosen by the applicant, except that JAR 25.335(b) requires a certain margin between Vb and Vc (43 knots in Change 14, 1.32 Uref in Change 15). Until now, applicants have maintained this margin, even for the reduced Vc below 8000 ft. One OEM has argued that the margin was established for other reasons (inadvertent speed increases due to severe atmospheric turbulence) than bird strike, and that Vc could therefore be reduced even below this margin, but this approach has been denied by JAA (and FAA).

JAA position

There is a serious safety concern regarding reduction of Vc below 8000 ft. Although accepted by JAA and FAA in the past on a case by case basis, this reduction, if generally applied, could reduce safety below a level acceptable to the JAA. The main reasons for this position are:

(1) In many countries Air Traffic Control restrictions are such that below 10.000 ft aircraft speed must be reduced to 250 knots. For aeroplanes equipped with turbofans, whose Vc on the average is approximately 320 - 340 knots, this leads to an additional margin in terms of bird strike capability. Undoubtedly this additional margin has contributed significantly to the current level of safety regarding bird strike damage. Reducing Vc below 8000 ft would take away much (if not all) of this safety margin, and would put safety at risk.

(2) A survey of serious (world-wide) bird strike incidents over the last 30 years has shown that even with a correct application and interpretation (no cut-backs in Vc below 8000 ft) of JAR 25.631 the level of safety offered by the current bird strike regulations is only marginally

acceptable. Since impact damage is approximately proportional to the speed of the aeroplane cubed (V^3), a cut-back in Vc of 10% (e.g. from 320 knots to 290 knots) is actually a decrease in impact criterion of 25%. Given the large amount of recent bird strike related incidents this is not an acceptable situation.

(3) Over the last 10 years a large increase in the bird population (particularly Canadian Geese) has been observed. This also supports the need for a correct application and interpretation of the current bird strike requirements.

Proposal

Taking the above into consideration, the JAA proposes to further modify (as indicated in bold text) JAR 25.631 as proposed by the GSHWG.

(a) The aeroplane must be designed to assure capability of continued safe flight and landing, after impact with a 4 lb (1.81 kg) bird when the velocity of the aeroplane (relative to the bird along the aeroplane's flight path) is equal to **the most critical Vc expressed in KEAS, from sea-level to the altitude of the intersection with the constant cruise Mach number line.** When compliance is shown by analysis, it must be supported by bird strike tests carried out on sufficiently representative structures of similar design.

(b) Windshield panes must be assessed in accordance with JAR 25.775(b) and (c).

Further clarification

The current regulations require an applicant to compare the sea-level condition with the 8000 ft condition. For this comparison the Vc at 8000 ft should be taken in KTAS. The factor 0.85 is understood to be (approximately) the square root of the ratio of the air densities at 8000 ft and sea level. So effectively the Vc (in KTAS) at 8000 ft is converted to KEAS. The most critical velocity (in KEAS) from this comparison is subsequently used in the bird strike substantiation (analysis and/or testing).
The same philosophy is maintained in the above proposal, except that, in lieu of two conditions (sea-level and 8000 ft), the full altitude range must be considered between sea level and the altitude of the intersection with the constant cruise Mach number line. The most critical Vc (in KEAS) in this altitude range should be used in the bird strike substantiation.
For most aeroplanes this intersection altitude would be somewhere between 20.000 and 25.000 ft, an altitude above which a bird strike becomes very unlikely.

* * *

ATTACHMENT C

TRANSPORT CANADA

BIRDSTRIKE POSITION PAPER

TRANSPORT CANADA
Bird Impact Position Paper

Bird's mass

Transport Canada is in favor of a common bird mass in a requirement applying to the empennage as well as to the rest of the airplane including the windshield. The four-pound requirement appears to be easy to implement, for a non-harmonized, intermediate step in presence of the enduring FAA dissenting opinion. Also, in view of recent bird strike events and concerning statistics about population of certain species, Transport Canada and the airworthiness community could become more sensitive to studies and statistics that, in the near future, would help all parties converge to a bird mass intermediate between 4 and 8 lbs.

Altitude

It is agreed that no particular meaning is connected to the altitude of 8000 ft other than a few decades of arbitrary assumption that no bird impact will take place beyond such altitude. The assumption might well be justified. Even the Viscount accident took place at 6000 ft, well below this arbitrary threshold. Transport Canada would agree to retaining the 8000 ft ceiling as a lower limit for a cutback of the envelope. Also, T.C. would consider discussing a different ceiling of say, 10000 or 12000 ft

Speed

The present JAA formulation, requiring a birdproof structure up to Vc or .85 Vc at 8000 ft, serves the vast majority of airplanes that make use of a constant KCAS value to define Vc. For these airplanes, the JAA formulation is equivalent to Vc at sea level adopted in FAR 25.631.

Envelope

The practice of envelope cutbacks or "notches" for bird impact purposes has been in use during the last 25 or more years and no adverse effect has been recorded by Transport Canada. Implementation of this feature poses no problem for fast jet airplanes where the 43 Kts or 1.32 Uref separation of Vc from Vb is easily satisfied while certain slower turboprops might not qualify. In any case, it remains understood that there is no "structural Vc" or "windshield Vc". The flight envelope has to be one and has to satisfy with no exception all the requirements of para 25.335.

The benefits obtained by the use of speed cutbacks can be better seen in a flight envelope drawn in terms of KTAS. This gives a better picture of the crippling action introduced by the preclusion of speed cutbacks. That is, either the advantage of high altitude flight is denied or the airplane will have to be designed with unnecessary strength. Either way will mean a needless reduction in performance. A better approach would be the adoption of a higher upper limit or a tapered cutback justified by probability considerations.

In summary:
-- 4 lb bird on the empennage. Non-harmonized.
-- Notched envelope allowed.

ATTACHMENT D

OEM BIRDSTRIKE POSITION PAPER

OEM Bird Strike Position
June 10, 2003

Summary Position

The OEMs remain committed to the existing GSHWG proposal to adopt a common weight bird for FAR §§ 25.571/25.775/25.631 of 4 pounds, the net effect of the proposal would be to reduce the current 8 pound birdstrike impact weight requirement of § 25.631. In the spirit of harmonization, the OEMs would support enveloping the current FAA and JAA requirements of this rule. Although specific supporting data for the FAA eight pound bird mass requirement on the empennage is not evident from the preliminary report from the U of I, the OEMs are willing in the spirit of harmonization to envelope the current FAA and JAA requirements. The OEMs remain opposed in principle to the prohibition of "cutback" speeds for birdstrike.

Background

The following are some of the key events related to the development and progress of the draft Birdstrike NPRM and AC developed within the GSHWG:

16 March 1993	First meeting of the General Structures Harmonization Working Group (GSHWG) – birdstrike harmonization discussions were initiated.
12 May, 1995	General Structures HWG reached technical agreement and signed off draft NPRM and AC.
7 July, 1995	GSHWG submitted draft NPRM and AC to TAEIG for review and requested it be submitted to FAA for legal and economic evaluation. A dissenting opinion, held by the FAA, was noted and the GSHWG resolution of the dissenting opinion was enclosed with the submittal package. TAEIG voted to accept the package and to forward it to FAA.
1 May, 1996	GSHWG chair learned from assigned economist (Greg Won) that TAEIG had not submitted the package to FAA for evaluation and that no work had been done. TAEIG then submitted the package.
2 May, 1996	GSHWG chair received a fax with issues and questions from the economist.
26 May, 1996	GSHWG chair, FAA representative, and economist telecom regarding issues and questions.
12 December, 1997	JAA initiated rulemaking with P NPA 25D-289.

15 September, 1998	GSHWG chair and FAA representative discussed data needed by the new economist (Anthony Apostolides) to start on the economic evaluation. Large package of data and background material was provided to the economist.
9 December, 1998	GSHWG chair learned from the economist that the FAA had never requested "formal" evaluation and that the item is being treated with a low priority.
18 December, 1998	FAA representative received from economist status that a "preliminary" evaluation would be completed during week of January 7-11, 1999.
19 January, 1999	GSHWG chair received memorandum from the economist providing a "rough estimate" of the evaluation. The economist had determined that the safety level had been reduced and that the expected decrease in cost to the industry is so small that it does not appear to justify the proposal. Based on this preliminary result, the FAA indicated they did not wish to waste any more time in completing the evaluation, since it would not be accepted.
16 March, 1999	GsHWG reported to TAEIG the rough estimate. In the opinion of the GSHWG chair, the FAA economist largely ignored the GSHWG report and its conclusions regarding the required level of safety and the justifications for the changes, and essentially reverted to the FAA's position from 1991. It is felt that the economic evaluation should be based on the GSHWG report, not on the conclusions and opinions held by the economist.
4 August, 1999	Letter from Craig Bolt, Assistant Chair - TAEIG, to Dorenda Baker – FAA requesting a formal technical position regarding bird weight from the FAA and JAA so that it could be determined if harmonization is possible.
24 April, 2000	Letter from Dorenda Baker, FAA, to Thaddee Soloki, providing justification for the FAA position on the eight-pound bird requirement.
23 August, 2000	FAA requests TAEIG opinion on whether to close issue or not.

19 October, 2000	GSHWG recommends to TAEIG not to close tasking. Group agrees to review outcome from FAA sponsored study by the University of Illinois (U of I) on "Assessment of Wildlife Strike Risk to Airframes."
23 January, 2001	SSG issues draft Temporary Guidance Material (TGM) on birdstrike cutback speeds.
13 August, 2002	JAA withdraws support of GSHWG agreed position on birdstrike, indicating that issue of "cutback" speeds must be addressed, i.e. "cutback" speeds to no longer be allowed.
25 October, 2002	GSHWG Meeting #34 – group discussion, proposal to envelope rule and adopt prohibition of "cutback" speeds accepted by all members except CAA/UK. Proposal to impose prohibition of "cutback" speeds and remain unharmonized on empennage bird mass accepted by FAA and JAA regulators but rejected by all others in the group. Agreement reached to disagree. Agreed to submit separate white papers to TAEIG along with statement that harmonization cannot be achieved within the group.

Birdstrike FAR/JAR §25.571(e)(1), 25.631, 25.775(b)(c)

The following table presents the evolution of the regulations associated with birdstrike.

Rule	Amendment Level	Text
25.571(e)	25-45 Effective 12/01/78	The airplane must be capable of successfully completing a flight during which likely structural damage occurs as a result of impact with a 4-pound bird at likely operational speeds at altitudes up to 8,000 feet.
25.571(e)	25-72 Effective 08/20/90	The airplane must be capable of successfully completing a flight during which likely structural damage occurs as a result of impact with a 4-pound bird at V_C at sea level to 8.000 feet.
25.571(e)	25-96 Effective 03/31/98	The airplane must be capable of successfully completing a flight during which likely structural damage occurs as a result of impact with a 4-pound bird when the velocity of the airplane relative to the bird along the airplane's flight path is equal to V_C at sea level or 0.85 V_C at 8,000 feet, whichever is more critical.
25.631	25-23 Effective 05/08/70	The empennage structure must be designed to assure capability of continued safe flight and landing of the airplane after impact with an 8-pound bird when the velocity of the airplane (relative to the bird along the airplane's flight path) is equal to V_C at sea level, selected under Sec. 25.335(a). Compliance with this section by provision of redundant structure and protected location of control system elements or protective devices such as splitter plates or energy absorbing material is acceptable. Where compliance is shown by analysis, tests, or both, use of data on airplanes having similar structural design is acceptable.
25.775(b)	25-0 Effective 02/01/65	Windshield panes directly in front of the pilots in the normal conduct of their duties, and the supporting structures for these panes, must withstand, without penetration, the impact of a four-pound bird when the velocity of the airplane (relative to the bird along the airplane's flight path) is equal to the value of V_C, at sea level, selected under Sec. 25.335(a).

Birdstrike FAR/JAR §25.571(e)(1), 25.631, 25.775(b)(c)

Discussion

The OEMs favor enveloping the current FAA and JAA requirements of this rule in the spirit of harmonization. Although specific supporting data for the FAA eight pound bird mass requirement on the empennage is not evident from the preliminary report from the U of I, the OEMs are willing in the spirit of harmonization to envelope the current FAA and JAA requirements. The OEMs remain opposed in principle to the prohibition of "cutback" speeds for birdstrike.

There is an increased level of safety being proposed if the requirement is to specifically protect crew and/or individual passengers. The current requirement is for continued safe flight and landing, except for the windshield requirement in 25.775 that specifies no penetration. It should be noted that there has been no Part 25 aircraft losses attributed to birdstrike damage on the airframe since the Vicount.

Between April 24, 2000 and February 21, 2003 the FAA sponsored research to ascertain a birdstrike criterion grounded in a risk assessment approach. This research did not result in a definitive conclusion; nevertheless, it did reveal some new information. The OEMs point to some of the initial findings of the U of I study initiated by the FAA:

- Bird Mass
  - 95% of the 700 species of birds that breed in North America have mean body masses of ≤ 4 lbs. For at least one gender. (Reference 1, Section 2.3, page 18)
  - Only 14 species have mean body mass ≥ 8 lbs. (Reference 1, Section 2.3, page 18)
- Top 10 Species Struck in U.S. (Reference 1, Section 2.3, page 17)
  - 1) Blackbirds – general category 605 Reports
  - 2) European Starling 570 Reports
  - 3) Rock Dove 409 Reports
  - 4) Mourning Dove 230 Reports
  - 5) Canada Goose 205 Reports
  - 6) American Kestrel 188 Reports
  - 7) Killdeer 158 Reports
  - 8) Red-Tailed Hawk 153 Reports
  - 9) Mallard 109 Reports
  - 10) Herring Gull 96 Reports
- Number of Strikes
  - 3% of all strikes (882) between 1990 and 2001 were mammals and reptiles and 56% of these collisions caused damage to the aircraft (Reference 1, Section 1.1, page 4)
  - 97% of all strikes (33,488) between 1990 and 2001 were birds, but only 15% of these collisions caused damage to the aircraft (Reference 1, Section 1.1, page 4)
  - The combined reported birdstrike data from all sources during the time period of 10/04/1919 to 08/28/2000 has been 105,797 occurrences (Reference 1, Table 3, page 13)

- Number of Flights
  - During the past 40 years, the report indicates there are 39,253 aircraft in the commercial fleet that have accumulated 637,390,214 total hours during 737,063,581 flights Reference 1, Table 12, page 41)

- Altitude
  - In regard to the altitude that the majority of birdstrikes occur, the initial study results indicate that the overwhelming majority of birdstrikes occur at altitudes less than 8000 ft. (> 99.5%). (Reference 2, Slide 9) Although the reference to an altitude of 8000 ft. in defining the impact speeds for which bird impacts are to be considered may have been chosen arbitrarily, the data on birdstrikes gathered by the U of I tend to support the selection of this altitude as an upper limit to the overwhelming number of birdstrikes.
  - Additionally, 93.8% of all birdstrikes occur at ≤ 1000 ft. AGL. (Reference 2, Slide 10)

- Speed at Time of Impacts
  - Maximum speed below 10,000 ft. was assumed to be 250 kts. if a real speed was not recorded in the data. (Reference 1, Section 4.2.2, page 40)
  - Approach speed was estimated at 150 kts. if a real speed was not recorded in the data. (Reference 1, Section 4.2.2, page 40)
  - Takeoff and landing speeds were estimated at 120 kts. if a real speed was not recorded in the data. (Reference 1, Section 4.2.2, page 40)
  - 95% of all strikes occur below 210 kts. (Reference 3, Item 2)

- Extrapolation of Probability for all Part 25 Aircraft
  - For an assumed speed of 250 knots at the 10^{-9} probability level for flight hours, the expected mass of the bird would be approximately 2.4 pounds. (Reference 1, page 45)

Conclusions

A review of the data presented in this position paper leads one to the following conclusions:

- Greater than 99.5% of birdstrikes occur at an altitude of less than 8000 feet where the maximum aircraft velocity is 250 knots and typically 120 to 150 knots.
- The analysis indicates that to ensure a 10^{-9} level of safety at 250 knots the expected mass of the bird would be approximately 2.4 pounds, not 4.0 or 8.0 pounds as currently required in the regulations.
- Climb rates of current aircraft ensure minimal time is spent in the air space where impacts are likely to occur.
- Even for those designs not certified to the latest amendment levels, safety does not appear to be an issue.

In conclusion, the OEM position to adopt a common weight bird for FAR §§ 25.571/25.775/25.631 of 4 pounds, the net effect of which would reduce the current 8 pound birdstrike impact weight requirement of

General Structures Harmonization Working Group Report

Birdstrike FAR/JAR §25.571(e)(1), 25.631, 25.775(b)(c)

§ 25.631 is valid, based on field service history and the results of the study funded by the FAA with the University of Illinois (U of I).

References:

1) FINAL REPORT, Assessment of Wildlife Strike Risk to Airframes, Conducted by Airport Technology Center of Excellence University of Illinois at Urbana-Champaign For U. S. Department of Transportation Federal Aviation Administration William J. Hughes Technical Center – AAR 410, Contract # DOT 95-C-001-11, By Edwin E. Herricks, Phil Mankin, and David J. Schaeffer, Dated December 2002.
2) Power Point Presentation to GSHWG Members at Meeting #31 June 11, 2002, Supporting FAA Research and Development Activities, Project: Assessment of Wildlife Strike Risk to Airframes by Edwin E. Herricks, University of Illinois at Urbana-Champaign Center of Excellence. 3) GSHWG Observations From Presentations RE: Bird Impact R&D Studies, February 13, 2001, Enclosure (9) of GSHWG Meeting #27 Minutes, Boeing Letter BYR20-AWH-M01-003 dated9 March2001.

25.1309 Phase 2 Task Plan
- Concept -

TAEIG meeting

Overview

- Objectives:
  - 25.1309: Address the high priority items recommended in Phase 1
  - 25.1529: Address Instructions for Continued Airworthiness (ICA) issues identified in Phase 1 and by Safer Skies/CPS recommendations
- Project management: under 2 years to finish

Overview (cont')

- Vision at the finish line:
  - Revision to Arsenal AC1309 – but no revision to Phase 1 proposed FAR
  - Revision to 1529 and Appendix H25.4 and new AC materials
  - Possible revision to AC25-19 (CMR)
  - Incorporate, as appropriate, CPS (Certification Process Study) recommendations
    - 1A charter: To identify "safety critical features" and the information necessary to protect those features in operation
    - Possibly 1B process: To insure FAA and Industry data management systems effectively provide data to identify accident precursor.

Preliminary Consensus

- Coordination with JAA (UKCAA and DGAC):
  - Authorities are harmonized regarding Phase 2 directions and scope (reference: JAA's TOR on 1309.)
- "Reality checks" with past Co-Chairs of SDA, FC, and PPI HWG's

Tasks

(see accompanied detail description)

- Safety Analysis: From Phase 1
  - Specific Risk (a.k.a. Deviation from Average)
  - Consistent assignment of Hazard Classification
  - Development assurance v.s. common mode failure
  - Expansion of Continued Airworthiness considerations (see expansion on next slide)
  - Additional item: Human Factor guidance. Present FAA research data.

Tasks (cont')

(see accompanied detail description)

- ICA:
  - Driven by considerations of CPS and Safer Skies recommendations:
    - Close the gap between Certification and Maintenance
    - Better 25.1529 compliance with respects to Systems
  - A rather large task. Will need a sub-team – and an integration plan.

What's new with Specific Risk thinking?

- Differentiating **known** high risk scenarios (e.g. wear-out, MEL) from anticipated risk scenarios (e.g. manufacturing quality, adverse environment, latent failures)
  - There are situations where risks are **known** to be significantly higher than allowed by the standards
  - FAA has no consistent guidance to manage these scenarios
- Previous proposal was very broad and encompassed both the known and the anticipated, and caused strong pushback from industry

What's new with Specific Risk thinking?

- Philosophy: Treatment of specific risk
  - Should be bounded to avoid being a "what if" tool
  - Allows justified relief from the <u>quantitative</u> minimum guidelines without violating the intent of the FAR.

Logistics

- For “Specific Risk” discussion, need experts from SDAHWG, FCHWG, and PPIHWG to ensure complete and consistent coverage of issues.
- For ICA discussion, need participation from
  - FAA’s AEG
  - Operators
  - Plus representatives from one or more of above HWG’s
- Integration between sub-groups to be managed by FAA, EASA, and Co-Chairs.

Outlook

- Formal tasking proposal by next meeting
- RPR by February, 2004
- Project kick-off in Spring 2004
- Request: identify Co-chairs ASAP
  - Purpose: FAA & EASA and Co-chairs to jointly develop task definitions and integration plan for the 1309/1529 sub-groups.
  - Early/well-thought-out coordination is vital to the project's success.

TAEIG Feedbacks

- Your feedbacks on the detail plan are requested by October 31st, 2003
- Technical questions? Contact
  - Email: Linh.Le@faa.gov
  - Phone: 425-227-1105

1309 Phase 2 and 1529 Work Plans - Concepts

OVERALL PROJECT OBJECTIVES AND SYNOPSIS:

- Plan includes priority 1 and 2 items from Phase 1 (see Table 3 below). Priority 3 and 4 items from Phase 1 to be addressed in later Phases as necessary.
- Program duration: under 2 years.
- As result of Safer Skies and CPS findings, Instruction for continued airworthiness (ICA) issues will also be addressed.
  - Parallel 1309 and 1529 working groups.
  - Integration to involve mainly several members from each sub-group.
- For 1309 tasks: participation from SDAHWG, FCHWG, PPIHWG, HF specialists
- For 1529 tasks: participation from AEG and Operations are needed. MIDO for internal support.
- FAA provides project management and integration.
- **Vision at the finish line:**

  - **new 25.1529 and/or appendix H25.4 language and AC material. Possibly some revision to AC25-19. Incorporate, as appropriate, Certification Process Study Team 1A and 1B recommendations.**
    [For your information : The goal of the CPS 1A team is to identify the "safety critical features" and the information necessary for the protection of those features. CPS1B team's goal is to insure data management programs effectively provide data to identify accident precursor.]

  - **new AC1309 material only – no new 1309 rule revision.**

JAA Coordination:

- Preliminary coordination with JAA (UKCAA and DGAC) indicates FAA and JAA are on same page regarding Phase 2 directions (see highlighted selections in Table 3 below.) Proposed FAA plan has been harmonized with JAA's TOR.

INDUSTRY Coordination:

- Discuss plan with past chairs of SDAHWG, FCHWG, PPIHWG for "reality check." [Done.]
- Present plan to TAEIG for comments.

ACTUAL TASKING STATEMENT:

- To be developed - taking into considerations TAEIG's feedbacks.
- Early joint FAA/EASA/Co-chairs effort to develop sub-group integration plan should
  - Promote clear and common understanding of task definitions
  - Increase likelihood of achieving project schedule and goals

TABLE 1 – 25.1309 Topics to be addressed in Phase 2

Category	Task Description	Comments	Estimated Schedule
1309	Discuss "Deviation from Average Risk": • Review current methodologies, standards, and practices (including any SAE material, if available) associated with "specific risk" and "average risk" analyses, and their contribution (in terms of benefits and cost impacts) to safety. • Define the term "Specific Risk" and the situations where specific risk analysis is appropriate. In other words, find the balance and boundary to the application of specific risk analysis. • Develop the appropriate guidance. • Define if or how <u>consistent</u> (not necessarily identical) policies across systems and powerplants (25.671/901/933/1309) can be achieved.	• While some industry members question the need for Specific Risk analysis, some other industry members have also commented that Specific Risk calculations are valuable and necessary to assess certain categories of safety issues, and not doing this calculation at all is not the right answer. However, it is clear that Specific Risk should be used in a limited manner to avoid becoming unbounded "what if" scenarios. Thus one objective in Phase 2 is to find the proper balance. • Bring together SDA, FC, PPI to ensure better chance for finding consistent policies.	9 to 12 months and 3 to 4 meetings.
	Develop guidance for consistent assignment of Failure Condition Classification	• Involve HF specialists because classification can be heavily dependent on assumed HF responses.	3 months
	JAA Development Assurance Vs common mode failure concern	• JAA (or EASA) to introduce and lead discussion.	3 months
	Expansion of continuing airworthiness consideration • Due to Safer Skies and CPS recommendations, this has become a larger effort than originally envisioned in Phase 1. Therefore, a sub-group is recommended to focus on this item.	See Table 2.	

	Human Factor issues: • Review the result of a human factor research project entitled "Pilot Intervention Credit in System Safety Assessment" funded by the FAA Transport Airplane Directorate and engineered by the National Aerospace Laboratory (NLR) of the Netherlands. Determine if, or how, the data and methodology developed by NLR should be incorporated into AC25.1309. • Review HFHWG output and possible impact on existing 25.1309. • Develop guidance for Human Error considerations in safety assessment	FAA HF representative on HFHWG to introduce subject and lead discussion.	3 months

TABLE 2 – ICA Topics

Category	Task Description	Comments	Estimated schedule
1529	Revise appendix H25.4 (and 1529 as necessary) to include airworthiness limitations applicable to aircraft systems (in addition to the currently provided airworthiness limitations to structures.) At the minimum, following items shall be considered:-	Review the "A" appendices of Parts 27/29/33 as references/models for this work.	
	• Certification Maintenance Requirement (CMR) for scheduled maintenance actions or restrictions to be mandated by FARs 43.16 and 91.403. • *Review and recommend any necessary revisions to AC25-19*		5 months
	• "Certification Dispatch Restriction" for the mandatory restrictions on releasing an airplane for flight (ref FARs 91.213, 121.303, 121.605,121.628, 125.201, 125.355, and 135.179)		3 months
	• "Certification Inspection Requirement" for the maintenance procedures that must be included as required inspection items. (Ref FARs 91.409, 121.369, 125.247, and 135.427)		3 months
	• "Certification Reporting Requirement" for each special reporting requirement to be mandated (ref FARs 21.3, 121.703, 121.705, 125.409, and 135.415.)	Review and incorporate, as appropriate, CPS1B recommendations.	3 months
	• "Certification Feature Identifier" for the means required to ensure that maintenance, repairs, or alterations do not unintentionally violate the integrity of the original type design approval (ref FARs 91.407, 121.367, 135.425.)	Review and incorporate, as appropriate, CPS1A recommendations. In coordination with 1309 sub-group.	3 months

Reference: TABLE 3 - Phase 1 Recommendations and Selection for Phase 2 activities

Topic	Phase 1 Recm'd Priority	Selection for Phase 2 work
Deviation from average risk	1	**Yes – main reason for having phase 2.**
Failure Condition Classification Guidance	1	**Yes – The need for this guidance is very strong.**
JAA Development Assurance Vs Common Mode Failure concern	1	**Yes – Very strong push from JAA side in Phase 1 and subject of current discussion in many system/software forums.**
Different safety criteria for part 25 small aircraft	1	No – A more general and higher philosophy on how small "transports" should be handled before 1309 issues can be meaningfully discussed.
Expansion of continuing airworthiness considerations	2	**Yes – this item is part of the larger 1529 effort due to Safer Skies and CPS recommendations.**
Integrated and Modular Systems	2	No. This item was advanced by Honeywell before existence of AC 20-145 which was recently issued. It is dedicated to IMA. Recent coordination indicates HI is more concerned about the integration of FBW in an IMA environment, and not so much about any regulatory/policy issues. I suggested to HI that this concern may be more directly met by SAE S18 committee who is revising ARP4754 and AR4761. HI has a co-lead on S18.
Threats to people outside the airplane.	2	No – Aside from OSHA issues (don't want mechanics to get electrocuted, etc.) statistics shows risk to people outside the airplane is in the noise.
Review of Electrical Wire Interconnect System (EWIS) safety assessment methodology and its relationship with 1309	2	No – UKCAA, DGAC and FAA specialists unanimously do not support this activity in Phase 2. NPA and NPRM on EWIS are in progress.
DO-254 (if harmonized by then)	3	No – However, HWG will be informed of any progress on FAA AC 20-XXXX which recognizes DO-254 in some TBD capacity.
Validation of safety assessment against in-service experience.	3	No - Low priority. Should be addressed by manufacturer's continued airworthiness program.
Continued work on Appendix 4 as appropriate	4	No – However, FAA has been doing research (with cooperation from CAA Netherlands) on the conditional probabilities listed in Appendix 4. May share info with HWG as time permits.
Review applicability of any referenced document that have changed.	4	No – Low priority. Regarding ARP4754 and 4761 specifically, because S18's work is happening concurrently, and some members of S18 are also on HWG, the coordination is expected to be somewhat automatic.

L&D HWG Status Report

Larry Hanson, Chairman
Todd Martin, FAA Focal

15-16 October 2003 TAEIG Meeting

Discussion Item

- Progress since June TAEIG Meeting
  - FAA Tech Center Testing for 25.865 Fire Protection draft AC

FAA Tech Center Testing for 25.865 Fire Protection Draft AC

- As reported to TAEIG in June
  - The results from the FAA Tech Center testing show that the either larger diameter bars must be used or the heat application time must be reduced in order to avoid excessive material temperatures
  - The task group was to evaluate the best way forward

FAA Tech Center Testing for 25.865 Fire Protection Draft AC

- Progress since June
  - Testing has been completed.
  - Preliminary review of results indicate that Inconel 718 compares to steel and therefore may be considered “fireproof” for engine mounts. Aluminum and titanium, however, did not pass.
  - Airbus and GE have proposed additional testing of larger diameter bars, which could potentially show better results for titanium. At this time, there is no other support for this testing from other members.
  - Current plan for completion of task:
    - No additional testing
    - Remove "fireproof rating" table from AC. Replace with a paragraph noting Inconel 718 as fireproof material.
    - Improve AC (paragraphs 7 – 9) with regard to acceptable means of compliance, using past compliance findings as a basis.