Below we provide FAA's projected average estimates for the next three years: [1]

Current Actions: New collection of information.

Type of Review: New Collection.

Affected Public: Individuals and Households, Businesses and Organizations, State, Local or Tribal Government.

Average Expected Annual Number of activities: 2.

Respondents: 2,813.

Annual responses: 2,813.

Frequency of Response: Once per request.

Average minutes per response: 15.

Burden hours: 704.

An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid Office of Management and Budget control number.

Public Comments Invited: You are asked to comment on any aspect of this information collection, including (a) Whether the proposed collection of information is necessary for FAA's performance; (b) the accuracy of the estimated burden; (c) ways for FAA to enhance the quality, utility and clarity of the information collection; and (d) ways that the burden could be minimized without reducing the quality of the collected information. The agency will summarize and/or include your comments in the request for OMB's clearance of this information collection.

Issued in Washington, DC, on March 21, 2011.

Carla Scott,

FAA Information Collection Clearance Officer, IT Enterprises Business Services Division, AES–200.

[FR Doc. 2011–7179 Filed 3–25–11; 8:45 am]

BILLING CODE 4910–13–P

[1] The 60-day notice included the following estimate of the aggregate burden hours for this generic clearance Federal-wide:

Average Expected Annual Number of activities: 25,000.

Average number of Respondents per Activity: 200.

Annual responses: 5,000,000.

Frequency of Response: Once per request.

Average minutes per response: 30.

Burden hours: 2,500,000.

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 new task assignment for the Aviation Rulemaking Advisory Committee (ARAC).

SUMMARY: The FAA assigned ARAC a new task to consider whether changes to part 25 are necessary to address rudder pedal sensitivity and rudder reversals. This notice is to inform the public of this ARAC activity.

FOR FURTHER INFORMATION CONTACT: Robert C. Jones, Propulsion/Mechanical Systems Branch, ANM–112, Transport Airplane Directorate, Federal Aviation Administration, 1601 Lind Avenue, SW., Renton, Washington 98057, telephone (425) 227–1234, facsimile (425) 227–1149; e-mail *robert.c.jones@faa.gov.*

SUPPLEMENTARY INFORMATION:

Background

The FAA established the Aviation Rulemaking Advisory Committee (ARAC) to provide advice and recommendations to the FAA Administrator on the FAA's rulemaking activities with respect to aviation-related issues. This includes obtaining advice and recommendations on the FAA's commitments to harmonize Title 14, Code of Federal Regulations (14 CFR), with its partners in Europe, Canada, and Brazil; in this instance, on rudder pedal sensitivity and rudder reversals. The committee will address the task under the ARAC's Transport Airplane and Engine Issues, and will reestablish the Flight Controls Harmonization Working Group, to assist in analysis of this task.

Recent research shows that regardless of training, pilots make inadvertent and erroneous rudder inputs, some of which have resulted in pedal reversals. Accident and incident data show airplanes that have experienced pedal reversals that surpassed the airplane's structural limit load and sometimes ultimate load. One case resulted in loss of the vertical fin, the airplane and 265 lives.

On November 12, 2001, an Airbus A300–600 crashed at Belle Harbor on climb-out resulting in 265 deaths and an airplane hull loss. The National Transportation Safety Board (NTSB) found "that the probable cause of this accident was the in-flight separation of the vertical stabilizer as a result of the loads beyond ultimate design that were created by the first officer's unnecessary and excessive rudder pedal inputs. Contributing to these rudder pedal inputs were characteristics of the Airbus A300–600 rudder system design and elements of the American Airlines Advanced Aircraft Maneuvering Program."

In two additional events, commonly known as the Miami Flight 903 event and the Interflug event, pilot commanded pedal reversals caused A300–600/A310 fins to experience loads greater than their ultimate load level. Both airplanes survived because they possessed greater strength than required by the current standards.

In January 2008, an Airbus 319 encountered a wake vortex. The pilot responded with several pedal reversals. Analysis shows that this caused a fin load exceeding limit load by approximately 29 percent. The pilot eventually stabilized the airplane and safely landed. The Transportation Safety Board (TSB) Canada investigated this event, with the NTSB providing accredited representatives.

On May 27, 2005, a de Havilland DHC–8–100 (Dash 8) airplane (registration C–GZKH, serial number 117) was on a passenger revenue flight from St. John's to Deer Lake, Newfoundland, with 36 passengers and 3 crew on board. During the climb-out from St. John's, the indicated airspeed gradually decreased to the point that the airplane entered an aerodynamic stall. The airplane descended rapidly, out of control, losing 4200 feet before recovery was effected approximately 40 seconds later. The incident occurred during daylight hours in instrument meteorological conditions. There were no injuries and the airplane was not damaged. During this event, the pilot commanded a pedal reversal.

The FAA sponsored studies [1] to understand parameters that affect the way pilots use the rudder. These studies included a survey of transport pilots from all over the world and real time piloted flight simulation. One of the studies found that many experienced pilots misused the rudder after wake vortex encounters. A follow-on study showed that the key parameter leading to excessive pedal use is short pedal travel. The analysis of a survey of large airplane pilots found:

1. Pilots use the rudder more than previously thought and often in ways

[1] 1. DOT/FAA/AM–10/14, The Rudder Survey Technical Report. For a copy, call Sarah Peterson at (405) 954–6840.

2. DOT/FAA/AR–09–5, Pilot Simulations Study to Develop Transport Aircraft Rudder Control System Requirements Phase 1 Simulator Motion System Requirements and Initial Results, Authors Hoh, Desrochers, Niscoll, 18 April 2007.

Note: HAI is about to release another report that has additional and more important results (essentially that pilot tendency to over-control correlates very strongly with pedal travel).

3. DOT/FAA/AR–10/17, Piloted Simulation Study to Develop Transport Aircraft Rudder Control System Requirements Phase 2 Develop Criteria for Rudder Overcontrol, Authors Hoh, Desrochers, Niscoll.

not recommended by the design approval holders (DAHs).

2. Pilots make erroneous pedal inputs, and some erroneous pedal inputs include rudder reversals.

3. After years of training, many pilots are not aware that they should not make pedal reversals, even below design maneuvering speed (V_A). Note: Over the past 4 years, training and Airplane Flight Manual (AFM) changes have directed the pilot not to make cyclic control inputs, but events occurred despite this effort.

4. Pilots in airplane upset situations (*e.g.,* wake vortex encounters) may revert to prior training and make excessive pedal inputs that they may then counter with pedal reversals.

The current standards in part 25 address large pedal inputs at airspeeds up to the design dive airspeed (V_D). This ensures safe structural airplane characteristics throughout the flight envelope from single full rudder inputs. However, the standard does not address the loads imposed by rudder reversals. Additionally, sections of part 25 require that controls operate with ease and smoothness appropriate to their function. However, these standards do not address specific control system parameters such as inceptor travel breakout force or force gradient.

The FAA is partially addressing this condition for new designs by requiring under § 25.601 that applicants for new type certificates show that the design is capable of continued safe flight and landing after experiencing rudder pedal reversals. The applicants have been able to show compliance with this requirement by appropriate rudder controls. These control schemes have been incorporated through software and therefore add no weight or maintenance cost to the airplanes. However, such controls might only be capable of a limited number of pedal reversals before exceeding airframe ultimate loads, and part 25 may need to address this situation.

The Task

Excessive use of rudder, beyond its design capabilities, has been identified as a contributing factor in several incidents and accidents. The FAA is tasking ARAC to consider:

1. the need to revise 14 CFR part 25, subpart C, to ensure airplane structural capability in the presence of rudder reversals and associated buildup of sideslip angles through a defined flight envelope (see question 1), or

2. if other sections of the airworthiness standard may more appropriately address this concern, such as certain pedal characteristics that discourage pilots from making pedal reversals (reduce pedal sensitivity).

If ARAC determines new requirements are necessary, it must recommend performance-based standards that allows manufacturers the flexibility to design airplanes to meet their needs while ensuring airplane safety. ARAC would also need to recommend methods of compliance (criteria), such as background simulation or piloted simulation, to support the rule change.

In addition, ARAC must consider the need to revise 14 CFR parts 26, 121, 125, 129, and 135, or to write airworthiness directives to address the safety concerns posed by rudder reversals in the existing transport airplane fleet. Finally, ARAC must recommend criteria that can be used to determine the need for retrofit.

ARAC is expected to provide a report that addresses the following questions regarding new airplane designs, with rationale for their responses. Any disagreement should be documented, including the rationale from each party and the reasons for the disagreement.

Questions

For New Transport Airplanes:

1. Define what is meant by pilot misuse/use of rudder and rudder pedal sensitivity, and determine the appropriate flight envelope that should be considered.

2. Consider what types of part 25 standards can be developed to prevent unintended or inappropriate rudder usage, or to ensure that unintended usage provides a level of safety commensurate with part 25. The working group should consider the following areas of the existing airworthiness standard:

a. Loads.
b. Maneuverability.
c. System design.
d. Control sensitivity.
e. Warning.

3. What is the best regulatory approach to address rudder usage? For example, is it better to assume certain inputs and provide mitigation to ensure safe flight (envelope protection), or to provide certain standards to ensure that the pilot will not make (inadvertent or inappropriate) inputs?

4. What changes, if any, to part 25—including details for compliance demonstration and guidance—are recommended for new type certification applications to prevent unintended improper rudder usage? Some considerations include use of analysis, desktop or piloted simulation, or actual flight testing.

5. Are there any regulations or guidance material that might conflict with the proposal?

6. Does current technology exist to support implementation of new requirements?

7. What are the effects and implications of any proposed change regarding commonly used system designs? For example, would a new standard cause adverse interaction with currently used fly-by-wire flight control systems, stability augmentation or auto-flight systems, or with current operations?

8. Does the proposed solution present any issues relating to specific flight phases or environmental conditions? If so, what are they, and how should they be addressed?

9. What recommended guidance material is needed?

10. After reviewing airworthiness standard, safety, cost, benefit, and other relevant factors, including recent certification and fleet experience, are there any additional considerations that should be taken into account?

11. Is coordination necessary with other harmonization working groups (e.g., Human Factors, Flight Test)?

For Existing Transport Airplanes:

The report must address the following questions while considering existing transport airplane designs, with rationale for the responses. Any disagreements should be documented, including the rationale from each party and the reasons for the disagreement.

1. What factors should be considered to determine if retrofit should be required?

2. For airplanes that require retrofit per the criteria, what differences should be considered from the requirements developed for new transport airplanes?

3. What are the effects and implications of any proposed retrofit standards and guidance for current system designs? For example, would the retrofit cause adverse interaction with currently used fly-by-wire flight control systems, stability augmentation or auto-flight systems, or with current operations?

4. After reviewing airworthiness standards, safety, cost, benefit, and other relevant factors, including recent certification and fleet experience, are there any additional considerations that should be taken into account?

5. If improvements are needed to ensure safe rudder usage, what is the recommended method to mandate retrofit? (Ad hoc airworthiness directives, part 26 rules, etc.) In responding, ARAC should address the factors set forth in "FAA Policy Statement: Safety-A Shared

Responsibility-New Direction for Addressing Airworthiness Issues for Transport Airplanes" (70 FR 40166, July 12, 2005), and the industry's ability to provide the necessary retrofit equipment that might be required.

ARAC should provide information that could lead to requirements in rudder load conditions, and/or system design that can be satisfied with practical design approaches.

The FAA will provide a copy of each DOT report mentioned in this tasking notice.

Schedule: The tasks described above are to be accomplished within 18 months of publication of this tasking notice in the **Federal Register**.

ARAC Acceptance of Task

ARAC accepted the task and will assign it to the reestablished Flight Controls Harmonization Working Group, under Transport Airplane and Engine Issues. This working group will use task groups to assist in their activities. Nominees should have experience in the areas of flight test, flight controls, loads, or human factors. The working group serves as support to ARAC and assists in the analysis of assigned tasks. ARAC must review and approve the working group's recommendations. If ARAC accepts the working group's recommendations, it will forward them to the FAA.

Working Group Activity

The Flight Controls Harmonization Working Group must comply with the procedures adopted by ARAC. As part of the procedures, the working group must:

1. Recommend a work plan for completion of the task, including the rationale supporting such a plan, for consideration at the next ARAC meeting on Transport Airplane and Engine Issues held following publication of this notice.

2. Give a detailed conceptual presentation of the proposed recommendations before proceeding with the work stated in item 3 below.

3. Draft the appropriate documents and required analyses and/or any other related materials or documents.

4. Provide a status report at each ARAC meeting held to consider Transport Airplane and Engine Issues.

Participation in the Working Group

The Flight Controls Harmonization Working Group will be composed of technical experts having an interest in the assigned task. A working group member need not be a representative or a member of the full committee.

If you have expertise in the subject matter and wish to become a member of the working group, write to the person listed under the caption **FOR FURTHER INFORMATION CONTACT** expressing that desire. Describe your interest in the task and state the expertise you would bring to the working group. We must receive all requests by April 25, 2011. The assistant chair and the assistant executive director will review the requests and advise you whether or not your request is approved.

If you are chosen for membership on the working group, you must represent your aviation community segment and actively participate in the working group by attending all meetings, and providing written comments when requested to do so. You must devote the resources necessary to support the working group in meeting any assigned deadlines. You must keep your management chain and those you may represent advised of working group activities and decisions to ensure that the proposed technical solutions don't conflict with your sponsoring organization's position when the subject being considered is presented to ARAC for approval. Once the working group has begun deliberations, members will not be added or substituted without the approval of the assistant chair, the assistant executive director and the working group chair.

The Secretary of Transportation determined that the formation and use of ARAC is necessary and in the public interest in connection with the performance of duties imposed on the FAA by law.

ARAC meetings are open to the public. Meetings of the Flight Controls Harmonization Working Group will not be open to the public, except to the extent individuals with an interest and expertise are selected to participate. The FAA will make no public announcement of working group meetings.

Issued in Washington, DC, on March 23, 2011.

Pamela Hamilton-Powell,

Executive Director, Aviation Rulemaking Advisory Committee.

[FR Doc. 2011–7180 Filed 3–25–11; 8:45 am]

BILLING CODE 4910–13–P

DEPARTMENT OF TRANSPORTATION

Federal Highway Administration

Environmental Impact Statement: Cook County, IL

AGENCY: Federal Highway Administration (FHWA), DOT.

ACTION: Notice of Intent.

SUMMARY: The FHWA is issuing this Notice of Intent to advise the public that an Environmental Impact Statement (EIS) will be prepared for the Grand Crossing Rail Project, which involves new railroad track work, structural work, grading, and signal improvements to provide a new direct route for Amtrak trains from New Orleans, Louisiana or Carbondale, Illinois into Chicago Union Station, and to provide sufficient mainline capacity to accommodate existing and additional Amtrak trains along with freight traffic in the City of Chicago, Cook County, Illinois.

FOR FURTHER INFORMATION CONTACT: Norman R. Stoner, P.E., Division Administrator, Federal Highway Administration, 3250 Executive Park Drive, Springfield, Illinois 62703, Phone: (217) 492–4600. Steve McClarty, Acting Bureau Chief, Bureau of Railroads, Illinois Department of Transportation, 100 W. Randolph Street, Suite 6–600, Chicago, Illinois 60601–3229, Phone: (312) 793–3940.

SUPPLEMENTARY INFORMATION: The FHWA, in cooperation with the Illinois Department of Transportation, Bureau of Railroads, will prepare an EIS on a proposal to construct a direct rail connection between the Canadian National (CN) and Norfolk Southern (NS) Chicago Line to provide a new, more direct route to Chicago's Union Station for Amtrak trains coming from New Orleans, Louisiana, and Carbondale, Illinois. The proposed project is an element of the overall Chicago Region Environmental and Transportation Efficiency Program (CREATE), a joint effort of the Illinois Department of Transportation, the Chicago Department of Transportation, and the Association of American Railroads to restructure, modernize, and expand freight and passenger rail facilities and highway grade separations in the Chicago metropolitan area. Alternative track configurations will be considered and refined. The no-action alternative will also be evaluated. A preferred alternative and associated potential impacts will be presented at a public hearing. Preliminary measures to minimize harm, construction cost estimates, and estimated right-of-way and relocation requirements will also be developed.

The proposed action will reduce travel time on the Amtrak's Illini-Saluki and City of New Orleans trains by eliminating a time-consuming back-up move into Union Station that these trains currently perform due to the existing track configuration. In addition, the proposed action will provide

U.S. Department
of Transportation
**Federal Aviation
Administration**

800 Independence Ave., SW.
Washington, DC 20591

Mr. Dan Elwell
Chair, Aviation Rulemaking
Advisory Committee
Airlines for America
1301 Pennsylvania Ave, NW, Suite 1100
Washington, DC 20004

Dear Mr. Elwell:

This is in reply to your December 30, 2013, letter that transmitted the Aviation Rulemaking Advisory Committee's (ARAC) recommendations regarding whether changes to part 25 are necessary to address rudder pedal sensitivity and rudder reversals. I understand that members of the Flight Control Harmonization Working Group (FCHWG), though not reaching consensus, did find substantial areas of agreement and that the report fairly represents the positions of all the group members. The report was approved unanimously by the Transport Airplane and Engine Subcommittee (TAE), and by the ARAC.

I wish to thank the ARAC, particularly the members associated with the TAE Subcommittee and its FCHWG that provided resources to develop the report and recommendation. The report will be placed on the ARAC website at: http://www.faa.gov/regulations_policies/rulemaking/committees/arac/.

We consider your submittal of the FCHWG report as completion of the tasking from the March 28, 2011, tasking statement (76 FR 17183). We will keep the ARAC apprised of the agency's efforts on this recommendation through the FAA report at future ARAC meetings.

Sincerely,

Lirio Liu
Designated Federal Officer

December 30, 2013
Federal Aviation Administration
800 Independence Avenue, SW
Washington, D.C. 20591

Attention: Ms. Margaret Gilligan, Associate Administrator for Aviation Safety

Subject: ARAC Recommendation, Airplane-Level Safety Analysis Working Group

Reference: ARAC Tasking, Federal Register, 2011-07180

Dear Peggy,

The Aviation Rulemaking Advisory Committee (ARAC) and the Flight Controls Harmonization Working Group (FCHWG) of the Transport Airplane and Engine Subcommittee are pleased to submit the attached report to the FAA. This report addresses the referenced tasking to provide recommendations for new and existing transport airplanes.

The consensus FCHWG recommendation is for Civil Aviation Authorities and other training organizations to consider enhanced flight crew training regarding appropriate rudder use. Details of the recommended enhanced training are contained in the report. The report presents multiple views regarding the need for additional part 25 standards to mitigate unintended or inappropriate rudder usage as consensus could not be obtained. The FAA is asked to fully consider all the views, substantiating data and economic impacts presented in the report.

In review of the existing transport airplane fleet, the FCHWG survey did not reveal any additional *relevant* rudder reversal service events beyond what was noted in the tasking. As such, the FCHWG recommends that retrofit be considered on a case by case basis and that existing retrofit mechanisms be utilized for any potentially unsafe conditions.

The report was unanimously approved by ARAC for transmittal to the FAA at our December 19, 2013 meeting.

I would like to express my thanks to the entire Working Group and the co-chairs for the extraordinary work that was done on this very difficult and challenging task.

Sincerely yours,

Dan Elwell
Chair, ARAC

Copy: Mike Kaszycki – FAA-NWR
Ralen Gao – FAA-Washington, D.C. – Office of Rulemaking

FAA Aviation Rulemaking Advisory Committee

Flight Controls Harmonization Working Group

Rudder Pedal Sensitivity/Rudder Reversal Recommendation Report

November 7, 2013

Table of Contents

List of Abbreviations

AA	American Airlines
AC	Advisory Circular, Air Canada
AD	Airworthiness Directive
AFM	Airplane Flight Manual
AFS	Flight Standards Service
ALPA	Air Line Pilots Association
ANAC	Agência Nacional de Aviação Civil
APC	Airplane Pilot Couple
ARAC	Aviation Rulemaking Advisory Committee
CFR	Code of Federal Regulations
CG	Center of Gravity
CS	Certification Specification
DAH	Design Approval Holder
EASA	European Aviation Safety Agency
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FBW	Fly By Wire
FCHWG	Flight Controls Harmonization Working Group
FDR	Flight Data Recorder
FH	Flight Hours
FTHWG	Flight Test Harmonization Working Group
FR	Federal Register
GNSS	Global Navigation Satellite System
HQ	Handling Qualities
NASA	National Aeronautics and Space Administration
NTSB	National Transportation Safety Board
Ny	Yaw Axis Acceleration
OEM	Original Equipment Manufacturer
PIO	Pilot Induced Oscillation
PR	Potential Reversals
SAFO	Safety Alert For Operators
SR	Safety Recommendation
TAEIG	Transport Airplane and Engine Issues Group
TBC	The Boeing Company
TCCA	Transport Canada Civil Aviation
TSB	Transportation Safety Board of Canada
VA	Design Maneuvering Speed
VC	Design Cruising Speed
VD	Design Dive Speed
VFR	Visual Flight Rules
VMC	Minimum Control Speed (with critical engine inoperative)
YD	Yaw Damper

Executive Summary

The FAA tasked the ARAC - http://www.regulations.gov/#!documentDetail;D=FAA-2011-0314-0001 - to consider the need to add a new flight maneuver load condition to 14 CFR part 25, subpart C, that will ensure airplane structural capability in the presence of rudder reversals and associated buildup of sideslip angles through a defined flight envelope, or to consider if other standards may more appropriately address this concern, such as certain pedal characteristics that discourage pilots from making pedal reversals. The ARAC was tasked to recommend a performance-based requirement that allows manufacturers the flexibility to design airplanes to meet their needs while ensuring airplane safety. The ARAC was also tasked to recommend methods of compliance, such as background simulation or piloted simulation.

The FCHWG makes three recommendations.

1) Enhanced Flight Crew Training Recommendation.
2) Proposed new regulation 25.353, which would apply to new transport airplanes.
3) For existing transport airplanes, the FCHWG believes that retrofit should be considered on a case by case basis and that if any potentially unsafe conditions are found that they should be addressed using airworthiness directives. (Note: Several airplanes were reviewed as part of the FCHWG deliberations. None were found to have an unsafe condition.)

There are dissenting opinions with regard to Recommendation 2. These dissenting opinions are outlined in “Recommendations” and “Consensus and Dissenting Opinions.”

Background

Service experience and recent investigation show that regardless of training, pilots make inadvertent and erroneous rudder inputs. Some actual cases have resulted in pedal reversals. Accident and incident data show some airplanes that have experienced such reversals have surpassed the airplane's structural limit load and sometimes ultimate load. The FAA finds it is necessary to revise the rules to ensure that airplanes are designed such that pilots will not (1) inappropriately make pedal reversals and/or (2) be capable of overloading the fin under foreseen conditions.

On November 12, 2001, an Airbus A300-600 operated as American Airlines Flight 587 crashed at Belle Harbor, New York, on climb-out resulting in 265 deaths and an airplane hull loss. The National Transportation Safety Board (NTSB) found “that the probable cause of this accident was the in-flight separation of the vertical stabilizer as a result of the loads beyond ultimate design that were created by the first officer’s unnecessary and excessive rudder pedal inputs. Contributing to these rudder pedal inputs were characteristics of the Airbus A300-600 rudder system design and elements of the American Airlines Advanced Aircraft Maneuvering Program.”

In two additional events, commonly known as the Miami Flight 903 event and the Interflug event (both included in the AA587 report), A300-600/A310 fins were loaded past the certification ultimate load level due to pilot commanded pedal reversals. Both airplanes survived these events due to having strength in excess of that required by the current standards.

In January 2008, an Airbus 319 operated as Air Canada Flight 190, encountered a wake vortex. The pilot responded with several pedal reversals. Analysis has shown that this caused a fin load exceeding limit load. The pilot eventually stabilized the airplane and safely landed. The Transportation Safety Board (TSB) of Canada investigated this event with the NTSB providing an accredited representative and advisors.

In May 2005, a de Havilland DHC-8-100 (Dash 8) experienced an upset during which the pilot commanded a pedal reversal during climb-out, when the airplane entered an aerodynamic stall. There were no injuries and the airplane was not damaged. The FCHWG loads subgroup determined that the loads occurring during this event were less than limit and was therefore only considered as evidence that pedal reversals may occur in service. Attachment F identifies the official reports for these events.

The current yaw maneuver standard addresses large pedal displacements at airspeeds up to the design dive airspeed (V_D). This ensures safe structural airplane characteristics throughout the flight envelope from single full pedal inputs and releases. However, the standard does not address the loads imposed by pedal reversals. Additionally, other certification standards require that controls operate with ease, smoothness, and positiveness appropriate to their function. However, these standards do not address specific control system parameters such as inceptor travel, breakout force or force gradient.

The FAA is addressing, in part, this condition for new designs by requiring under § 25.601 that applicants for new type certificates show that their design is capable of continued safe flight and landing after experiencing rudder pedal reversals. For fly-by-wire architectures, the applicants have been able to show compliance with this requirement by appropriate rudder control laws. These control laws have been incorporated through software and therefore add no weight or maintenance cost to the airplanes. However, depending on the design, such control laws might only be capable of a limited number of pedal reversals prior to exceeding airframe ultimate loads, any new regulation may need to consider this situation.

Historical Information

1. Systems Design Review

The combined group reviewed data of several airplane configurations to determine if some airplane designs were less sensitive to rudder pedal reversals. By reviewing several configurations we found that in addition to fly-by-wire airplanes, manually, or hydromechanically controlled airplanes with yaw dampers whose commands cannot be nulled by the pilot (unswampable) are much more tolerant to rudder pedal reversals than airplanes whose yaw dampers can be nulled by the pilots. The unswampable nature results in lower loads. This shows that FBW, hydromechanical, and manually controlled airplanes with yaw dampers can mitigate high loads due to large pedal inputs.

Our activity also showed that there are several airplanes currently in service that contain this beneficial design feature.

Conclusion:
Fly-by-wire as well as manual and hydro mechanical systems appropriately configured with unswampable yaw dampers can significantly lower fin loads resulting from pedal reversals relative to airplanes with swampable yaw dampers. This activity also showed that this type of design has been used on certain airplane models for many years, and is not new technology. However, requiring such a configuration on new airplanes is considered design prescriptive and is therefore one option, but not the only option, a manufacturer might use to address rudder pedal reversals.

2. Loads Task Group Activity

The loads task group (sub-group formed mainly by load specialists amongst FCHWG members) reviewed in-service events involving rudder reversals. The group used these events to inform the development of a static strength condition that would be used to evaluate the current fleet of commercial airplanes. Since the evaluation of the aircraft structure for all possible rudder commands is not feasible, one idealized condition was developed. This condition was considered to provide a reasonable level of safety based on the understanding from the fleet history data. The development of the static strength evaluation focused on five major areas: the number of doublet cycles, the factor of safety, failure scenarios, flight envelope, and static strength evaluation criteria.

Based on the in-service events, the loads task group designed a single-doublet rudder pedal reversal condition in which the rudder pedals are reversed at maximum sideslip based on the peak overswing sideslip. The idealized condition is as described below (Note this condition is different from the proposed 25.353 design load condition described under Recommendation).

Maneuver Definition
One complete doublet is applied consisting of an initial rapid application of maximum pedal force from 25.351(a). As the sideslip develops, the rudder pedals are rapidly reversed (maximum 25.351(a) pedal force applied to the opposite pedal) either at maximum overswing or so as to achieve the allowable reversed rudder deflection coincident with the peak overswing sideslip, yielding the highest vertical stabilizer loads. As the sideslip develops in the opposite direction, the rudder pedals are rapidly returned to neutral either at maximum overswing or so as to achieve zero rudder deflection coincident with the peak overswing sideslip, again yielding the highest vertical stabilizer loads.

Factor of Safety

There are four known notable rudder reversal events in commercial aviation history, two of which occurred as a result of a wake encounter, and the commercial airplane fleet has more than a combined 500 million flight hours. Assuming an equal probability across all airplanes in the commercial fleet, the probability of a rudder reversal that reaches or exceeds design limit loading is approximately 10^{-8} per airplane flight hour. For this reason, it was determined that use of an ultimate load condition (factor of safety = 1.00) was deemed appropriate. This probability is based on historical data; very accurate GNSS navigational accuracy that produces highly repeatable flight paths, and any changes in air traffic control, specifically vertical separation minimums, may change the probability of a wake encounter.

Failure Scenarios

Due to the low probability of a high load rudder doublet event, failure scenarios were not addressed in combination with the rudder pedal reversal condition. For example, fly-by-wire aircraft analyzed this maneuver in normal control law mode.

Yaw Damper

Since the conditions evaluated for the Loads study were typical operational flight conditions, if the yaw damper were typically on as per AFM procedures, the Loads calculations generally assumed yaw damper on in these calculations.

Flight Envelope Determination

Since this event is rare, it was deemed acceptable that this condition be evaluated using nominal and realistic flight conditions and parameters (in particular aerodynamic configurations not used frequently as airbrakes extended can be omitted). The analyses did not use the worst possible aircraft payload combined with the worst possible flight envelope condition, but instead the analysis used a representative fatigue mission condition.

Static Strength Evaluation Criteria

The evaluation of this load condition used the vertical stabilizer side-of-body bending moment, which is the primary design load for the vertical stabilizer structure.

The vertical stabilizer side-of-body bending moment was compared as a percentage to the design bending moment level, at ultimate load, produced by the current FAR regulations. Manufacturer imposed design requirements were removed from this comparison so that the loads could be presented as a percentage of level of safety provided by the current regulations.

In summary, the rudder pedal reversal static ultimate strength condition was analyzed for one full rudder pedal doublet with the pedal reversal initiated at or just before the maximum sideslip overswing, a nominal flight condition, and with all systems in normal mode.

Results

Each OEM evaluated a representative set of airplanes by running the time history loads analysis to the criteria defined above. The aircraft analyzed were categorized by size and general arrangement to provide a similar basis of comparison. The vertical stabilizer side of body bending moment for the pedal doublet was compared as a ratio to the ultimate static strength design load level as defined by the FAR design criteria. This ratio is presented in the second column of Table 1. Comments are provided to distinguish between the different rudder system designs.

Aircraft Type	Doublet/Ultimate	Comments
Small/Medium Business Jet	0.40 up to 1.0 (approx)	Approx value based on estimated yaw damper effect. Lower value powered rudder. Higher value manual rudder 300 lb pilot effort
Medium/Large Business Jet	0.34 up to 0.75	Powered rudder, rudder FBW produces lower value
Fuselage-Mounted Engine Regional Jet	0.42 up to 0.79	Lower value based on rudder FBW laws, upper value no FBW
Wing-Mounted Engine Regional Jet	up to 0.80	Open loop rudder FBW
Single Aisle Passenger Jet	0.61 up to 0.73	No Rudder FBW
Widebody Passenger Jet	0.50 up to 0.81	Lower value based on rudder FBW laws, upper value no FBW

Table 1. Single pedal doublet results by commercial transport category (rudder pedal reversal *initiated at* peak overswing sideslip). All results in Table 1 are generally with yaw damper on.

The work of Table 1 was repeated, but this time with the pedal reversal coincident with the peak overswing sideslip. Results are presented in Table 2 and show the sensitivity to timing of the rudder pedal reversal input. It should be noted that for most aircraft types there was no more than 2% difference.

Aircraft Type	Doublet/Ultimate	Change vs Table 1
Small/Med Biz Jet	0.41 up to 1.0 approx	Upper value unchanged
Med/Large Biz Jet	0.38 up to 0.75	Upper value increased by <2%
Eng/fuse mount Regional Jet	0.41 up to 0.81	Upper value increased by <2%
Eng/Wing mount Regional Jet	up to 0.92	Upper value increased by 15%
Single Aisle Passenger	0.62 up to 0.75	Upper value increased by <2%
Widebody Passenger	0.51 up to 0.83	Upper value increased by <2%

Table 2. Single pedal doublet results by commercial transport category (rudder pedal reversal *coincident with* peak overswing sideslip).

The results from Tables 1 and 2 show that the ultimate load single pedal doublet condition defined herein does not generate higher airframe loading than the current FAR design ultimate load level. With the exception of the Small/Medium Business Jet with a manual rudder system, the airframe loading of the current commercial fleet is approximately 20 percent below the current FAR design ultimate load level. The data also shows that, for aircraft with either advanced fly-by-wire systems or high authority yaw dampers, the pedal doublet load is less severe.

Effect of Multiple Doublets on Vertical Tail Side of Body Bending Moment

To understand the effect of multiple doublets, beyond the single full-stroke doublet, and to what extent the single full-stroke doublet envelopes multiple lower amplitude doublets, a side study was undertaken. This study sought to determine, at the same flight condition as the single full-stroke doublet, how much the single full-stroke doublet rudder pedal input would need to be reduced for 2, 3, 4, and 5 doublets in order to not exceed the loads of the single full-stroke doublet.

The critical (i.e., largest vertical tail side of body bending moment) single full-stroke doublet (rudder pedal reversal initiated at peak overswing sideslip) was used as the baseline condition. That same condition was run for multiple doublets with reduced rudder pedal input so that the multiple doublet load was equivalent to that of the single full-stroke doublet load.

Results are shown in Figure 1 for the four aircraft noted (representing 3 OEMs). The average of the results is shown by the solid line, while the dashed lines show the envelope of the minimum/maximum result values.

Figure 1 shows that for the airplanes studied, reducing the rudder pedal input to approximately 60% (±5%) of the full-stroke doublet input would allow 3 doublets to not exceed the load of the single full-stroke doublet. Furthermore, due to the asymptotic nature of the curve, that same level of pedal input would allow 4, 5, and potentially more doublets to be performed without exceeding the load of a single full-stroke doublet. For example, for a rudder control system in which the full stroke rudder pedal travel is 4 inches, reducing the rudder pedal travel to 2.4 inches (60%) would allow 3 doublets that would not exceed the load of the single full-stroke doublet.

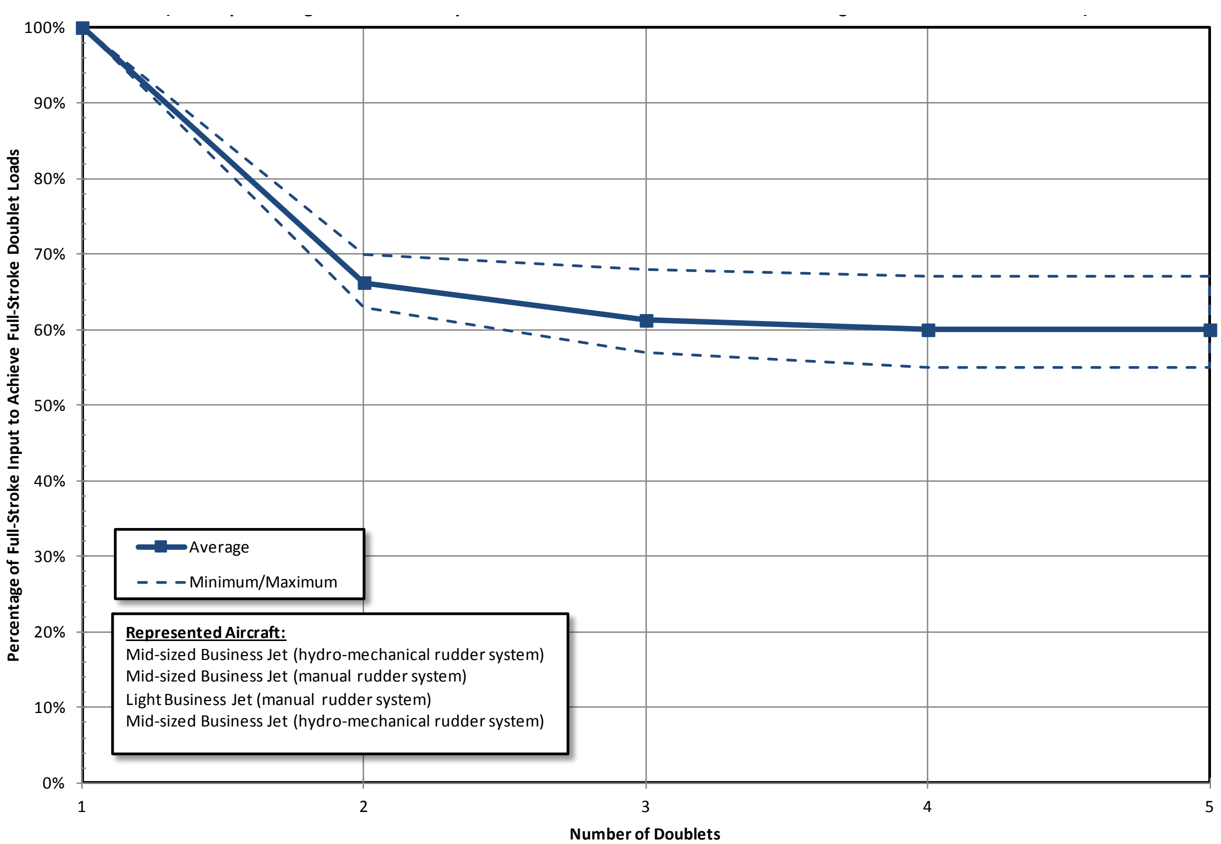

Figure 1. Percentage of full pedal stroke input to get for several doublets the one full stroke doublet load.

Conclusions

The most significant fleet history events were used to guide the creation of a reasonable static strength condition to represent severe vertical stabilizer loading. This condition represents a single full-stroke rudder pedal doublet, but also provides some coverage for lower-amplitude multiple doublets. The resulting static strength condition was analyzed for the current fleet of commercial airplanes and the airframe loading did not exceed the design ultimate loads defined in the current FAR regulations. The analysis shows that current requirements provide adequate structural protection against a single pedal reversal in the most likely flight conditions. The analysis also shows that after three doublets, fin loads did not increase, indeed even after two doublets there is little further increase, if rudder pedal displacement is limited to 60% of full travel.

Research Information

FAA sponsored studies had been conducted prior to the ARAC tasking to understand parameters that affect the way pilots use the rudder. (See the tasking statement for details). These studies included a survey[1] of transport pilots from all over the world and several real time piloted simulation studies.

The survey found that some experienced pilots unexpectedly used the rudder after wake vortex encounters. The survey also found:

1. Pilots use the rudder more than previously thought and often in ways inconsistent with the intended function recommended by the design approval holders (DAHs).
2. Pilots make erroneous pedal inputs, and some erroneous pedal inputs include rudder reversals.
3. After years of training, many pilots are not aware that they should not make pedal reversals, even below design maneuvering speed (V_A). Note: Over the past 4 years, training and Airplane Flight Manual (AFM) changes have directed the pilot not to make cyclic control inputs even below V_A. The Air Canada event occurred despite this effort.
4. Pilots in airplane upset situations (e.g., wake vortex encounters) may revert to prior training and make excessive pedal inputs that they may then counter with pedal reversals.

ARAC/FCHWG reviewed the simulator studies, which suggested that short pedal throws are more prone to pedal reversals. These simulator studies provide insight into the level of difficulty to try to assess a control that is not designed to be used very often, and almost never at higher speeds. All of the piloted studies had to provide somewhat artificial circumstances to ensure the pilots would interact with the pedals, which led to issues of how realistic the scenarios were. The capability of the simulators used was also called into question. Additionally, the data methods and statistical significance of the results were questioned. Ultimately, the FCHWG did not find that the FAA/NASA sponsored simulator studies directly addressed the tasking of the group (i.e., none of the reports were adequate to directly address any single tasking question). Additional information regarding FCHWG's assessments of these studies is contained in Attachment D.

The aircraft response of AC190 and AA587 was recomputed assuming the pilots did not use rudder pedal inputs for recovery, instead using normal roll control inputs from the largely roll-upset induced by the wake encounters. In both cases, the severity of the aircraft response would have been substantially reduced (in sideslip as well as bank angle) if the pilot would not have made rudder pedal inputs, but rather apply only roll commands in response to the roll upset.

[1] Peterson, Sarah L., et al, "An International Survey of Transport Airplane Pilots' Experiences and Perspectives of Lateral/Directional Control Events and Rudder Issues in Transport Airplanes (Rudder Survey)," DOT/FAA/AM-10/14, October 2010.

Recommendation

Summary

The FCHWG makes three recommendations.

1) Enhanced Flight Crew Training Recommendation.
2) Proposed new regulation 25.353, which would apply to new transport airplanes.
3) For existing transport airplanes, the FCHWG believes that retrofit should be considered on a case by case basis and that if any potentially unsafe conditions are found that they should be addressed using airworthiness directives. (Note: FCHWG reviewed several airplanes as part of the FCHWG deliberations. None were found to have an unsafe condition.)

NOTE: For recommendation 2, there are dissenting opinions, which are discussed later in this report.

Recommendation 1 - Enhanced Flight Crew Training:

FCHWG recommends that appropriate Civil Aviation Authorities and other training organizations consider enhanced flight crew training regarding appropriate rudder use. Details of the enhanced training outline are contained in Attachment A.

While training and AFM changes implemented in the wake of AA587 have been beneficial, FCHWG learned anecdotally of events (even in the presence of the changes to crew training from AA587) where some flight crews:

- Appeared to misunderstand the structural protections afforded by maneuvering speed,
- Appeared to be unaware that those structural partial protections are only inherently provided in the pitch axis,
- Appeared to be unaware of the magnitude of loads which can be generated by the rudder, especially in the presence of sideslip,
- Appeared to misunderstand the mechanism by which the rudder generates roll, and the effect of wing sweep on the (delayed) roll response to a rudder input,
- Appeared to generally misunderstand, or were apparently not aware of, what the manufacturer considers appropriate and inappropriate rudder use,
- Appeared to not fully understand the purpose of, or presence of, control system features like rudder-limiting, auto turn coordination, and how their functioning changes with airspeed and/or configuration.

Furthermore, in the re-creation of AA587 and AC190, but *without* the use of the rudder pedals, the upset was substantially reduced versus when the flight crews used the pedals in the accident events themselves. Meaning the crews' use of the rudder, in a flight condition where rudder use was not necessary, greatly exacerbated the magnitude of the upset leading to vertical tail limit-load exceedance.

For these reasons, the FCHWG recommends that FAA Flight Standards and industry groups that focus on pilot training review Attachment A, and as appropriate implement it as part of approved flight crew training programs. This training will benefit not only pilots that operate new transport airplanes, but also the existing transport fleet. FCHWG's training recommendation should be covered in Type Rating and Recurrent training, and is broken down in to a general academic module, as well as a module dedicated to the specific aircraft design, and a simulator demonstration (if the simulator can be used as a demonstrative tool, given its limitations, without negative transfer of training).

Recommendation 2 - Proposed new regulation 25.353, which would apply to new transport airplanes.

The FCHWG recommends that a new rule be adopted (25.353), together with a corresponding advisory circular (AC). These are shown in Attachment B (the rule) and Attachment C (the AC). The majority believe that a rule change is needed, but they are not in agreement on what it should require. One FCHWG member believes that no change to the subpart C maneuver loads requirements is necessary. See further discussion under Consensus and Dissenting Opinions below.

The proposed new rule, 14 CFR Part 25.353, includes a yaw maneuver condition that would be required in addition to the current yaw maneuver condition specified in 25.351. The rule would add a design ultimate load requirement that would consist of either a single pedal doublet maneuver, or a two pedal doublet maneuver. Five members are in favor of the single doublet condition, and five are in favor of the two doublet condition. This maneuver would be defined as either a full displacement input, followed by one reversal and return to neutral (single doublet condition); or a full displacement input, followed by three reversals and return to neutral (two doublet condition).

All 14 CFR Part 25.353 conditions, whether (a)-(c) (Version 1) or (a)-(d) plus return to neutral (e) (Version 2), would be considered ultimate load conditions with a safety factor of 1.0. The applicant would not need to consider failure conditions in combination with these ultimate loading conditions. The applicant must consider all approved airplane configurations and flight conditions (weights, cg, speeds up to V_C, altitude, etc.) in accordance with Sec. 25.321. These conditions are to be considered with the landing gear retracted and speed brakes (or spoilers when used as speed brakes) retracted. Flaps (or flaperons or any other aerodynamic devices when used as flaps) and slats extended configurations are also to be considered if they are used in en route conditions. For rudder reversals, the sudden displacement of rudder pedal occurs when the overswing sideslip angle is achieved, not before.

During the proposed condition, system effects should be taken into account. If the airplane is fly-by-wire, it should be evaluated in normal law. Systems which are used to show compliance must meet conditions outlined in the AC.

Recommendation 3 - For existing transport airplanes, the FCHWG believes that retrofit should be considered on a case by case basis and that if any potentially unsafe conditions are found that they should be addressed using airworthiness directives. (Note: Several airplanes were reviewed as part of the FCHWG deliberations. None were found to have an unsafe condition.)

The FCHWG believes that a review of the existing fleet is important to ensure fleet safety. We conducted an evaluation during the proceedings of the FCHWG, covering a representative spectrum of the Part 25 aircraft designs currently in service. This evaluation did not reveal any additional *relevant* rudder reversal service events beyond what was noted in the tasking (though in the survey, several pilots self-reported reversals). Further, the loads analysis demonstrated that the models studied have adequate protection from a single, full pedal stroke doublet. The FCHWG recommends that no further retrofit evaluation is needed for the models evaluated by the group.

Models that were not considered by the group may need to be considered for evaluation for acceptability. The FAA proposes criteria of service history, current structural capability and architecture as a means to determine whether airplanes are safe enough without modification. In particular the comparison of yaw system architecture and lateral dynamic behavior of the concerned airplane with a previously evaluated model could be sufficient to demonstrate its robustness to "doublets". If loads analysis is required, it will not impose any criteria more severe than was used during the Loads subgroup study mentioned under "Historical Information." Note, this effort would also support NTSB Safety Recommendation (SR) A-04-057. If the need arises for retrofit action in the future, the best approach would be to issue airworthiness directives as required on a case-by-case basis.

<u>Questions Raised in the Tasking Statement</u>

The FCHWG was asked to answer the following questions as it developed its recommendations.

Questions:

For New Transport Airplanes:

1. Define what is meant by pilot misuse/use of rudder and rudder pedal sensitivity, and determine the appropriate flight envelope that should be considered.

   Answer:

   <u>Pilot misuse/use of rudder:</u>

   After extensive discussion there was general consensus as to what is meant by pilot misuse of rudder. There was one dissenting opinion from ALPA which is contained below.

   The FCHWG views pilot rudder/pedal usage as falling into one of three categories:

1. Appropriate: Pilot rudder/pedal usage (or non-use) consistent with the manufacturer's recommendations, including failure cases, considering system architecture and functions, and verified to lead to structural loads covered by regulations (possibly including Special Conditions).
2. Inappropriate: Pilot rudder/pedal usage (or non-use) inconsistent with the manufacturer's recommendations, considering system architecture and functions. Inappropriate rudder/pedal usage can be further subdivided:
    a. Inappropriate/intentional: Pilot rudder/pedal usage which is inconsistent with the manufacturer's recommendation, but made intentionally by the crew. This could be due to the crew reverting to prior training, misunderstanding of the rudder function, improper failure diagnosis, overreaction, etc.
    b. Inappropriate/inadvertent: Pilot rudder/pedal usage which is inconsistent with the manufacturer's recommendation, but made inadvertently/accidentally (rudder inputs due to seat ingress/egress, stretching/reaching, etc.).

It is the opinion of the FCHWG, at least based on the available accident record, that the current regulations (Subparts B, C, D/F) provide adequate design requirements for appropriate pilot rudder/pedal usage (#1), even possibly including rudder reversals on the ground and at the low airspeeds of takeoff and landing. However, although rare, the accident record indicates that the regulations may not provide adequate design requirements for inappropriate pilot rudder/pedal usage, whether inappropriate-intentional (#2a) or inappropriate-inadvertent (#2b).

ALPA dissenting opinion

ALPA agrees that the regulations may not provide adequate design requirements for unexpected use of the rudder but has difficulty with use of the words "appropriate" and "inappropriate" in the statement above. ALPA is of the opinion that "appropriateness" of an action depends on the situation at hand. Use of the rudder control that is inappropriate in one scenario may be appropriate in another; i.e., should a situation arise in which the lateral control is ineffective then it may be appropriate to apply a small amount of rudder in the direction of desired roll as the only means remaining to facilitate an increase in roll rate. The appropriate use of the rudder control is determined by the pilot based on his perception of the current flight situation. This may result in an unexpected use of the rudder from the manufacturer's point of view. Therefore, unexpected use of the rudder should not result in an Airplane-Pilot Couple (APC) that may lead to multiple rudder reversals that have the potential to exceed the vertical fin ultimate load. Recommend the words "appropriate" and "inappropriate" be replaced with "expected" and "unexpected."

ALPA would consider misuse of the rudder to be pilot use of rudder in a manner that has a high likelihood of causing harm to the airplane.

Flight Envelope to be Considered:

For the FCHWG members recommending modification to existing 14 CFR Part 25 design standards – both proposed 25.353(a)-(c) and proposed 25.353(a)-(e) – a flight envelope for use in the proposed rule was agreed by all.

Airplane Response/Maneuverability and Rudder Pedal Sensitivity:

See discussion under 2b and 2d, below.

2. What types of part 25 standards can be developed to prevent unintended rudder usage or to ensure that unintended usage provides a level of safety commensurate with part 25? The working group should consider the following types of standards:
    a. Load
    b. Maneuverability
    c. System design
    d. Control sensitivity
    e. Warning

    Answer:

    The group determined that no standard can be developed to prevent unintended rudder usage. However, the group was able to develop a standard that accounts for inappropriate usage (a design load condition), described above. The referenced standards (a. thru e.) were considered.

    In responding to this question, the FCHWG also considered NTSB SR A-04-056, "Modify 14 CFR part 25 to include a certification standard that will ensure safe handling qualities in the yaw axis throughout the flight envelope, including limits for rudder pedal sensitivity." FCHWG investigated Airplane Response/Maneuverability (2b) and Control Sensitivity (2d), including engagement of the Flight Test Harmonization Working Group (FTHWG) and analysis of 9 different airplanes' responses to a contrived rudder pedal input aimed at determining a pass/fail criteria for rudder pedal control sensitivity. However, given the time/resources available, the group was unable to reach any conclusions regarding what kinds of sensitivity parameters pilots were sensitive to, especially with regards to what would make them less prone to making rudder pedal reversals. (Additional details are contained in Attachment H.) Hence, this recommendation contains no changes to Subpart B.

    Furthermore, after significant review of the existing Subpart D and F System requirements (2c), there was no logical place where system requirements, in isolation from the airplane, would aid reducing rudder reversals. Even when the airplane response to a rudder doublet (FTHWG, see above) was considered, the group was unable to reach any conclusions regarding systems parameters which would make pilots less prone to making rudder pedal reversals. Hence, this recommendation contains no changes to Subpart D or F.

    For this reason, the recommendation for changes to 14 CFR Part 25 contained herein is a change to Subpart C (Loads, 2a), largely because of the FCHWG's inability to determine reasonable and effective changes to the other subparts of 14 CFR Part 25.

    The group discussed the possibility of including in the rule the allowance to use deterrent systems, including warning systems, to mitigate the severity of the loading condition defined in 25.353 or deter the pilot from making subsequent doublets. However, the rule cannot anticipate the various solutions that manufacturers might propose. Therefore, references to deterrent systems including warning systems were not included in the final proposal. Deterrent systems like warning systems could be used only as part an Equivalent Level of Safety request of a compliance demonstration to 25.353.

3. What is the optimal regulatory approach for addressing rudder usage (to include unintended rudder usage)?

   Answer:

   A design loads condition, described above, was determined to be the optimal regulatory approach. We found systems solutions to be too design prescriptive and were not able to define a handling qualities maneuverability parameter that would address the tasking.

4. What standards, including details for compliance demonstration and guidance, are recommended for new type certification applications?

   Answer:

   A new loads condition and accompanying advisory material are proposed as shown in Attachments B (the rule) and C (the AC).

   However, as noted above, Attachments B and C have not been unanimously accepted by the FCHWG. The three positions are documented in Positions 1, 2, and 3 under "Consensus and Dissenting Opinions."

5. Are there any regulations or guidance material that might conflict with the proposed standard?

   Answer:

   No such conflicts have been identified.

6. Does current technology exist to support implementation of the proposed standard?

   Answer:

   Yes.

7. What are the effects and implications of proposed standards and guidance relative to commonly used system designs? For example, would the new standard cause adverse interaction with currently used fly-by-wire flight control systems, stability augmentation or auto-flight systems or with current operations?

   Answer:

   Insufficient work has been done to adequately answer this question. It would depend on the aircraft configuration and control system. While some current airplane designs would be able to meet the proposed criteria (either the single doublet or the two doublet design load condition) without any changes, loads analyses conducted by the OEMs as part of the FCHWG deliberations suggest that manual control systems and hydro-mechanical control systems whereby pilot commands can negate the yaw damper would have more difficulty complying with this rule. However, there are manual or hydro-mechanical control system designs where pilots cannot negate yaw damper. Therefore, designs currently are available that could be used to support future airplane compliance with this rule.

8. Do the proposed standards present any issues relating to specific flight phases or environmental conditions? If so, what are they, and how should they be addressed?

   Answer:

      The proposed standard does not present any issues to specific flight phases or environmental conditions.

9. What recommended guidance material is needed?

   Answer:

      An AC has been drafted. See Attachment C.

10. After reviewing airworthiness, safety, cost, benefit, and other relevant factors, including recent certification and fleet experience, are there any additional considerations that should be taken into account?

    Answer:

       Additional training procedures have been recommended. See Attachment A.

11. Is coordination necessary with other harmonization working groups (e.g., Human Factors, Flight Test)?

    Answer:

       The Flight Test Harmonization Working Group (FTHWG) was contacted to provide assistance in defining key parameters that predict rudder system sensitivity and propensity for reversals. A representative of the FTHWG attended all FCHWG meetings. The FTHWG representative, and the FTHWG as a whole, evaluated a stylized rudder command profile and were unable to identify sensitivity parameters that would be useful for rulemaking. The FTHWG did accept a task to examine the doublets issue further. However, the schedule for this review was too far in the future to acceptably support the FCHWG tasking.

For Existing Transport Airplanes:

The report will address the following questions, considering existing transport airplane designs, and provide the rationale for their responses. Any disagreements should be documented, including the rationale from each party and the reasons for the disagreement.

1. What factors should be considered to determine if retrofit should be required?

   Answer:

      For existing transport airplanes, the FCHWG believes that retrofit should be considered on a case by case basis and that if any potentially unsafe conditions are found that they should be addressed using airworthiness directives. (Note: Several airplanes were reviewed as part of the FCHWG deliberations. None were found to have an unsafe condition.)

As described earlier in this report, the loads task group reviewed in-service events involving rudder reversals. The most severe fleet history events were used to guide the creation of a reasonable static strength condition to represent severe vertical stabilizer loading. A single doublet executed in the most likely flight conditions was considered appropriate because airplanes that can safely withstand a single full pedal travel doublet, can also withstand multiple shorter stroke doublets. The FCHWG believes that this level of protection is an acceptable standard for the in-service fleet. The single doublet maneuver and the resulting loads were analyzed for many models in the current fleet of commercial airplanes. For the models evaluated, the airframe loading did not exceed the design ultimate loads defined in the current FAR regulations. This analysis shows that current requirements provide adequate structural protection against a single pedal reversal in the most likely flight conditions.

Based on these findings, together with service history and training improvements, the FCHWG concludes that no further airworthiness review is necessary on those airplanes evaluated by the FCHWG.

2. For airplanes that require retrofit per the criteria, what differences should be considered from the standards and guidance developed for new transport airplanes?

   Answer:

   If the authorities determine on a case by case basis that an airplane requires retrofit, the FCHWG proposed that the criteria include safety margin to a single full-stroke doublet, the fleet history relative to reversals and control system characteristics that have been shown to deter or inhibit doublets (for example alerts). In particular, the comparison of yaw system architecture and lateral dynamic behavior of the concerned airplane with an already evaluated model could be sufficient to demonstrate its robustness to "doublets." If any loads analysis was deemed required, it would not be more severe than employing the same criteria that were used to evaluate the airplanes in the OEM review of this report.

3. What are the effects and implications of proposed retrofit standards and guidance for current system designs. For example, would the new standard cause adverse interaction with currently used fly-by-wire flight control systems, stability augmentation or auto-flight systems or with current operations?

   Answer:

   None.

4. After reviewing airworthiness, safety, cost, benefit, and other relevant factors, including recent certification and fleet experience, are there any additional considerations that should be taken into account?

   Answer:

   Consideration should be given to exempt certain existing fleets from further evaluation for retrofit. Models evaluated by the FCHWG or models with small and declining fleet size may be exempted from the evaluation described in Recommendation 3.

5. If improvements are needed to ensure safe rudder usage, what is the recommended method to mandate retrofit? (Ad hoc airworthiness directives, part 26 rules, etc.) In responding, the ARAC should address the factors set forth in "FAA Policy Statement: Safety-A Shared Responsibility-New Direction for Addressing Airworthiness Issues for Transport Airplanes" (70 FR 40166, July 12, 2005), and the ability of industry to provide necessary retrofit equipment that might be required.

   Answer:

   The FCHWG determined that the best approach would be to issue airworthiness directives as required on a case-by-case basis.

Consensus and Dissenting Opinions

Recommendation 2 - Proposed new regulation 25.353, which would apply to new transport airplanes.

The FCHWG could not reach consensus regarding changes to 14 CFR Part 25 (proposed new 14 CFR 25.353 design loads condition).

The proposed rule (designated as 25.353) would add a design ultimate load requirement that would consist of either a single full-stroke pedal doublet maneuver, or a two full-stroke pedal doublet maneuver. Five members are in favor of the single doublet condition, and five are in favor of the two doublet condition. This maneuver would be defined as either a full displacement input, followed by one reversal and return to neutral (single doublet condition); or a full displacement input, followed by three reversals and return to neutral (two doublet condition).

One FCHWG member believes that no change to the Subpart C maneuver requirements is necessary.

Position 1: No new loads condition is necessary, the existing Part 25 rules and enhanced crew training are sufficient.

Supported by FCHWG member(s): Boeing

Justification:

In service event data show, though very rare, that transport airplanes have experienced in-flight rudder reversals that were the result of inappropriate control use by the pilot. The ARAC Flight Controls Harmonization Working Group (FCHWG) was tasked (FR Doc. 2011-7180) to examine all 14 CFR part 25 sub-parts and to recommend a performance-based requirement that allows manufacturers the flexibility to design airplanes to meet their needs while ensuring airplane safety during this inappropriate rudder usage. The FAA finds it is necessary to revise the rules to ensure that airplanes are designed such that pilots will not (1) inappropriately make pedal reversals and/or (2) be capable of overloading the airframe. The FAA proposed a new flight maneuver load condition to 14 CFR Part 25, subpart C that will increase structural tolerance in the presence of rudder reversals and the associated buildup of sideslip angles.

The ARAC tasking notes five inappropriate rudder reversal events in the commercial airplane fleet, three of which produced loads that exceeded the ultimate structural design level. These rudder reversals occurred as a pilot response to a wake upset, or as a pilot input to apply lateral control in a stall recovery. In both cases, these applications of rudder do not meet the intended control use as defined by the airplane designers, nor do they meet the standard airmanship norms for commercial transport airplanes. Furthermore, the working group has determined that there is insufficient evidence that rudder reversals to counteract an upset are a common piloting error. Based on these findings we, The Boeing Company (TBC), do not believe it is reasonable to mandate consideration of this pilot action in the airworthiness standards.

The FCHWG Loads Sub-Group assessed the current commercial fleet’s tolerance to inappropriate rudder inputs by analyzing a representative loads condition that was based on the four high load events from the fleet history data. A single rudder doublet, for the typical mission flight points, was generated to benchmark the current commercial airplane fleet’s structural capability. The results of the rudder doublet evaluation showed that aircraft designed to the current structural FAR requirements provide adequate structural protection against the inappropriate rudder doublet. We, TBC, do not believe that multiple rudder reversal cycles should be considered as this would indicate a potential PIO/APC event which would be in conflict with the existing CFR part 25, subpart B standards. In sum, the Loads Sub-Group’s data analysis reinforces that there is not a widespread commercial fleet safety concern. Additionally, a rudder reversal event is extremely rare (10^{-8} per flight hour, CS 25.302) and therefore does not warrant an increased level of structural tolerance.

It is not feasible to prevent pilots from exceeding structural limits for all possible instances of excessive and inappropriate maneuvering. Rather, industry relies on training and basic airmanship to minimize the potential for severe maneuvers. In 2004, the FAA and industry partnered to revise the Airplane Upset Recovery Training Aid to emphasize that multiple full deflection, alternating flight control inputs are not necessary to control transport-category airplanes and, in 2005, the corresponding safety alerts for operators (SAFO) was issued. Improvements to pilot training for wake vortex recovery to ensure appropriate in-flight control response familiarity should be pursued as recommended by the FCHWG. The working group strongly recommends that more comprehensive pilot training be required regarding pilot use of rudder on transport category airplanes. Such training should involve a general academic module followed by a module dedicated to the aircraft design specificities. A simulator module or some simulator evaluation conditions may be proposed as a demonstrative tool.

The FCHWG has reviewed the five rudder reversal events cited in the FAA ARAC tasking and found that (1) the pilot actions in all cases did not conform to the industry norms in airmanship, (2) rudder doublets are a misuse of the rudder control, (3) the current structural standards provide tolerance in the nominal flight conditions for a full rudder doublet, and (4) rudder doublets are an extremely rare misuse of the rudder controls. After consideration of the data analysis performed in support of the tasking and the conclusions reached by the FCHWG, The Boeing Company feels that there is insufficient evidence to suggest that the current 14 CFR part 25 certification standards require modification to further protect against inappropriate use of rudder control. Improving commercial airplane safety, in light of the extremely rare and inappropriate rudder use found in the fleet, must focus on minimizing the potential for severe maneuvers through pilot training for wake vortex recovery.

Position 2: Section 14 CFR Part 25.353 should be adopted as shown in Attachment B, Version 1. This is the single doublet condition.

Supported by FCHWG member(s): Airbus, Bombardier, Cessna, Dassault, Embraer

Justification:

The single full-stroke rudder control doublet of proposed draft 14 CFR 25.353(a)(b)(c) (Version 1 single-doublet) is a sufficient design standard to provide additional protection against rudder control reversals. There is no need for requirements beyond the single-doublet. This position is based on:

- Crew training, and regulatory changes to AFMs, as a result of AA587 have highlighted what structural protections are/aren't afforded at V_A, and that only single-axis/single-input are protected. Crews are cautioned that making multiple large and alternating inputs may cause structural damage even at and below V_A.
- One of the factors related to AA587 (the airline's upset recovery training which encouraged and trained crews to use rudder to effect recovery) has ceased, and is now in-line with OEM recommendations for rudder usage.
- Notwithstanding the above, FCHWG seeks to further bolster crew awareness and understanding of rudder usage with the FCHWG's Training Recommendation. This Training Recommendation requires initial and recurrent crew training (academic, type-specific, and simulator where appropriate) in the areas of: difficulty in using rudder for precise control of bank, the significant delay from rudder input to roll rate development, why using rudder for wake recovery is unnecessary, ineffectiveness in using rudder pedals to damp Dutch roll, and an appreciation of the magnitude of empennage loads resulting from rudder reversals. These factors were pertinent in the accidents/incidents stated in FCHWG's tasking.

Further,

- Based on available service history data it appears that significant rudder reversal events are very rare, on the order of 10^{-8}/FH. While single rudder control doublets cannot be completely ruled out in the future, through adequate crew training and awareness multiple large rudder control doublets would be even rarer. Therefore, the more severe regulatory action regarding multiple full-stroke rudder control doublets (proposed draft 14 CFR 25.353(a)-(e) of Version 2) is unnecessary.

- The AA587 accident consisted of one full rudder pedal reversal, followed by a full wheel reversal with maximum rudder pedal displaced, followed by an additional full rudder pedal reversal. The pilot inputs which led to the AA587 accident were unique to that event and it is very rare that this series of inputs would be repeated. The complete series of pilot inputs was too rare, and too chaotic, to serve as a new design standard.

- The single full-stroke doublet of proposed draft 14 CFR 25.353(a)(b)(c) (Version 1) criteria and associated conditions are much more severe (i.e., extreme CG, extreme design weight, reversing the rudder control at the maximum overswing sideslips, large pedal forces, etc.) than typical operational lateral criteria and conditions.

- Codifying the single full-stroke rudder control doublet of proposed draft 14 CFR 25.353(a)(b)(c) (Version 1) ensures that all future designs, which may contain features which would lower the severity of the existing 14 CFR 25.351 (such as overspeed protection to limit the severity of the rudder kick at V_D, other load alleviation functions, etc.), would remain robust against a conservative single full-stroke rudder control doublet.

- FCHWG work shows that the conservative single full-stroke rudder control doublet provides protection against multiple reduced (but nevertheless significant) amplitude doublets, such as those experienced by AC190, AA903, and Interflug.

- Overly severe requirements for more than the single full-stroke rudder control doublet could result in applicants pursuing design solutions such as further restrictions on rudder authority, or additional systems, which could have unintended detrimental operational consequences. Furthermore, if more than the single full-stroke rudder control doublet criteria were applied to the existing Transport Category fleet, some models could find the criteria difficult to meet without significant design changes and penalties. Overly severe vertical tail loads could also result in increased vertical tail structure and aircraft weight, leading to increased fuel burn and environmental impact.

- Evaluating response to a single doublet would provide valuable information to systems designers which may lead to inclusion of beneficial design features (i.e., functions to limit the single doublet loads, which would be beneficial to multiple doublet loads as well).

In summary,

- Significant rudder control reversal events appear to be very rare, on the order of 10^{-8}/FH.
- Only one accident, AA587, has a unique pedal and control wheel activity, with erroneous training procedures. It should not serve as a design standard.
- The conservative single full-stroke rudder control doublet covers all other known incidents of multiple rudder control reversals investigated.
- For some types of aircraft, overly severe criteria, including multiple full-stroke doublets, would lead to structural strengthening, a weight penalty, and/or system changes that could be detrimental to normal operations.
- Enhanced training (as recommended by FCHWG) is the single most effective countermeasure to inappropriate rudder control reversals.
- In conclusion, the conservative single full-stroke rudder control doublet is sufficiently severe.

The Position 2 Group's Understanding of the Other Alternate Positions

One alternate position of the FCHWG's Final Report seeks to implement FCHWG's Training Recommendation, but make no changes to 14 CFR Part 25. In part, that position is based on rudder reversals and the accidents stated in the tasking being primarily related to crew training, and that prevention of future events is adequately served only by enhanced crew training and awareness on the appropriate use of the rudder.

The proponents of the single full-stroke pedal doublet criteria strongly agree that enhanced crew training per the FCHWG's Training Recommendation is a vital and necessary part of *any* solution regarding rudder reversals. We believe adding a conservative single full-stroke doublet for future designs would be useful for the following reasons: single rudder control doublet cannot be completely ruled out in the future, advancement of flight control features may result in future designs having less inherent tolerance for rudder control doublets (such as overspeed protection lessening the 14 CFR 25.351 loads at V_D, other load alleviation functions, etc.) without including codification regarding rudder control reversals in 14 CFR Part 25. For the reasons stated above, the single full-stroke rudder control doublet criteria of proposed draft 14 CFR 25.353(a)(b)(c) (Version 1) ensures that future designs remain robust against a conservative single full-stroke rudder control doublet, as well as multiple rudder control doublets of reduced amplitude.

Another alternate position of the FCHWG's Final Report seeks to implement a *multiple* full-stroke rudder control doublet criteria (i.e., proposed draft 14 CFR 25.353 (c) (d) and (e) of Version 2) *in addition* to the single full-stroke rudder control doublet criteria of proposed draft 14 CFR 25.353(a)(b) (Version 1 first steps). In part, that position is based on fully containing the load growth of additional full-stroke rudder doublets within 14 CFR Part 25.

Of the events stated in the FCHWG tasking, only AA587 experienced multiple full-stroke rudder reversals. However, the pilot's actions were likely influenced by the airline's specific upset recovery training which encouraged and trained crews to use rudder to effect recovery, counter to OEM recommendations. Since that airline's training program has ceased and is now in-line with OEM recommendations, the proponents of the single full-stroke pedal doublet criteria believe that it is very rare that this series of inputs would be repeated, especially with implementation of FCHWG's Training Recommendation further stressing appropriate rudder use and the unique characteristics in attempting to use rudder for roll control. Therefore, it is not appropriate to use this case to set a design standard. While the other events stated in FCHWG's tasking experienced multiple rudder reversals, they were of reduced amplitude, for which the single full-stroke rudder control doublet provides protection.

Furthermore, the multiple full-stroke rudder control doublet criteria of proposed draft 14 CFR 25.353 (a)-(e) (Version 2) could drive applicants towards designs such as further restrictions (or elimination in some flight phases) of rudder authority which could have unintended detrimental operational consequences. For some aircraft types, this would not be a low-cost effort since structural and/or systems changes will likely be required.

As the proposed multiple full-stroke rudder control doublet criteria of proposed draft 14 CFR 25.353 (a)-(e) (Version 2) is both unnecessarily severe and could lead to undesirable design solutions, the single full-stroke rudder control doublet of proposed draft 14 CFR 25.353(a)(b)(c) (Version 1) affords reasonable protections against both a conservative single full-stroke rudder control doublet, as well as multiple rudder control doublets of reduced amplitude as have been seen in service.

The presence of the conservative single full-stroke rudder control doublet in the regulations could force a design change on future aircraft that contain unforeseen load alleviation or other systems which might tend to reduce safety margins relative to the existing regulations.

Moreover, FAA having accepted similar multiple doublet criteria as a means of compliance to the Yaw Oscillations Generic Issue Paper on previous programs is not a valid reason, in and of itself, to codify that criteria.

Position 3: Section 14 CFR 25.353 should be adopted as shown in Attachment B, Version 2. This is the two doublet condition.

Supported by FCHWG member(s): ALPA, ANAC, EASA, FAA, Transport Canada

Justification:

- While multiple rudder reversals appear to be a very low probability event, they have been seen in service and cannot be ruled out in the future. Without knowing the root causes of the multiple rudder reversals that have occurred in service, a design loads condition is the only practical solution available at this time to address this safety concern.
- The proposed design criteria, including paragraphs (a)-(e) (Version 2), provide a practical, relatively low-cost solution that will be achievable on future designs

without the need for significant strengthening of the vertical tail, or significant changes to system design. In fact, some current airplanes would be able to meet these criteria with no changes whatsoever.

- Designs tolerant to multiple doublets have been used since the 1980s to no detriment, both hydro-mechanical and fly-by-wire. In that sense, the proposed rule reflects the current state of the art. In case of changes in future designs that may include load alleviation features or other changes, the design criteria should be upgraded to ensure these designs do not have a lower level of safety.

- The proposed criteria would be responsive to NTSB Safety Recommendation(s) A-04-056, and if adopted on a new airplane, would provide more capability to withstand an event like the AA587 event. The justification for this is qualitative. First, if the two doublet conditions were imposed, the manufacturer could use a system to mitigate pedal reversals by limiting sideslip to safe levels. Second, the AA587 reversals did not occur at the Dutch roll frequency and may not have occurred at the maximum overswing yaw. The proposed load conditions are conducted such that the reversals occur at the maximum over-swing condition. Therefore, the proposed load conditions would provide more capability to withstand an event like the AA587 event.

- It is noted that the second doublet would be applied with the aircraft at a non-zero condition (at a non-zero sideslip, etc.). This condition would more likely represent a pilot reaction to an unexpected upset (such as a wake turbulence encounter) than a single doublet that begins at a zero state initial condition. Therefore, the proposed two-doublet design condition would provide more capability to better withstand a potential pilot response to an unexpected external condition such as a wake turbulence encounter.

- If only a single doublet were included in the proposed criteria, with a safety factor of 1.0, this would not materially increase the design load level from current design loads criteria. This is evident in the table in Attachment E. There would be little benefit to proceed with a rule change (single doublet only) that has such modest effects.

- The pedal force specified in 25.353 (Version 1 and 2) is reduced from the levels in 25.351 to 200 pounds, recognizing that it would be difficult for a pilot to maintain a high level of force (300 lb up to V_C) while performing rapid alternating inputs. This reduction in pedal force would reduce the loads for airplanes with manual control systems.

- An issue paper addressing multiple doublets has been applied on recent programs that have complied with few technical or cost issues.

In a final attempt to reach consensus, there was discussion on a compromise in which the proposed 14 CFR 25.353 would specify two reversals rather than one reversal (Version 1) or three reversals (Version 2). After discussion, it became clear that no one was in favor of this compromise.

Summation of Economic Impact Associated with Proposed Rule Changes

As noted in the various positions, there is disagreement about the relative cost of a rule change to add either the one doublet or the two doublet design load requirement. Therefore, the OEMs agreed to qualitatively evaluate recently certified designs against both options. The results are shown in Attachment E.

Fourteen airplane models were qualitatively evaluated by the six manufacturers represented on the group. These models were evaluated to determine whether they would meet the proposed single doublet or two doublet condition. If unable to meet either condition, the OEM determined the percentage by which the loads of the proposed condition would exceed the certification design loads of the airplane. Further, if unable to meet either condition, the OEM estimated the recurring costs, non-recurring costs, and increase in fuel burn and emissions. Due to resource constraints and lack of a supporting staff-economist, these estimates are only given in general terms - High, Medium, Low, Negligible, or None.

For each model, the certification date is provided by decade. If the airplane is a derivative, then the original certification date of the airplane is also provided.

In general, Attachment E shows that advanced flight control architectures (FBW) are able to meet the proposed criteria, whereas some hydro-mechanical and manual control architectures cannot. In some cases, OEMs assumed the yaw damper was not operational for their loads analysis of the single doublet and the two doublet conditions. (See line 17 of the table.) However, the yaw damper probably would be considered operational according to the final versions of the proposed rule and advisory material. If the yaw damper were "unswampable" and assumed to be operational in those cases, the loads (and the costs) would likely decrease. The use of an unswampable yaw damper (YD) may be able to reduce the load levels for the single doublet to a "low" or "no" economic impact. However, it might not adequately reduce the large loads of the two-doublet condition to a "low" economic impact. It would depend on the YD authority to reduce pilot commanded side slip angles to safe limits and the cost to redesign these items. Also the use of a high authority YD would need to consider the ramifications of failures and reliability.

Attachment A – FCHWG Training Recommendation

The FCHWG recommends that more comprehensive pilot training be required regarding pilot use of rudder on transport category airplanes. This training should be continuous throughout a pilot's career, and include knowledge (academic) and skill training at the appropriate level. This recommendation should be reviewed by FAA AFS-210 and by industry groups that have recently focused on pilot training.

(Note: AC120-109 – "Stall and Stick Pusher Training" addresses appropriate rudder use during the stall regime consistent with FCHWG's training recommendation. Furthermore, AC120-109 may serve as a useful template for FCHWG's enhanced crew training regarding appropriate rudder use in other regimes.)

The appropriate use of all flight controls should be covered in a general academic module during licensing training, while the airplane specific requirements should be covered in Type Rating and Recurrent training. Academic Training is appropriate at both the Licensing and Type Rating/Recurrent levels. Current regulations and training requirements are in place to ensure this training requirement, and this recommendation serves to add specifics to the issue of rudder usage training. This training must involve a general academic module followed by a module dedicated to the aircraft design specificities.

If the OEM specifies the use of rudder in operational normal and/or non-normal procedures, such maneuvers must be incorporated in the Type Rating Training. A simulator training module should be used if a simulator can be used as a demonstrative tool with the guaranty that its limitations will prevent any negative transfer of training.

The general academic module should contain the following topics:

- Inherent airplane characteristics regarding roll and yaw coupling;
- The effect of wing sweep on roll response due to a rudder input;
- The effect of pilot use of rudder in an attempt to establish a specific bank angle, with emphasis on the delayed response of roll rate to pedal input;
- The effect of pilot use of rudder in an attempt to establish a specific heading (bank angle control remaining under the control of the ailerons);
- The effect of rudder reversals on empennage forces (empennage loads if "loads" are explained to the pilot) to include a rough order of magnitude of such forces on their aircraft;
- Dutch roll and accepted Dutch roll damping strategies, including an explanation of reasons why a pilot cannot damp efficiently the Dutch roll with the rudder pedals;

- The general use of the rudder pedals
  - yaw control during takeoff and landing, in particular with crosswinds,
  - engine failure,
  - turn coordination if aircraft not equipped with automatic turn coordination function,
  - yaw control with abnormal situation as part of recommended procedures,
  - asymmetric surface configuration as part of recommended procedures;
- The effect and danger of using rudder pedal during upset, wake turbulence and stall or approach to stall recovery (using rudder pedal is not recommended unless specified by the respective OEM).

The aircraft specific academic module should contain the following topics:

- Explanation of the rudder control system to include rudder limiting as a function of speed (i.e., variable lever arm type, travel limit unit type), pedal characteristics as a function of speed, yaw damper effects, and an auto coordination system if installed.
- Include a listing of what rudder usage is assumed in the design of the specified aircraft design for normal and abnormal configurations.
- Training in the use rudder for bank control when the type aircraft has an emergency /abnormal procedure that specifies this use.

The simulator module should contain the following topics, and be taught only if the simulator has been appropriately qualified and the instructor has been trained and standardized in accordance with OEM recommendations:

- Acquaint pilots with the pedal characteristics required to achieve increasing rudder deflections, up to the maximum, as a function of different speeds.
- A demonstration to show why large pilot rudder pedal inputs are not recommended for establishing a specified bank angle or heading. This demonstration will illustrate the delayed response of roll rate to pedal input which may lead to PIO and unwanted rudder pedal reversals.
- If a particular airplane type has a manufacturer recommended emergency/abnormal procedure that calls for use of the rudder to control the airplane (e.g., jammed ailerons, or manual reversion) then practice in such use is necessary in order to equip the pilot with the knowledge and experience to use the rudder with care in these situations.

Attachment B – Proposed New Regulation 25.353

Section 25.353 Rudder control reversal conditions
(Version 1 – Single Doublet Condition)

The airplane must be designed for loads, considered as ultimate, resulting from the yaw maneuver conditions specified in paragraphs (a) through (c) of this section from the highest airspeed for which it is possible to achieve maximum rudder deflection at zero sideslip or V_{MC} , whichever is greater, to V_C. These conditions are to be considered with the landing gear retracted and speed brakes (or spoilers when used as speed brakes) retracted. Flaps (or flaperons or any other aerodynamic devices when used as flaps) and slats extended configurations are also to be considered if they are used in en route conditions. Unbalanced aerodynamic moments about the center of gravity must be reacted in a rational or conservative manner considering the airplane inertia forces. In computing the tail loads the yawing velocity may be assumed to be zero. A pilot force of 200 pounds is assumed to be applied for all conditions.

(a) With the airplane in unaccelerated flight at zero yaw, it is assumed that the cockpit rudder control is displaced as specified in Sec. 25.351(a) and (b).

(b) With the airplane yawed to the overswing sideslip angle, it is assumed that the cockpit rudder control is suddenly displaced in the opposite direction.

(c) With the airplane yawed to the opposite overswing sideslip angle, it is assumed that the cockpit rudder control is suddenly returned to neutral.

Section 25.353 Rudder control reversal conditions
(Version 2 – Two Doublet Condition)

The airplane must be designed for loads, considered as ultimate, resulting from the yaw maneuver conditions specified in paragraphs (a) through (e) of this section from the highest airspeed for which it is possible to achieve maximum rudder deflection at zero sideslip or V_{MC} , whichever is greater, to V_C. These conditions are to be considered with the landing gear retracted and speed brakes (or spoilers when used as speed brakes) retracted. Flaps (or flaperons or any other aerodynamic devices when used as flaps) and slats extended configurations are also to be considered if they are used in en route conditions. Unbalanced aerodynamic moments about the center of gravity must be reacted in a rational or conservative manner considering the airplane inertia forces. In computing the tail loads the yawing velocity may be assumed to be zero. A pilot force of 200 pounds is assumed to be applied for all conditions.

(a) With the airplane in unaccelerated flight at zero yaw, it is assumed that the cockpit rudder control is displaced as specified in Sec. 25.351(a) and (b).

(b) With the airplane yawed to the overswing sideslip angle, it is assumed that the cockpit rudder control is suddenly displaced in the opposite direction.

(c) With the airplane yawed to the opposite overswing sideslip angle, it is assumed that the cockpit rudder control is suddenly displaced in the opposite direction.

(d) With the airplane yawed to the subsequent overswing sideslip angle, it is assumed that the cockpit rudder control is suddenly displaced in the opposite direction.

(e) With the airplane yawed to the opposite overswing sideslip angle, it is assumed that the cockpit rudder control is suddenly returned to neutral.

Attachment C – Proposed New Advisory Material

AC 25.353-X "Rudder Control Reversal Design Load Conditions"

1. Purpose. This advisory circular (AC) describes acceptable means for showing compliance with the requirements of Title 14, Code of Federal Regulations (14 CFR) 25.353, Rudder control reversal conditions. Section 25.353 specifies structural design load conditions that apply to the airframe, and that occur as a result of multiple rudder pedal inputs.

2. Applicability.

a. The guidance provided in this document is directed to airplane and engine manufacturers, modifiers, foreign regulatory authorities, and Federal Aviation Administration (FAA) transport airplane type certification engineers and their designees.

b. The material in this AC is neither mandatory nor regulatory in nature and does not constitute a regulation. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the relevant regulations. These means are issued, in the interest of standardization, for guidance purposes and to outline a method that has been found acceptable in showing compliance with the standards set forth in the rule. If, however, we become aware of circumstances that convince us that following this AC would not result in compliance with the applicable regulations, we will not be bound by the terms of this AC, and we may require additional substantiation or design changes as a basis for finding compliance.

c. The material in this AC does not change or create any additional regulatory requirements, nor does it authorize changes in, or permit deviations from, existing regulatory requirements.

d. Except in the explanations of what the regulations require, the term "must" is used in this AC only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance described in this AC is used.

3. Related 14 CFR Regulations.

a. Section 25.351, *Yaw maneuver conditions*.

b. Section 25.353, *Rudder control reversal conditions*.

4. Background.

a. Requirements. Sections 25.351, *Yaw maneuver conditions*, and 25.353, *Rudder control reversal conditions*, specify structural design load conditions that occur as a result of rudder pedal inputs. These conditions are intended to encompass all of the rudder maneuver loads expected to occur in service.

b. Section 25.351 – Yaw maneuver conditions. Section 25.351 was established when 14 CFR part 25 was adopted in 1965, and has been modified several times since then. The design load conditions specified in § 25.351 are considered limit load conditions, and a 1.5 factor of safety is applied to obtain ultimate loads.

c. Section 25.353 – Rudder control reversal conditions. Section 25.353 was established at Amendment 25-XX. The design load conditions specified in § 25.353 are more severe than those in § 25.351 and include rudder control reversals. These conditions are anticipated to occur very rarely, and so these are considered ultimate load conditions, and no additional safety factor is applied.

5. Application of the requirements.

a. General

(1) The airplane must be designed for the rudder control reversal load conditions specified in § 25.353. These are considered ultimate load conditions and, therefore, no additional factor of safety is applied. However, any permanent deformation resulting from these ultimate load conditions must not prevent continued safe flight and landing.

(2) Design loads must be determined as specified in § 25.321. The load conditions are considered from the maximum airspeed for which it is possible to achieve full rudder deflection at zero sideslip or V_{MC}, whichever is greater, to V_C. A pilot force of 200 pounds is assumed to be applied for all conditions. These conditions are to be considered with the landing gear retracted and speed brakes (or spoilers when used as speed brakes) retracted. Flaps (or flaperons or any other aerodynamic devices when used as flaps) and slats-extended configurations are also to be considered if they are used in en route conditions.

(3) System effects. System effects should be taken into account in the evaluation of this maneuver. For example, fly-by-wire aircraft should be analyzed assuming the airplane is in the normal control law mode. Any system function used to demonstrate compliance with these requirements should meet the following criteria:

(a) The system is typically operative during flight in accordance with the airplane flight manual procedures; and

(b) Appropriate crew procedures should be provided in the event of loss of function. If loss of system function would not be detected by the crew, the probability of loss of function (failure rate multiplied by maximum exposure period) should be less than 1/1000.

(4) Failure conditions. Due to the very low probability of a full rudder doublet event, failure scenarios do not need to be addressed in combination with the rudder control reversal conditions specified in § 25.353.

[The proposed rule (designated as 25.353) would add a design ultimate load requirement that would consist of either a single rudder doublet maneuver, or a two doublet maneuver. Five members are in favor of the single doublet condition, and five are in favor of the two

doublet condition. The single doublet condition is defined in the FCHWG report as Version 1, and the two doublet condition as Version 2. The following section b. would depend on what is included in the final rule. Differences are highlighted in blue.]

----

b. Section 25.353(a) through (c) [Version 1 of proposed rule – single doublet condition]

(1) Conditions 25.353(a) through (c) are intended as a full displacement pedal input followed by a pedal reversal and return to neutral. Speed should be kept reasonably constant throughout the maneuver using pitch control.

(2) With the airplane in unaccelerated flight at zero yaw, it is assumed that the cockpit rudder control is suddenly displaced to achieve the resulting rudder deflection. In this context, "suddenly" means as fast as possible within human and system limitations. In the absence of a rational analysis, initial pedal displacement is achieved in no more than 0.2 seconds, and full rudder control reversal displacement is achieved in 0.4 seconds. Alternatively, the applicant may assume the rudder pedal is displaced instantaneously.

(3) The resulting rudder displacement should take into account additional displacement caused by sideslip build-up, and the effects of flexibility should be considered when relevant.

(4) As soon as the maximum overswing yaw angle is achieved, full opposite rudder pedal input is applied. The achieved rudder deflection may be limited by control laws, system architecture, or air loads, and may not be the same magnitude as the initial rudder deflection prior to the pedal reversal. For critically damped aircraft response, maximum overswing yaw angle may be assumed to occur when the sideslip angle is substantially stabilized.

(5) The airplane yaws to the opposite overswing yaw angle. As soon as this point is reached, the cockpit rudder control is suddenly returned to neutral.

----

b. Section 25.353(a) through (e) [Version 2 of proposed rule – two doublet condition]

(1) Conditions 25.353(a) through (e) are intended as a full displacement pedal input followed by three pedal reversals and return to neutral. Speed should be kept reasonably constant throughout the maneuver using pitch control.

(2) With the airplane in unaccelerated flight at zero yaw, it is assumed that the cockpit rudder control is suddenly displaced to achieve the resulting rudder deflection. In this context, "suddenly" means as fast as possible within human and system limitations. In the absence of a rational analysis, initial pedal displacement is achieved in no more than 0.2 seconds, and full rudder control reversal displacement is achieved in 0.4 seconds. Alternatively, the applicant may assume the rudder pedal is displaced instantaneously.

(3) The resulting rudder displacement should take into account additional displacement caused by sideslip build-up, and the effects of flexibility should be considered when relevant.

(4) As soon as the maximum overswing yaw angle is achieved, full opposite rudder pedal input is applied. The achieved rudder deflection may be limited by control laws, system architecture, or air loads, and may not be the same magnitude as the initial rudder deflection prior to the pedal reversal. For critically damped aircraft response, maximum overswing yaw angle may be assumed to occur when the sideslip angle is substantially stabilized.

(5) Two additional reversals are performed as defined in (4). After the second reversal, as soon as the airplane yaws to the opposite overswing yaw angle, the cockpit rudder control is suddenly returned to neutral.

Attachment D – Summary Report Following FCHWG Review of FAA-Sponsored Studies

Summary report following the analysis of:

1) Hess, Ronald A., "Rudder Control Strategies and Force/Feel System Designs in Transport Aircraft," Journal of Guidance Control and Dynamics, Vol. 28, No. 6, Nov-Dec. 2005.
2) Stewart, Eric C., "A Piloted Simulator Evaluation of Transport Aircraft Rudder Pedal Force/feel Characteristics," NASA/TP-2008-215109, January 2008.

3a) Hoh, Roger H., et al, "Piloted Simulation Study to Develop Transport Aircraft Rudder Control System Requirements Phase 1: Simulator Motion System Requirements and Initial Results," DOT/FAA/AR-09/5, March 2009.

3b) Hoh, Roger H., et al, "Piloted Simulation Study to Develop Transport Aircraft Rudder Control System Requirements Phase 2: Develop criteria for rudder overcontrol," DOT/FAA/AR-10/17, November 2010.

Introduction: The FAA tasking statement for the Flight Control Harmonization Working Group regarding rudder pedal sensitivity/reversal referenced the 3 documents above. The research behind these documents was sponsored by the FAA and NASA. The purpose of these reports was to try to determine parameters that most significantly affect handling qualities (HQ) associated with rudder usage and to try to determine characteristics that might predict or prevent over control; particularly pedal reversals or doublets. To support responding to the tasking statement, all the above documents were reviewed by the FCHWG members. Each of them has been subject to a group analysis. The group found that for various reasons these studies were of limited value. The various comments and conclusions have been recorded in the minutes of the relevant meetings. They are summarized here:

1) Hess document:

Based on the notion that linearity in a control system is most predictable for a pilot, Hess developed an "index" by which to judge the linearity of a rudder control system. The linearity index included parameters such as force gradient, breakout force and available travel. The linearity index presented in this study, while perhaps having some merit on its own as a measure of linearity, was not found to correlate well with measured pilot opinion. The group found that breakout force, a factor in nonlinearity, is necessary for good centering of powered flight controls and for a grounding point for yaw damping and autopilot control. Using the linearity index might lead to a low breakout force that would result in a good linearity index rating but poor system performance. The applicability of the pure math model used in the analysis was a concern. But it was beyond the scope of our group to fully address. Ultimately, we felt that these studies might be useful for design consideration. But, this data was not useful for fulfilling the tasking.

2) Stewart Document:

Stewart identified critical variables in rudder control system design such as breakout force, max travel force and pedal travel. He generated two equations; one to predict good handling qualities relative to rudder usage and one to predict potential for pedal reversals. He used the NASA Langley simulator, and conducted numerous piloted simulations. The results of this study showed weak correlation between HQ and maximum pedal force and breakout force. The same weak correlation was shown for potential reversals (PR). But his data showed a strong correlation between HQ and PR with longer pedal travels. Based on the Stewart study the group could conclude that pedal travel was a potential predictor of handling qualities and PR. But again it did not provide a performance based method by which to assess the adequacy of airplane HQ or PR. Additionally, there were concerns with the test methodology. These include 1. The cab was fixed base so the effect of motion could not be determined, 2. The subjects were line pilots not formally trained in handling qualities assessments, and 3. The test scenarios included only low speed visual conditions (landing); there may be different results for the higher speed conditions that generated the FCHWG tasking. For these reasons we consider the data to have limited value to our tasking. The case of unusual use of rudder pedals at high speed, without a runway in sight is not addressed at all by this experiment. At the end, this study was deemed to not provide an effective discriminator to address the FCHWG tasking.

<u>3a) & 3b) Hoh documents:</u>
In these studies Hoh too tried to determine a key characteristic that would predict good HQ and low PR. Hoh conducted their study in the NASA Ames Vertical Motion Simulator. It was selected as it could provide a reasonable level of Ny. This study too included performing numerous piloted simulations. The results of the simulations were similar to Stewart in low altitude VFR scenario, that longer pedal throws predict better HQ and lower PR and that breakout and gradient forces were less critical. However, the statistical meaning of the results was a major concern. For example the standard deviation of one parameter was found to be roughly equal to the mean.

Hoh found the yaw damper tended to reduce fin loads and was therefore beneficial.

Unlike Hess and Stewart, Hoh used mostly flight test pilots (11) in the study including two OEM test pilots. The way the experiment was conducted was criticized by the two OEM pilots who participated in the exercise. The two OEM test pilots felt the Ny was too low and not representative of a real airplane. They felt that higher Ny might have resulted in less aggressive pedal usage. Subsequently, Hoh raised the level of Ny in a few simulator tests and concluded that it didn’t significantly change the HQ. Again the results showed value in longer pedal travel (again the statistical meaning of the results is highly questionable because the standard deviation was roughly equal to the mean value) and lower loads with yaw damper. However, he did not provide a flight test methodology to assess handling qualities that seemed adequate to address the tasking

<u>Conclusion:</u> The three studies provide insight into the level of difficulty to try to assess a control that is not designed to be used very often, and almost never at higher speeds. All the piloted studies had to provide somewhat artificial circumstances to ensure the pilots would interact with pedals. This led to issues of how realistic the scenarios were and the capability of the simulator and called into question the data produced. Ultimately, the FCHWG did not find in the above documents material directly relevant and useful to address the tasks given to the FCHWG.

Attachment E – Economic Impact Assessment for Proposed Rule Changes

Top-Level "Simplified" Economic Analysis of Proposed Doublet(s) Criteria

For a given airplane model or models that have been recently certified, evaluate the loads for the single doublet condition in ARAC Final Report Attachment B Version 1, 25.353(a)-(c), and also the two doublet condition in Version 2, 25.353(a)-(e).
For the single doublet and the two doublet condition, use a 200 pound pedal force at all speeds.
Compare the resulting doublet load levels to the design ultimate load levels for that airplane (vertical tail side of body bending moment).
Provide rough cost estimates. Results may include rough cost numbers or qualitative values such as low, medium and high.

	OEM ->>														
	Proposed Criteria ->>	**1-Doublet**	**2-Doublet**	**1-Doublet**	**2-Doublet**	**1-Doublet**	**2-Doublet**	**1-Doublet**	**2-Doublet**	**1-Doublet**	**2-Doublet**	**1-Doublet**	**2-Doublet**	**1-Doublet**	**2-Doublet**
Assumptions	Decade of Certification?	'10+		'00-'09		'90-'99		'90-'99		'10+		'00-'09		'10+	
	If a derivative model, what is the decade of the *original* Certification?	'90-'99		original TC		'90-'99		original TC		'70-'79		'90-'99		'90-'99	
	Would the design meet proposed one/two doublet criteria without any modifications?	No	No	No	No	No	No	Yes	No	Yes	No	Yes	No	Yes	No
	If unable to meet proposed criteria, what percentage does the one/two doublet condition loads exceed the design ultimate loads (VT tail side of body bending moment)?	29%	88%	3%	35%	20%	67%	---	27%	---	25%	---	22%	1%	10%
	Is the design maneuver-load critical (i.e., not gust-critical) under current FARs?	Yes	Yes	Yes	Yes			No	No					No	No
	Type of Flight Control System architecture?	Manual	Manual	Manual	Manual	Hyr-Mech	Hyr-Mech	Hyr-Mech	Hyr-Mech	Hyr-Mech	Hyr-Mech	Hyr-Mech	Hyr-Mech	Hyr-Mech	Hyr-Mech
	Was Yaw Damper function assumed operational in these loads calculations?	No	No	No	No	No	No	Yes	Yes	Yes	Yes	No	No	No	No
	Is the Yaw Damper unswampable?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
	Assumed design solution for complying with doublet(s) criteria: (Note: other solutions may be possible, but were not fully vetted for this evaluation.)	Structural	Structural	Structural	Structural	Structural	Structural		Structural		Structural		Structural		Structural
Non-Recurring Costs to the Manufacturer		7 - High	7 - High	1 - Negl.	7 - High	5 - Med	7 - High	3 - Low	5 - Med	3 - Low	3 - Low	3 - Low	5 - Med	1 - Negl.	3 - Low
Recurring Costs to the Manufacturer		7 - High	7 - High	1 - Negl.	7 - High	5 - Med	7 - High	0 - None	5 - Med	0 - None	7 - High	3 - Low	5 - Med	1 - Negl.	5 - Med
Increase in Fuel Burn/Emissions?		5 - Med	7 - High	1 - Negl.	7 - High	3 - Low	5 - Med	0 - None	5 - Med	0 - None	3 - Low	0 - None	3 - Low	1 - Negl.	3 - Low
	GRAND TOTAL	**19.0**	**21.0**	**3.0**	**21.0**	**13.0**	**19.0**	**3.0**	**15.0**	**3.0**	**13.0**	**6.0**	**13.0**	**3.0**	**11.0**
	AVERAGE	**6.3**	**7.0**	**1.0**	**7.0**	**4.3**	**6.3**	**1.0**	**5.0**	**1.0**	**4.3**	**2.0**	**4.3**	**1.0**	**3.7**

	OEM ->>														
	Proposed Criteria ->>	**1-Doublet**	**2-Doublet**	**1-Doublet**	**2-Doublet**	**1-Doublet**	**2-Doublet**	**1-Doublet**	**2-Doublet**	**1-Doublet**	**2-Doublet**	**1-Doublet**	**2-Doublet**	**1-Doublet**	**2-Doublet**
Assumptions	Decade of Certification?	'80-'89		'00-'09		'10+		'00-'09		'10+		'00-'09		'00-'09	
	If a derivative model, what is the decade of the *original* Certification?	original TC		'00-'09		original TC		'80-'89		original TC		original TC		original TC	
	Would the design meet proposed one/two doublet criteria without any modifications?	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	If unable to meet proposed criteria, what percentage does the one/two doublet condition loads exceed the design ultimate loads (VT tail side of body bending moment)?	---	---	---	15%	---	1%	---	---	---	---	---	---	---	---
	Is the design maneuver-load critical (i.e., not gust-critical) under current FARs?	Yes	Yes	No	No					No	No	Yes	Yes	No	No
	Type of Flight Control System architecture?	Hyr-Mech	Hyr-Mech	FBW	FBW	FBW	FBW	FBW	FBW	FBW	FBW	FBW	FBW	FBW	FBW
	Was Yaw Damper function assumed operational in these loads calculations?	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Is the Yaw Damper unswampable?	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Assumed design solution for complying with doublet(s) criteria: (Note: other solutions may be possible, but were not fully vetted for this evaluation.)		Warning		System										
	Estimated years of production run:														
	Average production/units per year:														
	Average annual flight hours per unit:														
	Total Fleet Size (CALC'D):	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Fleet Flighthours at End of Production Run (CALC'D):	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Recurring Costs to the Manufacturer		1 - Negl.	5 - Med	1 - Negl.	3 - Low	3 - Low	3 - Low	3 - Low	3 - Low	1 - Negl.	1 - Negl.	1 - Negl.	1 - Negl.	1 - Negl.	1 - Negl.
Recurring Costs to the Manufacturer		0 - None	1 - Negl.	1 - Negl.	1 - Negl.	0 - None	3 - Low	0 - None	0 - None	1 - Negl.	1 - Negl.	1 - Negl.	1 - Negl.	0 - None	0 - None
Increase in Fuel Burn/Emissions?		0 - None	0 - None	0 - None	0 - None	0 - None	0 - None	0 - None	0 - None	0 - None	0 - None	0 - None	0 - None	0 - None	0 - None
	GRAND TOTAL	**1.0**	**6.0**	**2.0**	**4.0**	**3.0**	**6.0**	**3.0**	**3.0**	**2.0**	**2.0**	**2.0**	**2.0**	**1.0**	**1.0**
	AVERAGE	**0.3**	**2.0**	**0.7**	**1.3**	**1.0**	**2.0**	**1.0**	**1.0**	**0.7**	**0.7**	**0.7**	**0.7**	**0.3**	**0.3**

Attachment F – Upset Events

Some of the events described in the tasking and in the Background section of this report are described in detail in the following investigation reports.

1. NTSB/AAR-0404 - In-Flight Separation of Vertical Stabilizer
   American Airlines Flight 587
   Airbus Industrie A300-605R, N15043
   Belle Harbor, New York
   November 12, 2001
   * Also includes information Miami Flight 903 and Interflug event

2. TSB A08W0007 - Encounter with Wake Turbulence
   Air Canada (Flight AC 190)
   Airbus A319-114 C-GBHZ
   Washington State, United States
   10 January 2008

3. TSB LP007/2008 - Engineering Report – FDR Analysis
   Air Canada (Flight AC 190) Airbus A319-100, C-GBHZ
   Washington State, United States
   Occurrence Date: 10-Jan-08

4. TSB A05A0059 - Stall and Loss of Control during Climb
   Provincial Airlines Limited
   De Havilland DHC-8-100 C-GZKH
   St. John’s, Newfoundland and Labrador
   27 May 2005

Attachment G - Working Group Membership List

Original Working Group	Organization	Expertise
Greg Anderson	Cessna	Flight Dynamics
Dominique Chatrenet (co-chair)	Airbus	Flight Controls
Bill de Groh	ALPA	Flight Operations
Barry Hance (co-chair)	Boeing	Flight Controls
Robert Jones (sponsor)	FAA	Flight Controls
Stéphanie Lalonde	TCCA	Hydromechanical
Tony Linsdell	Bombardier	Structures/Loads
Didier Poisson	EASA	Flight Test
Nadine Polano	EASA	Flight Controls
Gerard Menard	Dassault	Structures/Loads
Marco Coccolin	Embraer	Structures/Loads
Luiz Jether de Holandino Vasconcelos	ANAC	Flight Test
Additional Support	**Organization**	**Expertise**
Philippe Eichel	Dassault	Flight Controls
Kyle Ford	Boeing	Structures/Loads
Jack Grabowski	TCCA	Structures/Loads
Laurent Lapierre	Airbus	Flight Test
Brian Lee	Boeing	Handling Qualities
Todd Martin	FAA	Structures/Loads
Muriel Pouzargue	Dassault	Structures/Loads
George Zografos	EASA	Structures/Loads

Attachment H – FTHWG Report on Rudder Control Sensitivity

Please view this document at the link below. Access to this link may not be publically available at this time. This document will soon be moved to an FAA site, and the link will be updated as needed to ensure it remains accessible.

Analysis_by_FTHWG_for_FCHWG_2013.pdf