# Aircraft Certification Considerations Associated With the Proposal to Expand the Upper Limit of RVSM Airspace

FAA

Federal Aviation Administration

# Separation Airspace and Safety Panel (SASP)

- To ensure all new or improved standards and recommended practices/procedures (SARPs) and procedures for air navigation services (PANS) will be effective and practical for end-users, the ICAO Air Navigation Commission (ANC) works through established panels of experts in various disciplines who are assigned specific tasks from the overall work program.
- ICAO SASP, a panel of the ANC, develops SARPS for air navigation services and/or related guidance material supporting separation minima, taking into account:
  - Future demands on airspace and airport capacity
  - Communication, navigation and surveillance systems available, and
  - Agreed levels of safety.

# Proposal to Expand Upper Limit of RVSM Airspace

- The twenty eighth Working Group meeting of the Separation and Airspace Safety Panel (SASP- WG/28) was held in Reykjavik, Iceland, from 23 May to 3 June 2016.
- During SASP-WG/28, it was proposed that the SASP undertake the necessary work to raise the upper limit of RVSM airspace to accommodate current and future aircraft operating capability.
- Two of the questions posed are:
  - Will avionics changes be required to support the change?
  - What would be the new upper limit of RVSM airspace?

# Certification Considerations

- An aircraft's RVSM certification is valid only up to the maximum FL410 due to the following reasons:
  - The maximum achievable W/δ (weight over atmospheric pressure ratio) for an RVSM Aircraft Group is based on the maximum possible flight weight at FL410.
  - In the altimetry system error (ASE) budget, the maximum avionics errors are those commensurate with flight at FL410.

# Avionics Considerations for RVSM Aircraft Group Certification Above FL410

## Altimetry System Error (ASE)

- Increasing the available flight levels impacts the upper boundary of the flight envelope since the maximum achievable W/δ is higher.
  - Therefore, the ASE evaluation of currently-certified RVSM Aircraft Groups would need to be re-evaluated to ensure ASE remains within the +,- 80 feet maximum mean ASE level at these newer and higher W/δ conditions.
- In addition, it must be confirmed that the mean +,- 3s does not exceed 200 feet.
  - If the critical flight condition currently exists at or near the highest W/δ, then the maximum ASE obtainable for RVSM will change if the maximum achievable W/δ increases.
  - This will then impact the error budget, because the larger the allowable mean ASE, the less fleet 3s variation is permitted. Aircraft manufacturers would need to conduct this ASE re-evaluation and revise the definitions of the flight envelopes currently reflected in their certification data packages.

# Avionics Considerations for RVSM Aircraft Group Certification Above FL410 (cont.)

## Static System Error Correction (SSEC)

- If ASE is found to be problematic, then a new SSEC may be required.
- Alternatively, the manufacturer could implement an operational restriction that does not permit RVSM operations above a certain altitude.
  - This could require an additional ICAO RVSM code to designate airplanes, which can be assigned a RVSM level above FL410.

# Avionics Considerations for RVSM Aircraft Group Certification Above FL410 (cont.)

## Avionics Errors

- The basic air data computer (ADC) equipment errors, for all ADC manufacturers, are a strong function of altitude.
- The ADC manufacturers have focused on minimizing equipment errors up to and including FL410.
- Based on the data available to date, the errors above FL410 increase. In some cases, the increase in errors is not linear.
  - Therefore, the avionics error specifications as a function of altitude are a significant consideration. It is recommended that the equipment providers provide input on this issue. Based on the currently available data, the avionics equipment errors above FL410 are not encouraging.
  - These large errors, coupled with a possible change in ASE performance at the higher W/δ conditions, necessitates re-evaluation of the error budget. The results of this re-evaluation could mandate changes to the systems.
  - For the aircraft manufacturers, re-evaluating the error budget is not a significant task, but they will require data from the avionics manufacturers in order to do this.

# Avionics Considerations for RVSM Aircraft Group Certification Above FL410 (cont.)

## Automatic Altitude Control System

- The automatic altitude control system should be verified to meet the +,- 65 feet requirement. Flight test data on some models shows slightly degraded altitude hold performance at higher altitudes and high weight.

## Availability of Flight Test Data

- Some airframe manufacturers have limited flight test data commensurate with the W/δ values you would obtain at flight levels above FL410. This may necessitate additional flight testing for the OEMs.

# Evaluation of the ASE Budget

- An evaluation of the ASE budget is necessary to account for the higher achievable flight levels (mostly in the form of increased ADC errors).
- Based on a data extraction of recent activity at FL 400 and FL 410 in the Gander Oceanic Control Area (OCA), the aircraft list in the following table is comprised mostly of modern airframes with complex systems and SSECs.
- It is possible that the majority of the aircraft listed will only require an evaluation/verification and a data package revision by the original equipment manufacturers (OEMs).

# Gander OCA Flights at FL 400 and FL 410
# April 2015 - March 2016

| Aircraft Type | Flights at FL400 | Flights at FL410 | Total |
|---|---|---|---|
| B788 | 6,689 | 5,547 | 12,236 |
| A332 | 5,147 | 1,153 | 6,300 |
| A333 | 2,581 | 350 | 2,931 |
| B772 | 2,346 | 453 | 2,799 |
| GLF4 | 1,127 | 1,242 | 2,369 |
| GLF5 | 866 | 1,234 | 2,100 |
| GLEX | 645 | 918 | 1,563 |
| A388 | 1,353 | 160 | 1,513 |
| FA7X | 581 | 591 | 1,172 |
| F2TH | 315 | 392 | 707 |
| F900 | 376 | 298 | 674 |
| B744 | 402 | 122 | 524 |
| GLF6 | 231 | 291 | 522 |
| B789 | 377 | 141 | 518 |
| B752 | 446 | 59 | 505 |
| GL5T | 119 | 284 | 403 |
| CL30 | 126 | 201 | 327 |
| K35R | 170 | 103 | 273 |
| A346 | 232 | 38 | 270 |
| B763 | 165 | 24 | 189 |
| Other | 865 | 746 | 1,611 |
| Total | 25,159 | 14,347 | 39,506 |

Source: GAATS+
May 2016

FAA

NextGEN

# Evaluation of the ASE Budget (cont.)

- It is recommended that the following questions be posed to the OEMs:
  - How does the change in maximum RVSM altitude affect the ASE of each system, for the Group?
  - How does the change in maximum RVSM altitude affect the avionics errors for the air data system?
  - What is the impact on the ASE budget of this altitude change?
  - Is the automatic altitude control system affected by this change?
  - Will SSEC changes, or hardware changes, be necessary to maintain the RVSM compliance status of airframes currently approved for RVSM operations?
  - Is additional flight testing required to obtain system performance data?
  - What are candidate aircraft?
  - Operational ceiling of candidate aircraft?

# Determination of the New Upper Limit of RVSM Airspace

- Regarding the upper limit of RVSM airspace, this may well be decided based on the avionics errors at altitudes above 41,000 feet and the ASE values for the aircraft types capable of flying above FL410.
- It is important for the aircraft OEMs to verify the ADC errors and ASEs at these higher RVSM altitudes.

# Conclusions

- Avionics changes may be required to support the proposed change. In the evaluation of increasing the maximum permissible RVSM altitude, it is important that the aircraft OEMs and/or design holders re-evaluate the RVSM flight envelope and assess the ASE levels at these new (higher W/δ) flight conditions.
- Consideration of the upper limit of RVSM airspace should be based on the available aircraft and avionics performance data.

# BACK-UP SLIDES

# Description of the Parameter W/δ

- It would be difficult to show all of the gross weight, altitude, and speed conditions which constitute the RVSM envelope(s) on a single plot. This is because most of the speed boundaries of the envelopes are a function of both altitude and gross weight.
- As a result, a separate chart of altitude versus Mach would be required for each aircraft gross weight. Aircraft performance engineers commonly use the following technique to solve this problem.
- For most jet transports the required flight envelope can be collapsed to a single chart with good approximation, by the use of the parameter W/δ (weight divided by atmospheric pressure ratio).
- This fact is due to the relationship between W/δ and the fundamental aerodynamic variables M and lift coefficient as shown on the next slide.

# Description of the Parameter W/δ (cont.)

- $W/\delta = 1481.4 C^{L} M^{2} S^{Ref}$, where:
  - δ = ambient pressure at flight altitude divided by sea level standard pressure of 1013.25 hPa
  - W/δ = Weight over Atmospheric Pressure Ratio
  - $C^{L}$ = Lift Coefficient
  - M = Mach Number
  - $S^{REF}$ = Reference Wing Area
- As a result, the RVSM flight envelope(s) may be collapsed into one chart by simply plotting W/δ, rather than altitude, versus Mach Number. Since δ is a fixed value for a given altitude, weight can be obtained for a given condition by simply multiplying the W/δ value by δ.
- Over the RVSM altitude range, it is a good approximation to assume that position

# Credits

- The U.S. Member of the SASP recognized Mr. Tony Wiederkehr (FAA Designated Engineering Representative (DER)1, # DERT-635881-NM) of Aeromech, Inc. for his valuable input on this topic.