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POPU Test Method
§ Process which improves efficiency of measuring RVSM performance
§ Results in Affordability, Efficiency, and Effectiveness (AE&E) improvements
§ Shorter test flights resulting in lower test costs

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Reduced Vertical Separation Minimum (RVSM) Push-Over Pull-Up (POPU) Testing

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4 June 2019

Topics

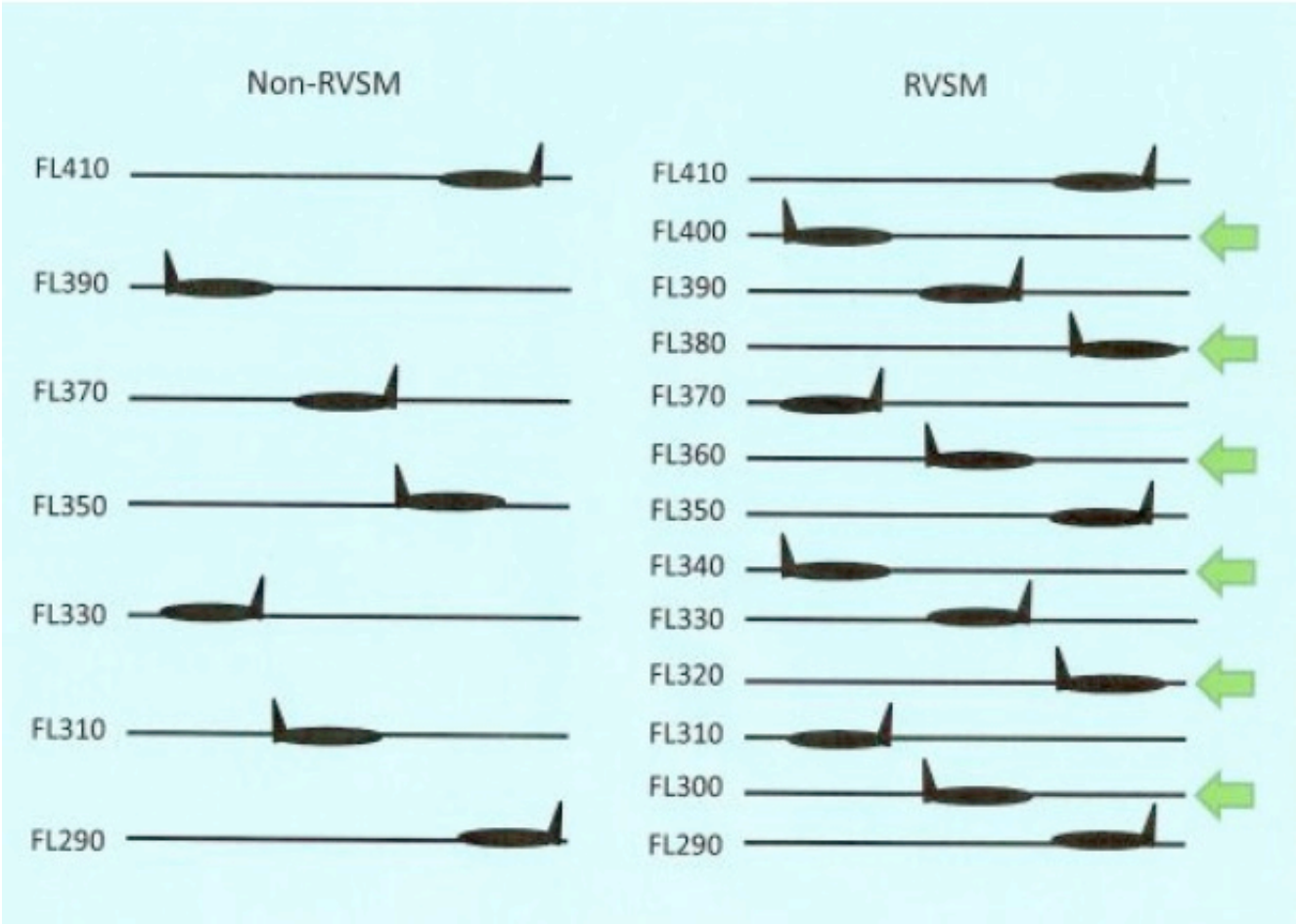
- RVSM Airspace Requirements
- Air Data System Architecture
- RVSM Test Techniques
  - POPU vs. Trailing Cone
- POPU Test Methodology
- Physics of POPU Parameters
  - Relation of Angle-Of-Attack/Mach/ASE
- POPU Execution
  - Tower-Fly-By/Transfer of Error
- References
- Summary

RVSM Airspace Requirements

- Regulation--CFR Title 14, Chapter 1, Subchapter F, Appendix G to Part 91
  - As presented in FAA AC 91-85B dated 1/29/2019
  - Reflects vertical separation requirement of 1000 feet between FL 290 and FL 410 in addition to other accuracy/alerting requirements
- System consists of Pitot Static System, Air Data Computer (ADC), and barometric readout
- Primary performance functions
  - Maintain straight and level flight with “not to exceed” altitude drift
  - Provide altitude alert function when altitude drift is exceeded
  - Ensure accuracy of total system within prescribed tolerances

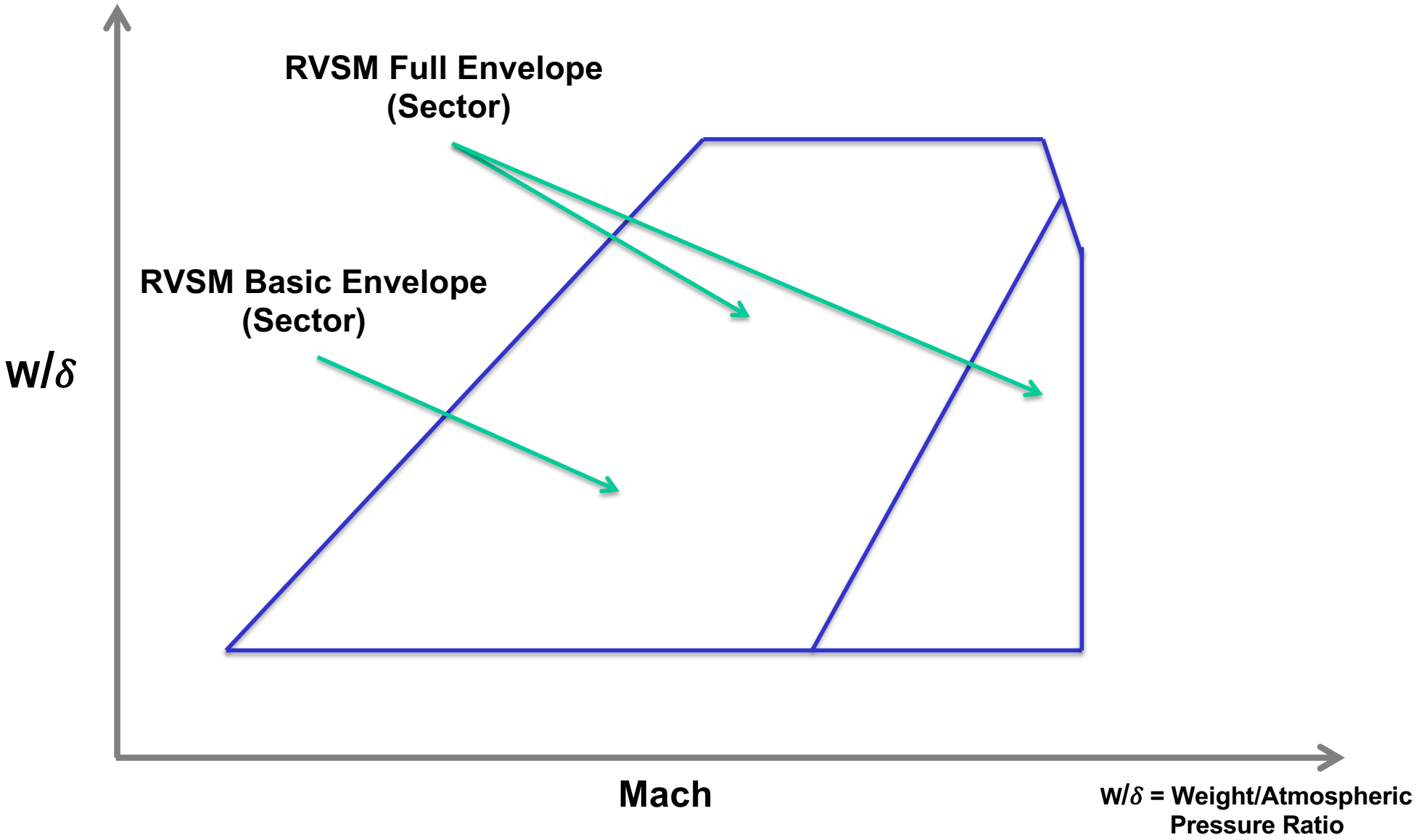
RVSM Airspace Requirements

FL290 – FL410 – 1,000 ft. Separation

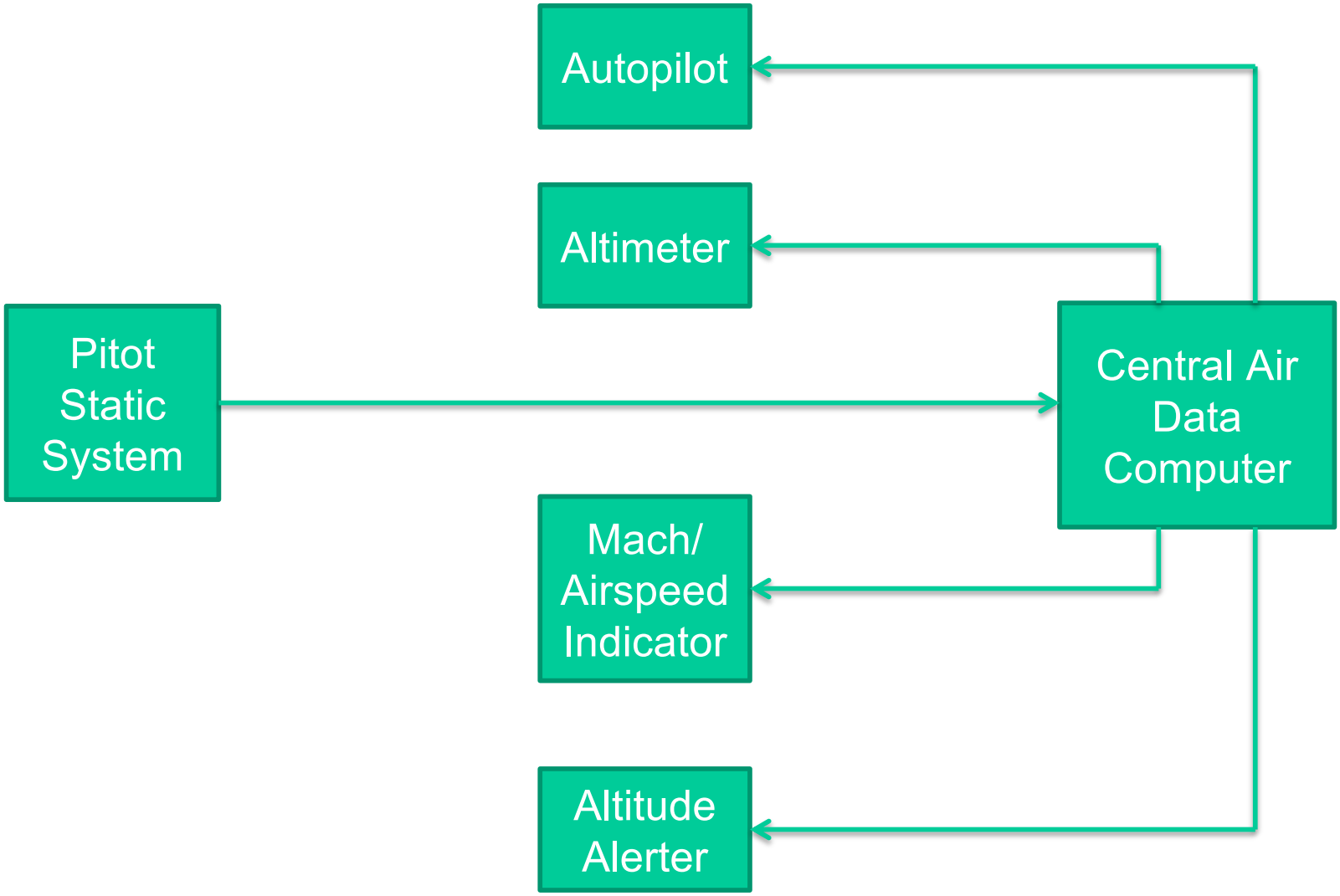


Source: https://www.faa.gov/air_traffic/separation_standards/rvsm/documents/ASE/2.3_NASA_RVSM_Certification_Process.pdf

RVSM Airspace Requirements



Air Data System Architecture



RVSM Test Techniques

- POPU vs. Trailing Cone Methods
  - Objective of both methods is determination of Altimetry System Error (ASE) related to barometric air data systems
    - Mean Sea Level (MSL) is the baseline altitude reference
  - Trailing Cone is a non-dynamic method of collecting data using an extended cone (with instrumentation) either on platform under test or on a chase plane
  - POPU is a dynamic test procedure which reduces test time necessary to collect RVSM data when compared to the classical “Trailing Cone” procedure

POPU Test Methodology

- POPU validates RVSM accuracies by using acceleration motion generated from rise and fall aircraft maneuvers (compared to roller coaster movements)
  - Vertical excursions may range from a peak to a null of 150-feet (test procedures and aircraft type will determine this range)
  - POPU requires fewer flight hours than standard trailing cone measurements resulting in less time/cost to accomplish
  - Also, POPU is more adaptable to high performance aircraft since these vehicles are capable of maneuvers which more efficiently provide data (i.e. POPU) than conventional measurement (i.e. trailing cone) techniques
  - Reduced flight time, fuel consumption, and quicker test aircraft return-to-operational status are benefits of POPU testing

Physics of POPU Parameters

- Relation of Angle-Of-Attack/Mach/ASE
  - ASE is a function of Angle of Attack (AOA) and Mach; the entire flight envelope to be tested is covered by running various flight combinations of AOA and Mach
  - Pressure Altitude accuracy is the required parameter to determine altitude accuracy (ASE) and is determined from the results of above
- Impact of accel/decel maneuvers
  - Used in conjunction with above to characterize RVSM flight envelope

POPU Execution

- Tower-Fly-By
  - POPU requires a baseline for error determination as a starting point
    - Accomplished by Tower Fly-By (TFB) testing
    - TFB baseline measurements are used for error determination only
      - TFB results are not used for RVSM altitude determination
- Transfer of Error
  - TFB error results are used only for adjustment of measurements taken at RVSM altitudes from POPU procedures

Summary

- POPU Test Method
  - Process which improves efficiency of measuring RVSM performance
  - Results in Affordability, Efficiency, and Effectiveness (AE&E) improvements
  - Shorter test flights resulting in lower test costs
  - Reduced impact to availability of operational assets

References

- “NASA Information Summaries”, Pushover-Pullup
- “The Accelerometer Methods of Obtaining Aircraft Performance from Flight Test Data (Dynamic Performance Testing)”, William R. Simpson, Center for Naval Analyses, 18 October 1979; contributor agencies included:
  - United States Air Force Edwards Air Force Base
  - U.S. Naval Air Test Center Patuxent River
  - Grumman Aerospace Corporation
- “Reduced Vertical Separation Minimum (RVSM) Qualification Document US Navy F/A-18E/F CAS Model Group Aircraft Initial Release”, Document Number: 2014A0041 16 December 2014

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