REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188		
The public reporting burden for this collection of information i sources, gathering and maintaining the data needed, and cou aspect of this collection of information, including suggestions a Operations and Reports (0704-0188), 1215 Jefferson Davis provision of law, no person shall be subject to any penalty for PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE A	is estimated to average 1 mpleting and reviewing th for reducing the burden, to Highway, Suite 1204, Arl failing to comply with a col ADDRESS.	hour per respons e collection of inf Department of D ington, VA 22202 ection of informa	se, including th ormation. Send Defense, Washi 2-4302. Respo tion if it does no	te time for reviewing instructions, searching existing data d comments regarding this burden estimate or any other ngton Headquarters Services, Directorate for Information ndents should be aware that notwithstanding any other ot display a currently valid OMB control number.	
1. REPORT DATE (DD-MM-YYYY) 2. REPORT	ТҮРЕ			3. DATES COVERED (From - To)	
4. TITLE AND SUBTITLE			5a. CONTRACT NUMBER		
			5b. GRANT NUMBER		
			5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S)			5d. P	5d. PROJECT NUMBER	
			5e. T	5e. TASK NUMBER	
			5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF: 1 a. REPORT b. ABSTRACT c. THIS PAGE	ITY CLASSIFICATION OF: 17. LIMITATION OF 18. N b. ABSTRACT c. THIS PAGE ABSTRACT 0 P P P	18. NUMBER OF	19a. NAME	OF RESPONSIBLE PERSON	
		PAGES	19b. TELE	PHONE NUMBER (Include area code)	

Τ

Г



Aerospace Management Systems Division



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

Joseph M. Hudak AFLCMC/HBAI (MITRE) Hanscom AFB, MA 4 June 2019

DISTRIBUTION STATEMENT A. Approved for public release. PA-66ABG-2019-0045 Cleared as Amended 3 Jun 2019

© 2019 The MITRE Corporation. All rights reserved. Approved for Public Release; Distribution Unlimited: 19-1532.







- 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





- 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





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



Integrity - Service - Excellence



Air Data System Architecture







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 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 returnto-operational status are benefits of POPU testing





- 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





Joseph Hudak AFLCMC/HBAI (MITRE Corp) 781-225-5002 jhudak@mitre.org





You don't generate Air Power without Air Fields!



HBA...Try Flying Without Us!