



PERSPECTIVES ON FLIGHT TEST MANAGEMENT

FOR CAA DESIGN DESIGNEE HOLDER (DDH) CONFERENCE, MAY 2018

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- While the information in the following presentation is of broad interest to the CAA NZ DDH community attendance at this presentation is not to be construed as receiving training in the discipline of flight testing.
- Additionally, neither the Presenter nor CAA NZ accept any responsibility for a recipient's application of the content of this presentation.

ABOUT THE PRESENTER – PACO UYBARRETA

- 14 years US Air Force officer and pilot
- 10 years Experimental Test Pilot: 4 years military + 6 years industry (OEMs)
 - Bombardier Aerospace (CAN/US), Scaled Composites (US), Martin Aircraft (NZ)
- B.S. in Aerospace Engineering, Boston University, 1998
- M.A.S. in Aeronautics, Embry-Riddle Aero. University, 2007
- M.S. in Flight Test Engineering, US Air Force Test Pilot School, 2009
- Ph.D. Candidate in Aerospace Sciences, University of North Dakota (2021-ish?)
- Assistant Adjunct Professor of Aeronautics, Embry-Riddle Aero. University
- Cat 1 Experimental Test Pilot, US Air Force Test Pilot School Graduate, 2009
- FAA/TCCA ATPL; FAA CFII, CAA CPL-A, 4,700+ pilot hours in 49 types
- Project Test Pilot of approx. 10 major mil/civ aerospace flight test programs

OBJECTIVES

- TO DISCUSS MY PERSPECTIVE ON FLIGHT TESTING
- TO DISCUSS MY PERSPECTIVE ON FLIGHT TEST RISK MANAGEMENT/MITIGATION/SAFEY PLANNING
- TO DISCUSS YOUR PERSPECTIVES AS DDH PROFESSIONALS
- TO ALL LEARN SOMETHING PROFESSIONALLY RELATING DDH AND FLIGHT TESTING

FLIGHT TEST MANAGEMENT TOPICS

- MACRO TO MICRO
- WHY FLIGHT TEST?
- WHAT IS FLIGHT TEST? WHO DOES FLIGHT TEST?
- WHAT ARE DIFFERENT TYPES OF FLIGHT TEST PROGRAMS?
- WHAT ARE FLIGHT TEST PHILOSOPHIES, PRINCIPLES, PROCESSES?
- WHAT ARE TYPICAL FLIGHT TEST SUB-DISCIPLINES?
- HOW TO MANAGE FLIGHT TEST PROGRAMS (I.E., RISK MANAGEMENT)?
 - PROGRAM RISK VS. TECHNICAL RISK VS. SAFETY RISK

WHY FLIGHT TEST?

- EXPLORE
- EXPLAIN
- EXCLAIM
- PROVE (OR DISPROVE)
- IMPROVE
- SHOW (CONCEPT)
- SHOW (COMPLIANCE)

WHY FLIGHT TEST?

- EVALUATE
- DETERMINE
- VERIFY
- VALIDATE
- DEMONSTRATE
- COMPARE

WHAT IS FLIGHT TEST?

- **NOT** “KICK THE TIRES, LIGHT THE FIRE.”
- **NOT** “SHE’LL BE FINE.”
- **NOT** “POINT THE PLANE STRAIGHT DOWN, AND SEE WHAT HAPPENS.”
- **NOT** “HAND IT TO THE PILOT, FLY, AND TICK A BOX.”
- **NOT** “DESIGN IT, BUILD IT, FLY IT ONCE, CERTIFY IT, SELL IT, GOOD-BYE.”
- **NOT** “IF I FOLLOW A BOOK OR ATTEND A COURSE, THEN I CAN DO IT SAFE AND RIGHT EVERY TIME.”
- **NOT** OFTEN EASY, SIMPLE, HAZARDLESS, AUTOMATIC, COOK-BOOK, FAST, CHEAP, CUT-AND-PASTE, RIGID, LINEAR, PREDICTABLE...”

WHAT IS FLIGHT TEST?

- CAREFULLY PLANNED/DOCUMENTED WITH ALL STAKEHOLDERS
 - PROGRAM MGT, DESIGN ENGINEERING, TECHNICIANS, FLIGHT (TEST) OPERATIONS
 - MANUFACTURERS, SUPPLIERS, PARTNERS, OPERATORS, REGULATORS, CUSTOMERS
 - CLEAR, ACHIEVABLE, COORDINATED TEST OBJECTIVES
 - SAFELY, EFFECTIVELY, EFFICIENTLY OBTAIN NEW (RISKY) FLIGHT TEST DATA
- CAREFULLY EXECUTED (FLOWN) WITH PAINSTAKING DISCIPLINE/COORDINATION/COMMUNICATION/DOCUMENTATION
 - SAFELY, EFFECTIVELY, EFFICIENTLY OBTAIN NEW (RISKY) FLIGHT TEST DATA
- CAREFULLY REPORTED/DOCUMENTED TEST RESULTS
 - QUANTITATIVE/QUALITATIVE DATA REDUCTION, DEDUCTION, REPORTING, RESOLUTION

WHAT IS FLIGHT TEST?

- ONE SMALL BUT CRITICAL PIECE OF MANY PUZZLES, DEPENDING ON PROGRAM
- ENGINEERING: DESIGN, BUILD, TEST, REPEAT...
- VERIFICATION/VALIDATION: ANALYSIS, INSPECTION, SIMULATION, GROUND TEST, FLIGHT TEST
- TEST: MODEL, SIMULATE, PREDICT, COMPONENT, BENCH, LAB, RIG, GROUND, FLIGHT TEST
- FLIGHT TEST: PLAN, FLY, REPORT, REPEAT...
 - THEORY, DESIGN, PREDICT, PLAN, PROVISION, BUDGET, EXECUTE, RECOVER, REDUCE, DEDUCE, REPORT, RESOLVE, REPEAT...
- DEVELOPMENTAL AEROSPACE FLIGHT PROGRAMS ARE LIKE CYCLES
 - NON-LINEAR, COMPLEX, UNCERTAIN
 - OFTEN UNDER-ESTIMATED: COST, TECHNICAL, RESOURCES, COMPLEXITY, SAFETY, TIME

WHO DOES FLIGHT TESTING?

- **NOT** RECKLESS COWBOYS
- **NOT** LONERS
- **NOT** RANDOM “FILL-IN”
- **NOT** “BUSINESS AS USUAL” “9-TO-5-ERS” “WEEKDAYS ONLY”
- **NOT** RISK-AVERSE
- **NOT** PENCIL-PUSHING ONLY
- **NOT** DESK-TOPPING ONLY

WHO DOES FLIGHT TESTING?

- FROM USAF TEST PILOT SCHOOL MISSION STATEMENT...
 - “HIGHLY-ADAPTIVE” AND “CRITICAL-THINKING” “TEAM LEADING” “PROFESSIONALS”
 - ENGINEERING ACUMEN
 - TECHNICAL CURIOSITY, POST-GRADUATE ENGINEERING DEGREES
 - FLYING SKILLS
 - DIVERSE AEROSPACE VEHICLE EXPOSURE
 - ABILITY TO FLY POOR HANDLING AIRCRAFT
 - ABILITY TO PRECISELY FLY DIFFICULT FLIGHT TEST MANEUVERS
 - ABILITY TO EVALUATE HOW AIRCRAFT HANDLES, FEELS, INTERFACES, ACHIEVES TASKS/MISSIONS
 - TEAM SKILLS
 - COMMUNICATIONS, PROBLEM-SOLVING, DECISION-MAKING, JUDGMENT, ETC
 - VERBAL AND WRITTEN REPORTING – TRANSLATION ACROSS ALL STAKEHOLDERS

WHO DOES FLIGHT TESTING?

- MUCH, MUCH, MORE THAN JUST A GOOD PILOT...
- TRAINED, QUALIFIED, EXPERIENCED PROFESSIONAL EXPERIMENTAL TEST PILOTS
- TRAINED, QUALIFIED, EXPERIENCED PROFESSIONAL FLIGHT TEST ENGINEERS
- TRAINED, QUALIFIED, EXPERIENCED, PROFESSIONAL CONTROL ROOM ENGINEERS
- TRAINED, QUALIFIED, EXPERIENCED PROFESSIONAL MAINTENANCE/INSTRUMENTATION TECHNICIANS
- TRAINED, QUALIFIED, EXPERIENCED PROFESSIONAL TEST PROGRAM MANAGERS
- PROFESSIONAL FLIGHT TEST TEAM, OFFICE, DEPARTMENT, ORGANIZATION, CENTER

SO IT'S JUST LOTS OF FLYING, RIGHT?

- PYRAMID EFFECT
- LOTS OF MEETINGS, EMAILS, DOCUMENTS, TELECONS
- LOTS OF PLANNING, ARGUMENTS, DISCUSSIONS, CHANGES, DELAYS
- LOTS OF WAITING, UPS AND DOWNS, TRAVEL, CANCELLATIONS
- FOR **A LITTLE BIT** OF FLYING
- BUT VERY **MEANINGFUL** FLYING
- LOTS OF REPORTS, MEETING, EMAILS, DOCUMENTS, TELECONS, REPEAT...

FLIGHT TEST IS “MEANINGFUL” FLYING?

- **MILESTONES**

- FIRST OF NEW TYPE, FIRST OF FLEET, FIRST OF NEW CONCEPT, FIRST OF NEW MOD
- FIRST FLIGHT, FIRST MANEUVERS, FIRST DATA, FIRST X, Y, Z, A, B, C
- FIRST MARKETING OF NEW AIRCRAFT/PRODUCT

- **DATA**

- VERIFICATION AND VALIDATION OF NEW DESIGN, SYSTEM, MODIFICATION
- ENGINEERS SHOULD BE HUNGRY FOR FLIGHT TEST DATA – TRUTH ABOUT DESIGN/MOD
- PILOTS SHOULD BE EAGER ABOUT FLIGHT TEST – WHEN CAN I FLY, HOW DOES IT FLY?
- MANAGERS SHOULD BE EAGER ABOUT FLIGHT TEST – COST, SCHEDULE, DELIVERIES?

FLIGHT TEST TYPES

- **EXPERIMENTAL (CAT 1)**
 - Proof-of-concept demonstrators, X-planes
 - X-1, XV-5, Sikorsky X2, Scaled Composites SS1, Martin Jetpack Series 1, Zephyr Cora, Bell V-280
- **RESEARCH (CAT 1-2)**
 - New wing shape, science missions
 - NASA F-15 with Aerion hypersonic airfoil, NASA F-18 sonic booms
 - NASA SOFIA, Atmospheric Science Platform (during mod)
- **ENGINEERING/DEVELOPMENTAL (CAT 1-2)**
 - Prototype, major design change affects airworthiness
 - AW609, CSeries, A-380, Global 7000, F-35C, B-787-10 envelope expansion

FLIGHT TEST TYPES

- TEST BED (CAT 2-3)
 - New equipment on existing airframe
 - B-747 Engine Test Bed flying with prototype turbofan engine (Rolls-Royce, GE, PW)
- CERTIFICATION (CAT 1-3)

To find compliance with FARs/CARs

 - A-350, B-787, G-600 after 2-3 yrs initial flight testing
 - FAA/CAA/EASA test pilot or DER/DAD/UM/DDH test pilot to find compliance
- PRODUCTION/ACCEPTANCE (CAT ?)
 - A-320 off factory production lines (post-certification, low/high-rate production/delivery)
- POST-DEPOT/MAINTENANCE (CAT ?)
 - In-service B-737 after overhaul, repairs, etc

FLIGHT TEST PHILOSOPHIES AND PRINCIPLES

PLAN – TEST – REPORT

- **BUILD-UP** APPROACH
- PREDICT – TEST – VALIDATE
- PLAN THE FLIGHT - FLY THE PLAN
- REDUCE RISK TO LOWEST LEVEL
- EXPECT THE **UNEXPECTED**
- PREPARE TO BE **UNPREPARED**

FLIGHT TEST PROCESSES

TAKE-AWAYS

- TECHNICAL AND OPERATIONAL TEAM EFFORT!
- DEVELOP TEST PROCEDURES
- **MITIGATE RISKS TO MAXIMUM PRACTICAL EXTENT POSSIBLE**
- STANDARDIZE MANEUVER TECHNIQUE
- FLY DEDICATED TEST MISSIONS
- PLAN/BRIEF/FLY TEST CARDS
- CAPTURE OBJECTIVE DATA
- PROVIDE REPORTS TO ENGINEERING
- PLAN THE FLIGHT – FLY THE PLAN

WHAT ARE DIFFERENT FLIGHT TEST SUB-DISCIPLINES

- AIRWORTHINESS

- (HOW WELL) DOES IT FLY? “ENVELOPE EXPANSION”
- STRUCTURES (STATIC/DYNAMIC LOADS, AERO-SERVO-ELASTICS)
- FLYING AND HANDLING QUALITIES (STABILITY AND CONTROL)

- PERFORMANCE

- HOW HIGH/LOW/FAR/FAST/SLOW DOES IT FLY?
- TAKEOFF/LANDING DISTANCES, TIME-TO-CLIMB, BEST RANGE/ENDX
- PERFORMANCE CHARTS

- INTEGRATED SYSTEMS

- HOW WELL DOES THIS HELP IT FLY (ITS MISSION)?
- AVIONICS, AUTOPILOT, RADARS, SENSORS, EGPWS, ANTI-ICING, OTHER SUBSYSTEMS
- MILITARY: WEAPONS, SENSORS, JAMMERS
- UAS: RPAS, UAV

FLIGHT TEST RISK MANAGEMENT

- AS A DDH, YOU HAVE TO SHOW/FIND COMPLIANCE
- OFTEN, MEANS OF COMPLIANCE IS THROUGH FLIGHT TESTING
- FLIGHT TESTING IS A RISKY ENDEAVOR
- HOW TO SHOW/FIND COMPLIANCE BY MITIGATING FLIGHT TEST RISK

FLIGHT TEST/SAFETY PLANNING (RISK MITIGATION)

- SAFETY MANAGEMENT SYSTEMS (SMS)
 - SEPARATE GROUND AND FLIGHT SAFETY PROCESSES/OFFICES/MANAGERS
 - SLIPPING ON THE FLOOR VERSUS V_{mca} FLIGHT TESTING
 - PEOPLE OFTEN GET THESE CONFUSED
- RISK TYPES
 - PROGRAM (COST/SCHEDULE)
 - TECHNICAL (ENGINEERING VERIFICATION/VALIDATION ADEQUACY)
 - SAFETY (LOSS OF LIFE/HULL)
 - PEOPLE OFTEN THESE GET CONFUSED
- INDEPENDENT REVIEW
 - WHO IS GUARDING THE GUARDS?

FLIGHT TEST/SAFETY PLANNING (RISK MITIGATION)

- RISK MATRIX ELEMENTS
 - DIFFERING SEMANTICS
 - SEVERITY
 - PROBABILITY/LIKELINESS
 - EXPOSURE
 - LOW, MEDIUM, HIGH, EXTREME RISK LEVELS
 - HAZARDS, CAUSAL FACTORS, MITIGATIONS, RECOVERY ACTIONS
 - GENERAL MITIGATION CONSIDERATIONS VS. THREAT HAZARD ANALYSIS (SPECIFIC)
 - FLIGHT TEST ORGANIZATIONS SHOULD SET UP TEST/SAFETY PROCEDURES
 - JUDGEMENT AND EXPERIENCE ALWAYS TRUMP COLORS AND BOXES
- TEST/SAFETY PLANNING WORKING GROUPS
 - INTERDISCIPLINARY TEAMS, ALL STAKEHOLDERS (PROJECT/INDEPENDENT)
 - CHAIR; TECHNICAL, OPERATIONAL REPRESENTATIVES (PROJECT/INDEPENDENT)

FLIGHT TEST/SAFETY PLANNING (RISK MITIGATION)

- TEST/SAFETY PLANNING WORKING GROUPS – **EARLY AND OFTEN**
 - KICK-OFF **MEETINGS**
 - DRAFT **PLANS**
 - ASSIGN TASKS/ACTION **ITEMS**
 - TASK **DEADLINES**
 - PROGRAM MANAGEMENT
 - FOLLOW-UP MEETINGS
 - **DEBATE, DISCUSSION, ARGUMENT, ACTIONS, RE-DRAFTS, EMAILS, MEETINGS**
 - **OUTPUTS: FULLY-STIPULATED (WITH ALL STAKEHOLDERS) FLIGHT TEST/SAFETY PLANS THAT CAN BE PROVISIONED FOR AND EXECUTED (FLOWN) FROM**
- THERE'S STILL RISK, BUT IT'S BEEN AS **MITIGATED AS PRACTICAL AS POSSIBLE**
 - **IT IS WHAT IT IS – CAT 1 AND 2 TEND TO BE ELEVATED-RISK FLIGHT TESTING**
- TEST AND SAFETY PLANNING ARE PARALLEL/STAGGERED (TEST THEN SAFETY)

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