NASA's Flying Qualities Research Contributions to MIL-STD-1797C

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Presented to
Flying Qualities Working Group
17 September 2019

Mitchell Aerospace Research
Handling Qualities Research & Development

Outline

- BLUF: Proposed mods to 1797B
- The Team
- Work Performed at Different Levels (Phases)
- Phase I: Topic Areas
- Phase II: High-Priority Topics from Phase I
- Recommendations
  - New Demo Maneuvers
  - New Criteria
  - Potential Focal Areas for Phase III Research

Bottom Line Up Front: Proposed Changes

- High-Alpha/Post-Stall demo maneuvers (already planned per Will Thomas)
- Qualitative requirement/guidance on ICR effects (ongoing research at USAF TPS)
- Existing longitudinal criteria may be effective for supersonic flight (still under evaluation)
- Tighter roll damping and time-to-bank for transports
- Roll Bandwidth limits for Class IV aircraft in landing
- Guidance on aeroelastic effects (need to obtain data); Category II PIO detection/prevention (top-level only at present); cockpit feel system characteristics
- Discussion of equivalent time delay limits

The Team

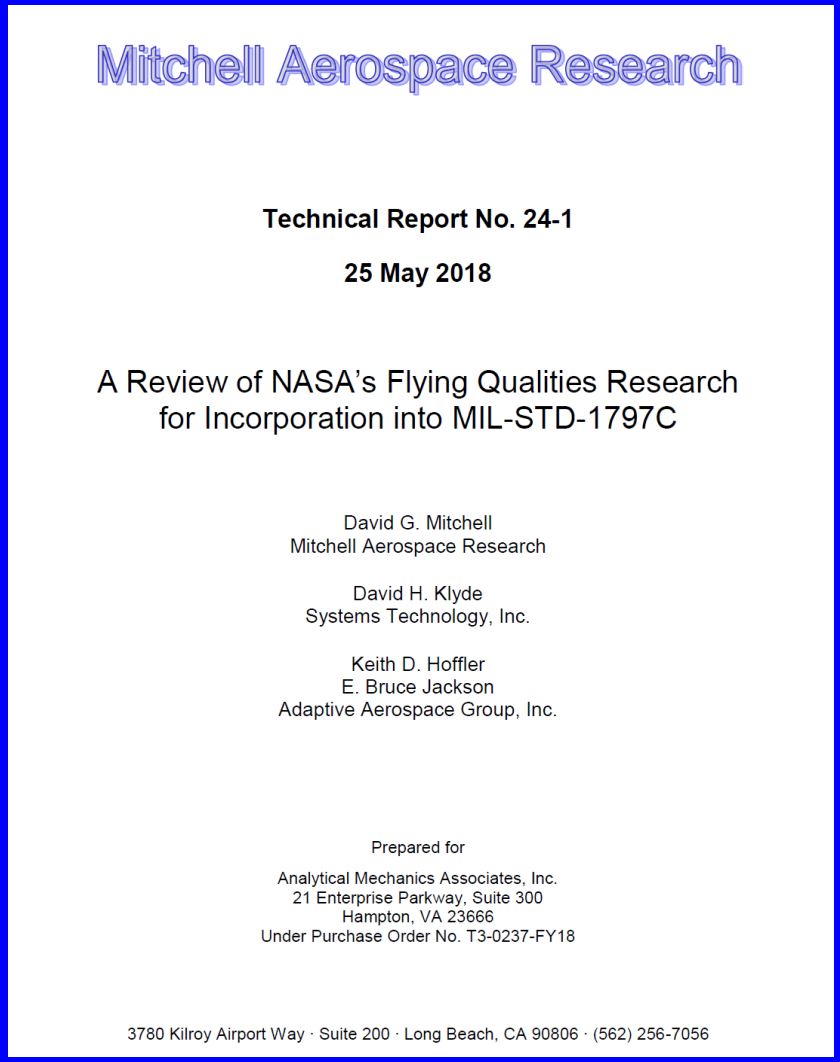
- Mitchell Aerospace Research
- Systems Technology, Inc.
- Adaptive Aerospace Group, Inc.
- Marilyn Ogburn, Distinguished Research Associate, NASA Langley Research Center
- Bimal Aponso & Bill Chung, NASA Ames

Work Performed in Phases

- I: Identify key topics not covered (or not adequately) in 1797B (Jan. – May ’18)
- II: Assemble information on Phase I high-priority areas (Mar. – Sep. ’19)
- III (planned, if funded): Detailed analysis of topics, including source data, to develop new requirements, criteria, limits, or guidance

Phase I : Four Major Topic Areas

- Identified as…
  - High-priority
  - Easy access to reports, data, test results
  - Familiar topics for the test team
- Topics identified:
  - High-Alpha Technology
  - High-Speed Research
  - Pilot-Induced and Pilot-Assisted Oscillations
  - Inceptor Characteristics



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Technical Report No. 24-1

25 May 2018

A Review of NASA's Flying Qualities Research for Incorporation into MIL-STD-1797C

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Phase II: High Priorities

- 5.2.2.1 Longitudinal Response to Pitch Controller
- 5.2.2.1.7.1 Longitudinal Control Margin
- 5.2.3.1 - 5.2.3.5 Roll Response/Effectiveness
- 5.2.5 High AoA Requirements
- 5.2.5.5 Departure from Controlled Flight
- 5.2.8.3 Cockpit Controller Characteristics

5.2.2.1 Longitudinal Response to Pitch Controller

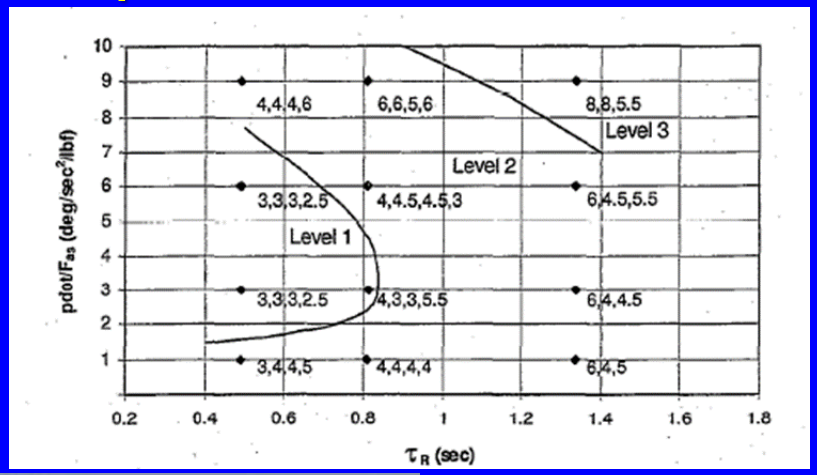
- Primary focus was on high-speed research
- Generally criteria supported by data
- Possible mods to Neal-Smith and Bandwidth limits
- Working paper just delivered, assessing recommendations

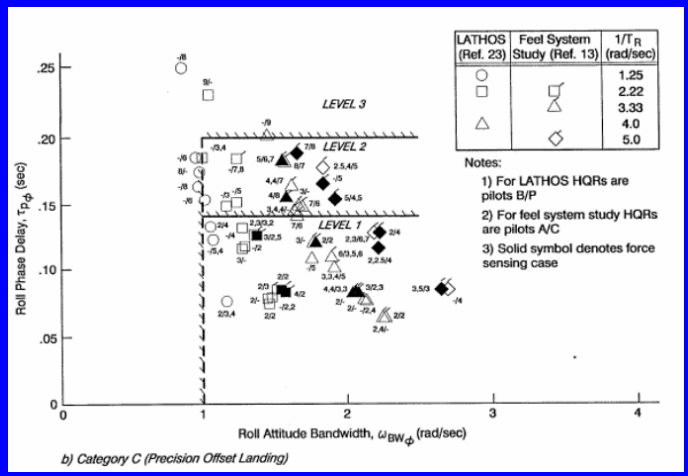
5.2.2.1.7.1 Longitudinal Control Margin

- Not addressed in this phase
- Some of the material already appears in 1797B
- Challenging to assess for handling qualities: data contained in numerous reports, some of which are ITAR/US Government only
- Topic deserves a thorough review

5.2.3.1 - 5.2.3.5 Roll Response/Effectiveness

- Primary data sources from High Speed Research moving-base simulations
- Results support tightening limits on roll time constant and control power
- Proposed roll Bandwidth limits should be added





5.2.5 High AoA Requirements

- Incorporate proven Standard Test and Evaluation Maneuver Set (STEMS) into demo maneuvers (5.1.1.1 Verification)
  - Current discussion mentions simulations only
  - Flight test results available
    - Tech paper (Klyde, Citurs, Fawer, Mitchell, “In-Flight Evaluation of the Standard Evaluation Maneuver Set (STEMS) with the NASA F/A-18 HARV”) presented in 1996
    - Report containing the paper (NASA CP-1998-207676) is ITAR/USG
    - Five STEMS were identified as effective in flight
- Other High-AoA work (control power, departure criteria, etc.) deferred to Phase III

5.2.5.5 Departure from Controlled Flight

- Analytical criteria are discussed in 1797B
- Criteria were applied during HATP (F-18 HARV, X-31)
- No systematic assessment or single source exists
- Data often contained in ITAR/USG documents
- Considered too challenging for this phase

5.2.8.3 Cockpit Controller Characteristics

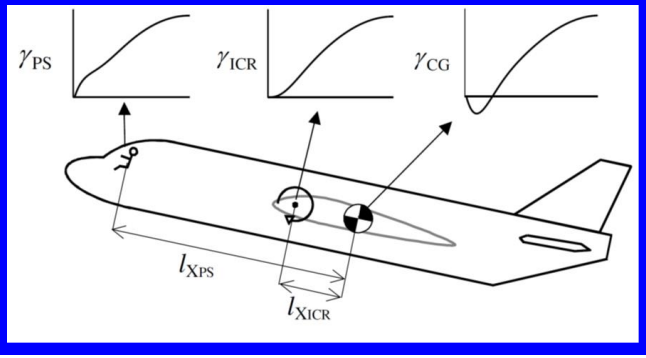
- Overview of feel systems research
- A decades-old discussion: are the effects of feel system dynamics on handling qualities similar to those of time delay?
  - Studies by NASA, USAF, others, with no clear answer
  - Detailed analysis to develop or modify criteria requires considerably more time (and funding)
  - Definitive answer needs more research!

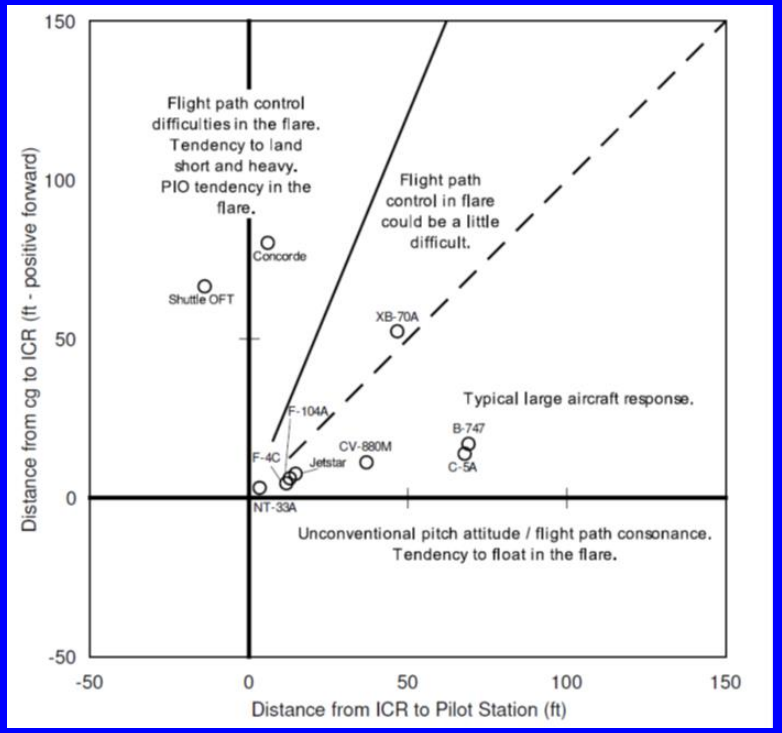
Additional Phase II Efforts

- Detailed data were not easily located for some high-priority topic areas
- We chose to shift focus to other areas
- Workload for AAG precluded major contributions
  - Some funding reassigned to STI
  - Several working papers were generated

Unusual Center of Gravity Effects

- Best fits under 5.2.2.1.6 Normal acceleration at the pilot station
- Initial research supported by NASA (Field, Armor, Rossitto, Mitchell, “Effects of Pitch Instantaneous Center of Rotation Location on Flying Qualities,” AIAA-2002-4799)
- USAF TPS student project ongoing (using VISTA NF-16 and NASA Ames VMS)





Pilot-Induced Oscillations

- Numerous NASA studies following Shuttle PIO in 1977
- NASA has sponsored follow-on work
- Summary review of suppression methods has been written
- Detailed criteria development under USAF sponsorship

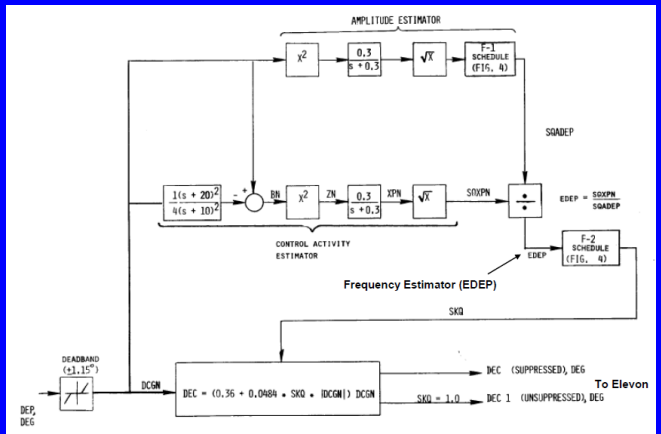


Figure 2. Shuttle PIOS and Pitch Stick Shaping Function (from Ref. 5)

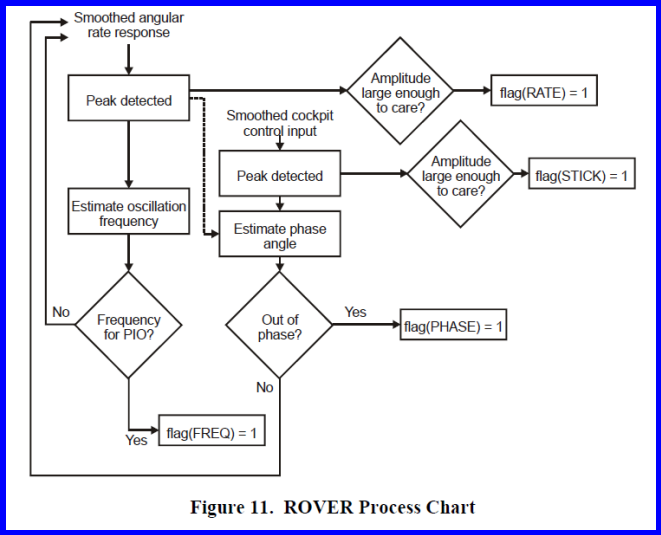


Figure 11. ROVER Process Chart

Pilot-Assisted Oscillations

- Based on large/flexible aircraft studies
- Initial results from HSR program
- Need detailed data if criteria are to be developed

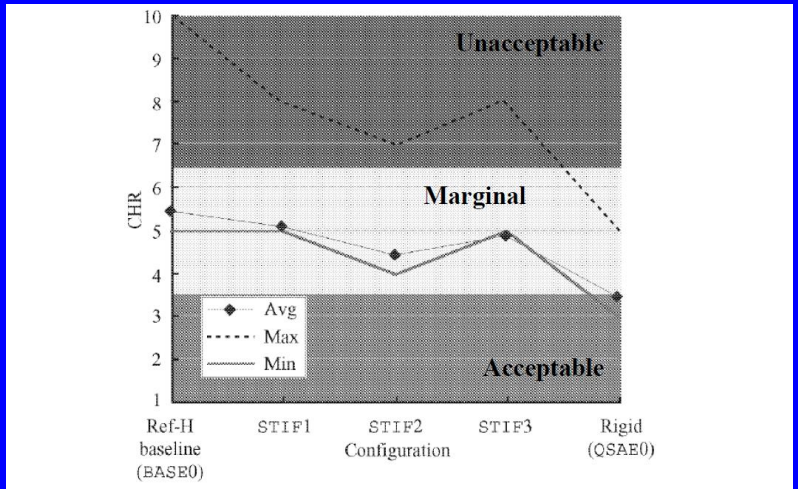


Figure 17: Variation of Average CHR with Increasing Structural Stiffness (Ref. 1)

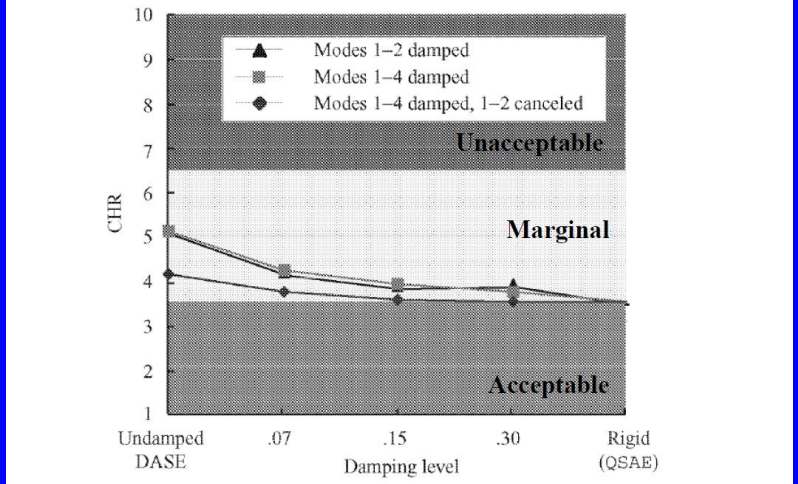


Figure 18: Variation of Average CHR with Increasing Damping and Modal Cancellation (Ref. 1)

Phase II Status

- All technical work complete
- STI recently delivered several working papers
- Contributions will be assembled into a summary report
- Main section of report will be recommendations for new requirements and guidelines
- Analysis collated in appendices
- Plan to deliver draft to NASA by 23 Sept.

Follow-On Work

- NASA Phase III funding required to assemble detailed data for some topics
- Coordination with DoD justified since there were several parallel and complementary research efforts
- Positive results could be expected for
  - Transport/flexible advanced transports
  - PIO test methods and criteria
  - PAO guidelines

Questions?