An Online Resource for Flight Test Safety Planning

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Goal

- If the only goal is to be safe
  - Easy solution - don’t fly
- The real goal is to get flight test data,
  - and to be as safe as possible while doing it
- Risk should be balanced against technical merit
Test Hazard Analyses

• Steps to balance risk with merit include:
  – Analyze the hazards
    • Identify causes and effects
  – Determine risk
  – Establish mitigating procedures
    • Consistent with objectives

• Results of THA’s
  – Allow management to
    • Understand residual risks
    • Decide if risks are technically merited
# Test Hazard Analysis Worksheet

<table>
<thead>
<tr>
<th>Test Title: Stall Characteristics</th>
<th>Hazard Category</th>
<th>Subjective Probability of Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft/System: NTPS Demo Sortie</td>
<td>catastrophic</td>
<td>high</td>
</tr>
<tr>
<td></td>
<td>critical</td>
<td>probable</td>
</tr>
<tr>
<td></td>
<td>marginal</td>
<td>uncertain</td>
</tr>
<tr>
<td></td>
<td>negligible</td>
<td>remote</td>
</tr>
<tr>
<td></td>
<td></td>
<td>improbable</td>
</tr>
</tbody>
</table>

**Hazard:** Aircraft departs controlled flight and impacts ground.

**Cause:** Loss of control.

**Effect:** Loss of aircraft and crew.

**Minimizing Procedures:**
1. Minimum entry altitude - 2000 ft AGL (B -35 4000 ft AGL, turboprop/jet 5000 ft AGL)
2. No aggravated input stalls. All stalls accomplished “ball centered”
3. No asymmetric power stalls in multiengine aircraft.
4. Build up approach:
   i. forward cg before aft
   ii. power off before power on
   iii. wings level before turning
   iv. 1 kt/sec before accelerated
   v. terminate build up if FAR bank angle limits are exceeded
5. Do not add power during recovery until above 1.2 Vs

**Emergency Procedures:**
1. If aircraft departs controlled flight, immediately retard power to idle and centralize controls.
2. If aircraft enters spin, accomplish spin recovery procedure.

**Risk Level** (after minimizing procedures taken into account):
- High _____  Medium _____  Low ____X____.
Online Database Background

• SETP/Flight Test Safety Committee
  – In 1997 tried to establish an online database of Lessons Learned
  – Effort aborted due to cost and web hosting issues

• NTPS
  – Developed and published THA’s for all curriculum demo sorties
  – Those THA’s made available to everyone online since 1998

• In 2004, NASA-Dryden and the FAA forged a joint agreement
  – To establish an online THA Database
  – Open website to anyone in the business
  – NASA develop website and manage FAA data development

• NASA-Dryden sub-contracted NTPS
  – To gather the data and populate the FAA THA data
Data Gathering

• Strawman effort
  – NTPS THA’s
    • Demonstration of classic Flight Test Techniques
    • Conservative limits
• Added inputs from the FAA
  – Aircraft Certification Offices in New York and Atlanta
• Next collected data from manufacturer’s
  – Boeing Long Beach, Gulfstream, Lockheed, Bombardier, Cessna, Raytheon, and Boeing Seattle – data still coming in
  – All existing safety planning info, freely shared
• Most recent
  – Solicited inputs from Schweizer, Tiger, Boeing Rotary Systems, New Piper and Sikorsky
NTPS Role

- Solicit and collect data
  - Primarily from manufacturer’s doing civil certification
  - Those willing to share their flight test safety details
- We put the data into a common format
  - Not asking industry to change their safety planning process, just share what they have
NTPS Role (cont’d)

• “Mature” the data
  – To make the database useful to a user, there must be some integration of inputs
  – Searching for “stall” would have produced 66 separate records just from the early inputs
  – NTPS is consolidating mitigations by
    • Hazard (e.g. Loss of Control) and by
    • Maneuver (e.g. Stalls with Ice Shapes)

• This process requires
  – Common maneuver names
  – Common hazard names
  – Related to all appropriate FAR paragraphs
Organizations

• Six different organizations submitted THA information regarding stall flight testing
  – Bombardier (12)
  – Cessna (1)
  – FAA (5)
  – Gulfstream (6)
  – NTPS (26)
  – Tiger (2)
Hazard Titles

• 19 different titles including:
  – Stalls
  – Stall Speed
  – Stall Speed (Ice Shapes Installed)
  – Stalling Period
  – Stall Characteristics
  – Stall Characteristics with Delayed Turn (On Ice Shapes)
  – Wings level stall
  – Turning flight and accelerated turning stalls
  – Position Light System Installation
  – Demonstration of Misinstalled Thrust Reverser
  – Rudder Available Determination - A/C with 40% increased PCUs installed
FAR Paragraphs

• Seven different Part 25 paragraphs originally had stall related hazards, but the matured data applies to:
  – 25.103, Stalling Speed
  – 25.201, Stall Demonstration
  – 25.203, Stall Characteristics
  – 25.207, Stall Warning
Maneuver Name

- **14 different maneuver names**
  - Stall speed determination
  - Stall characteristics determination
  - Stall
  - Stalls conducted with power on and off
  - Full stall (straight)
  - Full stall (turning)
  - Full stall (accelerated turning)
  - Straight stalls – contaminated leading edge
  - TCAS testing
  - Windshear Testing
  - Windmill airstart
  - APU flight test
  - Rudder available determination with 40%-increased PCUs installed
  - Simulated rejected takeoffs
Identified Hazard

• Most varied field in submitted data
• The focus of maturing effort, along with minimizing procedures for the agreed-upon hazard identified
• As an example:
  – Original
    • “There is a risk of stall/departure from controlled flight when increasing angle-of-attack at low airspeeds.”
  – Became:
    • “Loss of control”
• For Part 25 stall tests, we ended up with just six hazards
Matured Hazard Titles

- After submitted by NTPS and reviewed by the FAA and NASA, six hazards were identified with respect to Part 25 stall testing
  1. Loss of control
  2. Stall/spin chute fails to deploy
  3. Stall/spin chute fails to jettison when commanded
  4. Departing runway surface
     (During ground test of stall spin chute)
  5. Recovery chute uncommanded deployment
  6. Loss of operating engine(s)
Loss of Control Causes

• Many contributions of test safety planning did not include the “causes” – just the hazards and mitigations

• Of the ones submitted, the following were included in the matured THA’s
  1. Unpredicted aerodynamic response.
  2. Stick Pusher fails to prevent aircraft from reaching aerodynamic stall.
  3. Improper control inputs.
Mitigations

• Literally hundreds of varied mitigations were matured into just twelve –

• The matured mitigations include:

  1. Do stall testing in a **buildup approach**:
     a. from least risk to highest risk
        i. forward cg, mid cg, aft cg
        ii. Power off before power on
        iii. Wings level before turning
        iv. 1 kt/sec before 3 kt/sec
     b. **terminate buildup** if FAR limits on bank angle are exceeded at any point of the buildup
Mitigations (continued)

2. **Establish minimum altitudes** for:
   a. entry,
   b. recovery initiation,
   c. recovery chute deployment and
   d. manual bailout.

3. Perform **pre-flight checks** of stall warning and stick pusher, as applicable.

4. **Anti-spin chute** must be installed, functional and armed. Perform pre-flight and pre-maneuver checks of chute as applicable.

5. **Minimum crew** onboard.

6. **Emergency Egress system** must be installed and armed. Perform pre-flight and pre-maneuver checks of egress system as applicable.
Mitigations (continued)

7. Crew to wear helmets and parachutes.

8. Surface winds must be less than xx kts (parachute dependent).

9. No aggravated input stalls. All stalls will be ball centered.

10. No asymmetric power stalls.

11. If departing controlled flight retard throttles to idle and centralize controls.

12. Do not add power during recovery until airspeed is increasing above 1.2 Vs.
Database Now Open to the Public

http://pbma.nasa.gov/ftsdb/
Look for “Test Hazard Database”
### Test Hazard Analysis Search

#### Data Reference

<table>
<thead>
<tr>
<th>FAA Certification (FAR)</th>
<th>Number</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>(All)</td>
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<table>
<thead>
<tr>
<th>Military Development:</th>
<th>Number</th>
<th>Title</th>
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</thead>
<tbody>
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<td>(All)</td>
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<table>
<thead>
<tr>
<th>Research:</th>
<th>Number</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>(All)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Record Fields

- **Discipline:** (All)
- **Maneuver:** (All)
- **Hazard:** (All)
- **Aircraft Type:** (All)
- **Aircraft Power Plant:** (All)
- **Uninhabited:** (All) Yes No

#### Record Field Keyword

Finds keywords in selected fields to be searched. Results are limited to records satisfying criteria selected in record search above.

Select fields for your search: Select all Deselect all

- Maneuver
- Hazard
- Reference Number
- Reference Title

Keyword(s): Clear Keywords

Submit Clear
### FAR Reference Search

#### Test Hazard Analysis Search

<table>
<thead>
<tr>
<th>Data Reference</th>
<th>Number</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAA Certification (FAR):</td>
<td>25.201</td>
<td>Stall Demonstration</td>
</tr>
</tbody>
</table>

#### Record Fields

- **Discipline**: (All)
  - 25.177
- **Maneuver**: (All)
  - 25.201
- **Hazard**: (All)
  - 25.203
- **Aircraft Type**: (All)
  - 25.207
  - 25.253(a)/3
  - 25.831
- **Aircraft Power Plant**: (All)
  - 25.854
  - 25.856
  - 25.857
  - 25.858
  - 25.1301

#### Record Field Keyword

Field keywords are selected fields to be searched. Results are limited to records satisfying criteria selected in record search box.
# Record Field Search

<table>
<thead>
<tr>
<th>Record Fields</th>
<th>Locates drop-down entry that best matches typed word</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discipline</td>
<td>(All)</td>
</tr>
<tr>
<td>Maneuver</td>
<td>Stall</td>
</tr>
<tr>
<td>Hazard</td>
<td>(All)</td>
</tr>
<tr>
<td>Aircraft Type</td>
<td>(All)</td>
</tr>
<tr>
<td>Aircraft Power Plant</td>
<td>(All)</td>
</tr>
<tr>
<td>Uninhabited</td>
<td>(All) □ Yes □ No</td>
</tr>
</tbody>
</table>

**Record Field Keyword**

Finds keywords in selected fields to be searched. Results are limited to records satisfying criteria selected in record search above.
Keyword Search

1. Select fields for your search: select Maneuver, Hazard, Reference Number, Reference Title.
2. Enter the keyword(s): stall
3. Click Submit or Clear Keywords.
# Results of FAR Reference Search

## Search Results

**FAA Reference No.**: 25.201  
**FAA Reference Title**: Stall Demonstration

Check top box to select ALL records  
OR  
Check individual box(es) for desired records

<table>
<thead>
<tr>
<th>Maneuver</th>
<th>Hazard</th>
<th>Discipline</th>
<th>Aircraft Type</th>
<th>Aircraft Power Plant</th>
<th>Uninhabited</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recovery Chute Functional Test</td>
<td>Departing runway surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stall</td>
<td>Loss of Operating Engine(s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stall</td>
<td>Recovery chute uncommanded deployment</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Stall</td>
<td>Loss of Control</td>
<td></td>
<td></td>
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<td>Stall</td>
<td>Stall/spin chute fails to deploy when commanded</td>
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<td>Stall/spin chute fails to jettison</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

View Selected Records Sequentially  
Combine Selected Records
## Combined Test Hazard Analysis

<table>
<thead>
<tr>
<th>Reference No.:</th>
<th>Reference Title:</th>
<th>Risk Level:</th>
</tr>
</thead>
<tbody>
<tr>
<td>25.201</td>
<td>Stall Demonstration</td>
<td>High</td>
</tr>
</tbody>
</table>

### Maneuver Title: Stall

### Maneuver Details:
- As per AC 25-7A Section 6 “Stalls” Para 29
- 1) Trim hands off between 1.13 and 1.3 Vsr1
- 2) 1 kt/sec decel wings level
- 3) 1 and 3 kt/sec turning
- 4) Power off and power on;
- 5) Power on = PLF at MLGW and 1.5 Vsr1, flaps approach
- 6) Stall defined by nose down pitch not readily arrested; deterrent buffet; stick pusher; or stick at the aft stop (2 sec min)

### Hazard(s):
- Loss of Operating Engine(s)
- Loss of Control

Note: The following Causes and Mitigations are listed in order of the hazards above.

### Cause(s):
1. Inlet distortion leading to compressor stall
   - Unpredicted aerodynamic response.
2. Stick Pusher fails to prevent aircraft from reaching aerodynamic stall.
3. Improper control inputs.

### Mitigation(s):
1. Conduct approach to stall maneuvers at idle thrust before power on maneuvers.
2. At first onset of compressor distress, reduce AOA and reduce power to IDLE (if not already set to IDLE).
3. Shut down engine(s) if unable to prevent “locked-in” surge.
4. Conduct tests with APU running whenever possible.
5. Critical engine parameters will be monitored real-time using telemetry, on-board GFTS system or cockpit indications. Pre-brief CRM and engine knock-it-off calls.
6. Initial stall should be done with engine ignition and bleeds on.
7. All stalls should be done ball centered with symmetric power and if possible, sideslip should be monitored in real time and kept less than 5 degrees prior to stall (pre-brief CRM and knock it off calls).
1. Do stall testing in a buildup approach:
   a. from least risk to highest risk
      i. forward cg, mid cg, aft cg
      ii. Power off before power on
      iii. Wings level before turning
      iv. 1 kt/sec before 3 kt/sec
   b. terminate buildup if FAR limits on bank angle are exceeded at any point of the buildup
2. Establish minimum altitudes for:
   a. entry,
   b. recovery initiation,
   c. recovery chute deployment and
   d. manual bailout.
3. Perform pre-flight checks of stall warning and stick pusher, as applicable.
4. Anti-spin chute must be installed, functional and armed. Perform pre-flight and pre-maneuver checks of chute as applicable.
5. Minimum crew onboard.
6. Emergency Egress system must be installed and armed. Perform pre-flight and pre-maneuver checks of egress system as applicable.
7. Crew to wear helmets and parachutes.
8. Surface winds must be less than xx kts (parachute dependent).
9. No aggravated input stalls. All stalls will be ball centered.
10. No asymmetric power stalls.
11. If departing controlled flight retard throttles to idle and centralize controls.
12. Do not add power during recovery until airspeed is increasing above 1.2 Vs.

Factor(s):

Corrective Action(s):
In Conclusion

• Database status
  – Civil Part 25 THA’s “complete”
  – Civil Part 23/27/29/31 under construction
  – Military & research THA’s - TBD

• The matured THA database is NOT an auto-safety planning device
  – The matured hazards, causes and mitigations are necessarily generic
  – Your test will have unique problems and will require unique solutions

• Lessons learned should be shared
  – The THA database can be an excellent starting point
  – We don’t have enough time to learn every lesson firsthand

• Lessons learned should be shared