Textron Aviation Test Safety Risk Management

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Engineering and Defense Flight Test
The Broadest Product Lineup in the Industry

**JETS**
- Citation Longitude
- Citation CJ4 Gen2
- Citation Latitude
- Citation CJ3+
- Citation XLS Gen2
- Citation M2 Gen2

**TURBOPROPS**
- King Air 360/ER
- SkyCourier
- King Air 260
- Grand Caravan EX
- Denali*
- Caravan

**PISTONS**
- Baron G58
- Turbo Stationair HD
- Bonanza G36
- Skylane / Turbo Skylane
- Skyhawk

**DEFENSE**
- AT-6
- T-6
- Scorpion

*Aircraft in development*
FAA Order 4040.26

- Textron Aviation is an Organization Designation Authorization (ODA)


- Program documented in FT000-203 Rev G Engineering Flight Test Safety Program

- Applied to all Engineering and Defense Flight Test operations
Flight Test Safety Program

Prevention philosophy – created before SMS was cool!
Flightworthiness Process

- Covers technical, engineering design, manufacture and maintenance aspects of the test aircraft
- Flight test instrumentation is included
- Ensures that the test article is airworthy
- Usually only a first flight activity and culminates in a First Flight Readiness Review (FFRR)
- Four primary participants
  - Flightworthiness Authority: Senior Vice-President Engineering
  - Engineering Authority: Project Engineer
  - Aircraft Maintenance Authority: Experimental Engineering Manager
  - Flight Test Authority: Director, Engineering and Defense Flight Test
Operational Risk Management

- ORM in past only applied to non-test missions

- Test conditions are only one element of the risk encountered in an EDFT mission

- Broken down into five operational risk categories:
  - Mission
  - Aircraft
  - Crew
  - Environment
  - Other

- Each line item rated as Low, Moderate or High based on the description

- Line-item weight can be adjusted
ORM

• What do the scores mean?
• Primarily a briefing tool
  • Low risk avionics test turns into Moderate or high-risk event
• Integrated into our in-house mission planning software
• Secondary benefits
  • Safety metric
  • Predictive
Concepts

1. Accept no unnecessary risks. An “unnecessary risk” is any risk that, if taken, will not contribute meaningfully to the task.

2. Reduce risks to an acceptable level. Risk is a part of flight test, but by applying risk management principles, flight-testing can be accomplished in a safe and efficient manner.

3. Manage risks in the concept and planning stages of operations. Risk management is a deliberate team approach.

4. Make risk decisions at the appropriate level. The level of the management decision must be commensurate with the level of risk. The higher the risk, the higher the level of management supervision.

5. Focus on test-related risk. Flight test risk management should focus on the test-unique hazards that are more likely to occur due to the configuration being tested and the test technique(s) being performed.

6. Review all plans. All flight test plans shall be subjected to a safety review process to identify potential hazards.

7. Utilize all available resources. Review the results of previous tests for lessons learned. Consult colleagues within EDFT or other flight test organizations who may have conducted similar tests. Examine flight test organizations’ databases. SETP, the NASA Flight Test Safety Database and Flight Test Safety Committee websites are recommended as references.

8. Allow time for critical thinking. Risk Management should not be a last-minute activity. Use of past risk mitigation plans should not be blindly applied. The value of Risk Management is in the preparation by the team members prior to presenting the results for review and acceptance.
4. Make Risk Decisions at the Appropriate Level

- Various philosophies on management oversight and acceptance of risk
  - AETE
  - USAF
- First Flight Readiness Review has Senior leadership involvement
- Certification (military or civilian) drives test requirements
- New test program means leadership has accepted a certain level of risk
- Test requirements define “cookie cutter” risk that ranges from low to high
  - Envelope Expansion and Flutter
  - Initial Stalls

- Approval routing includes Chief Pilot and Lead FTE Manager for program
- CPSST approves the overall risk assessment, Director is briefed
- “Unusual risk” is highlighted to leadership
- Risk level drives other requirements in our SOPs
Flight Test Conditions

• Test plans are required for all ground and flight tests

• Two types
  • Test Plan – formal document
  • Engineering Flight Test Data Request (EFTDR) – web-based test plan

• Both have an electronic approval routing

• Recent challenges
  • Vendor provided test plans
  • SILs
Formal Test Planning Process
Normal Test Planning Process

Round 1: Collaboration
- SharePoint
- Occasional meetings

Round 2: Formal approval

Generally not required
Test Hazard Analysis Worksheets

<table>
<thead>
<tr>
<th>Test Plan</th>
<th>FTXXXXX.X (Title of Test Plan)</th>
<th>THA Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>Usually the title of the section from the test plan</td>
<td></td>
</tr>
<tr>
<td>Hazard</td>
<td>Unplanned or undesired event as a result of performing the test</td>
<td></td>
</tr>
<tr>
<td>Cause</td>
<td>Why the event occurred</td>
<td></td>
</tr>
<tr>
<td>Effect</td>
<td>The result of the event occurring (VERY subjective in nature)</td>
<td></td>
</tr>
</tbody>
</table>

**Minimizing Procedure**

1. Use this section to list the procedure(s), techniques, limitations that could prevent or mitigate the hazard identified above.
2. Generally list in order of occurrence (e.g. flight planning, flight brief, preflight, in-flight, etc.)
3. Use numbered steps with letters for sublevels.

**Emergency Procedure**

1. Use this section to address the procedures to be following in the event the hazard occurs.
2. Do not duplicate any AFM procedures.
3. Procedures listed should cover the hazards unique to the aircraft, from and return to land.
4. If a controllability check (per in-flight guide) is specified, the configuration and landing procedures are contained therein and do not need to be repeated in this section.
5. Use numbered steps with letters for sublevels.

**WX**

WX related limitations for the test that can prevent or minimize the effect of the hazard identified above.

<table>
<thead>
<tr>
<th>Aircraft Damage Risk Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catastrophic: Damaged beyond repair</td>
</tr>
<tr>
<td>Minor Damage: Greater than 2 weeks to repair</td>
</tr>
<tr>
<td>Minor Damage: 2 weeks to less than repair</td>
</tr>
<tr>
<td>Negligible Damage: Repairable within 3 days</td>
</tr>
<tr>
<td>No Safety Effect: Damage not likely</td>
</tr>
</tbody>
</table>

**Personal Injury Risk Assessment**

| Hazardous: Full recovery not guaranteed; hospital + 1 day | Low | Medium | High | Extreme/Avoid | Extreme/Avoid |
| Major Injury: Impacts work capability; hospital + 1 day | Low | Low | Medium | High | High |
| Minor injury: Injury not impact work capability | Low | Low | Low | Medium | Medium |
| No Safety Effect: Injury not likely | Low | Low | Low | Low | Low |

<table>
<thead>
<tr>
<th>Severity</th>
<th>Probable</th>
<th>Improbable</th>
<th>Remote</th>
<th>Occasional</th>
<th>Probable</th>
<th>Frequent</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Overall Risk</th>
<th>Aircraft Chutes</th>
<th>Min Crew</th>
<th>TM</th>
<th>Personal Chutes</th>
<th>Helms</th>
<th>Escape Hatch</th>
<th>GESE</th>
<th>Chase</th>
</tr>
</thead>
</table>

Number in sequence. Use “i” and “p” as defined on preceding page if applicable.

Specify risk assessment using bold, black underline font. Ensure severity selected matches the “effet” above.

Probability between aircraft damage and personal injury is always the same.
THAs

• Only do post minimizing risk assessment
  • Contrary to FAA Order 4040.26C

• Pre can determine if the impact or cost of the minimizing procedures is worth it
  • At TxtAv, minimizing procedures are always required

• Pre provides insight into the flight test risk if the minimizing procedures fail to work
  • Most test conditions have a standard level of risk
  • Standard risk is already accepted as part of the development and certification process
  • If there is concern over the effectiveness of the minimizing procedures, option to convene an SRB “Unusual risk”
• "Manage risk in the concept or planning stage"
• Standard safety equipment listed at bottom

• GESE varies by program
  • Arctic Fire / Cold Fire
  • Smoke Hoods
  • Escape Saw
  • PRT
  • Cut here markings

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</tr>
</thead>
<tbody>
<tr>
<td>Severity</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Probable</td>
<td>Remote</td>
<td>Dimensional</td>
<td>Probable</td>
<td>Frequent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

THA Summary Table
Identifying the Hazards – biggest challenge

- Test plans from previous programs
- Team members and other EDFT experts
- Engineering
- CPSST
- External sources
  - SETP / FTSW / NASA
- Standard THA Library
Standard THA Library

- Current library has 175 standard THAs

- Numerous Sub libraries
  - Single Engine vs. Multi Engine
  - Jet vs. Prop
  - First Flight Specific
  - Defense specific

- Started about 6 years ago

- Combined best of THAs from multiple programs from over 20 years of history

- Written assuming brand new aircraft design
  - Easier to remove vs. Add

- THA Review Committee
Standard THAs

- Every program is unique
- **Starting point** for hazard mitigation
- Covers the known hazards
- Frees time to focus on identifying other hazards
- Need to be tailored for the program and the test
- Lot of recent growth with increase in METP and SETP programs
Standard THAs – Alternate Hazard Mitigation

Standard Margin
- Runway for performance testing must have at least 50% more length available than required considering predicted/known aircraft performance.
- If more than one runway is available that meets these requirements, use the longest suitable runway.

Alternate mitigation plan
- Build-up from light weight to heavy weights. Consider temperature impacts on build-up if weight is increased during the day with lighter weights in the morning.
- Build-up in flap setting from shortest predicted distances to longest.
- Re-evaluate rolling mu, braking mu, and predicted distances against test data prior to conducting heavier weight testing.
- Stop testing and re-evaluate performance model if actual distance is greater than 200 ft of predicted distance.
- Runway length must be at least 500’ greater than predicted requirement.

<table>
<thead>
<tr>
<th>Test Plan</th>
<th>Doc Num (Doc Title)</th>
<th>THA Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>Runway Performance (Accelerate-Stop, Takeoff, Landing)</td>
<td></td>
</tr>
<tr>
<td>Hazard</td>
<td>Departing end of runway.</td>
<td></td>
</tr>
<tr>
<td>Cause</td>
<td>Improper pilot technique, system failure or unexpected aircraft response.</td>
<td></td>
</tr>
<tr>
<td>Effect</td>
<td>Aircraft damage and crew injury.</td>
<td></td>
</tr>
</tbody>
</table>

1. Predicted and/or development aircraft performance data should be reviewed before flight.
Capturing the Lessons Learned – Standard THA Library

• Challenge to document the mistakes of the past

• THA worksheets are living documents to incorporate lessons learned

• New hazards or better ways to mitigate known hazards

• Recent examples
  • Real time incorporation during external presentations – Vm cg and Nosewheel Shimmy Board
  • Real vs simulated WAT limited takeoff
  • Fuel starvation during sustained +5 deg sideslip during flight matching
Single Engine WAT Limited Takeoff

<table>
<thead>
<tr>
<th>Test</th>
<th>Single Engine WAT Limited Takeoff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard</td>
<td>Inability to climb or accelerate leading to impact with ground</td>
</tr>
<tr>
<td>Cause</td>
<td>Inaccurate predicted aircraft performance.</td>
</tr>
<tr>
<td>Effect</td>
<td>Loss of aircraft and crew.</td>
</tr>
</tbody>
</table>

1. Minimum runway width will be 150' with no obstacles within 400' from runway centerline.
2. Runway for performance testing must have at least 50% more length available than required considering predicted/known aircraft performance. If more than one runway is available that meets these requirements, use the longest suitable runway.
3. Review runway departure corridor and ensure fly-away zone is clear of obstacles.
4. Stall speeds must be provided for all applicable weights and configurations and briefed prior to each run. In-ground effect (IGE) impact on stall speeds should be considered.
5. Predicted aircraft performance data, specifically WAT limitations, shall be reviewed before flight and confirmed before each takeoff.
6. **Review Auto Feather Logic and potential impact from reduced power takeoffs.**
7. After each weight band is completed, compare predicted targets with actual results. Update heavier weight predicted targets with flight test data to ensure the heaviest end point condition remains feasible.
8. Test will not be conducted at the WAT limit, but slightly below to give some margin.
9. Buildup as follows:
   a. Complete more conservative flap setting first, if applicable.
   b. Lower weight to higher weight.
   c. Simulate single engine WAT limited takeoffs with reduced symmetric power before progressing to single engine takeoffs.
   d. **Simulated engine cut prior to actual engine cut.**
10. Airport personnel will be notified before conducting these tests. It is expected that firefighting equipment will be stationed at the runway.
Fuel Starvation During Sustained +5 Deg Sideslip During Flight Matching

<table>
<thead>
<tr>
<th>Test</th>
<th>Large (&gt; 1 ball) Sustained Sideslip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard</td>
<td>Fuel Starvation</td>
</tr>
<tr>
<td>Cause</td>
<td>Sustained Large Sideslip (&gt; 1 ball) empties hopper tank</td>
</tr>
<tr>
<td>Effect</td>
<td>Loss of thrust to one engine</td>
</tr>
</tbody>
</table>

**Minimizing Procedure**

1. Review unusable fuel test data for sideslips, if available.
2. Brief AFM / LSI Limitations for unusable fuel and/or sideslips.
3. **Brief the impacts of auto fuel-balance during sustained sideslips with fuel migration.**
4. Engine restart procedures shall be briefed prior to flight.
5. Brief instrumentation parameters and potential engine indications and/or CAS messages that might occur if abnormal engine operation occurs. If these occur, immediately cease test and remove the sideslip.
6. When possible, conduct testing above 3,000 ft AGL.
7. Monitor hopper tank quantity, if available, via instrumentation or aircraft systems.
8. Consider (per test procedure requirements) either
   a. Reversing direction of sideslip between conditions.
   b. Allow time between test maneuvers with zero sideslip to allow the hopper tank to refill.

**Emergency Procedure**

1. Return to straight and level flight.
2. Follow AFM procedures as appropriate.
3. If able, considering engine start limitations, attempt restart when within engine start envelope and the hopper has refilled.
4. If engine will not restart, secure per AFM procedures, and return to airport for single engine approach and landing.
Standard THAs – Common Issues and Pitfalls

Test plan author doesn’t tailor the THA for the program or test

If I ever see another TR on a prop aircraft!

We have standard THAs – all hazards are covered!

Isn’t the last program’s THA close enough? Or even an earlier test plan on this program?

How do I know which standard THAs apply to which tests?

Biggest challenge – corporate knowledge

Working on linking test to THA, at least for cert
Final Words

Standard THAs capture our lessons learned

It is our best practice for ensuring we don’t make the same mistakes again
Questions?