Cessna | Beechcraft

BY TEXTRON AVIATION

Textron Aviation Test Safety Risk Management

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Engineering and Defense Flight Test

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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

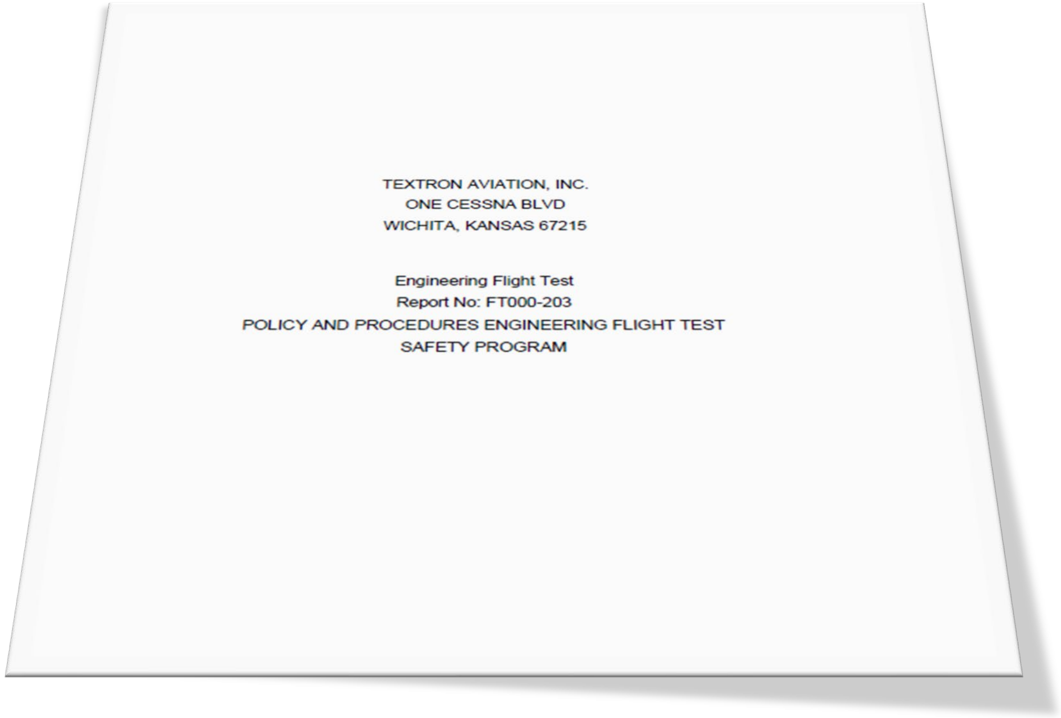

T-6


Scorpion

* Aircraft in development

FAA Order 4040.26

- Textron Aviation is an Organization Designation Authorization (ODA)
- Required to comply with FAA Order 4040.26, “Aircraft Certification Service Flight Test Risk Management Program”
- Program documented in FT000-203 Rev G Engineering Flight Test Safety Program
- Applied to all Engineering and Defense Flight Test operations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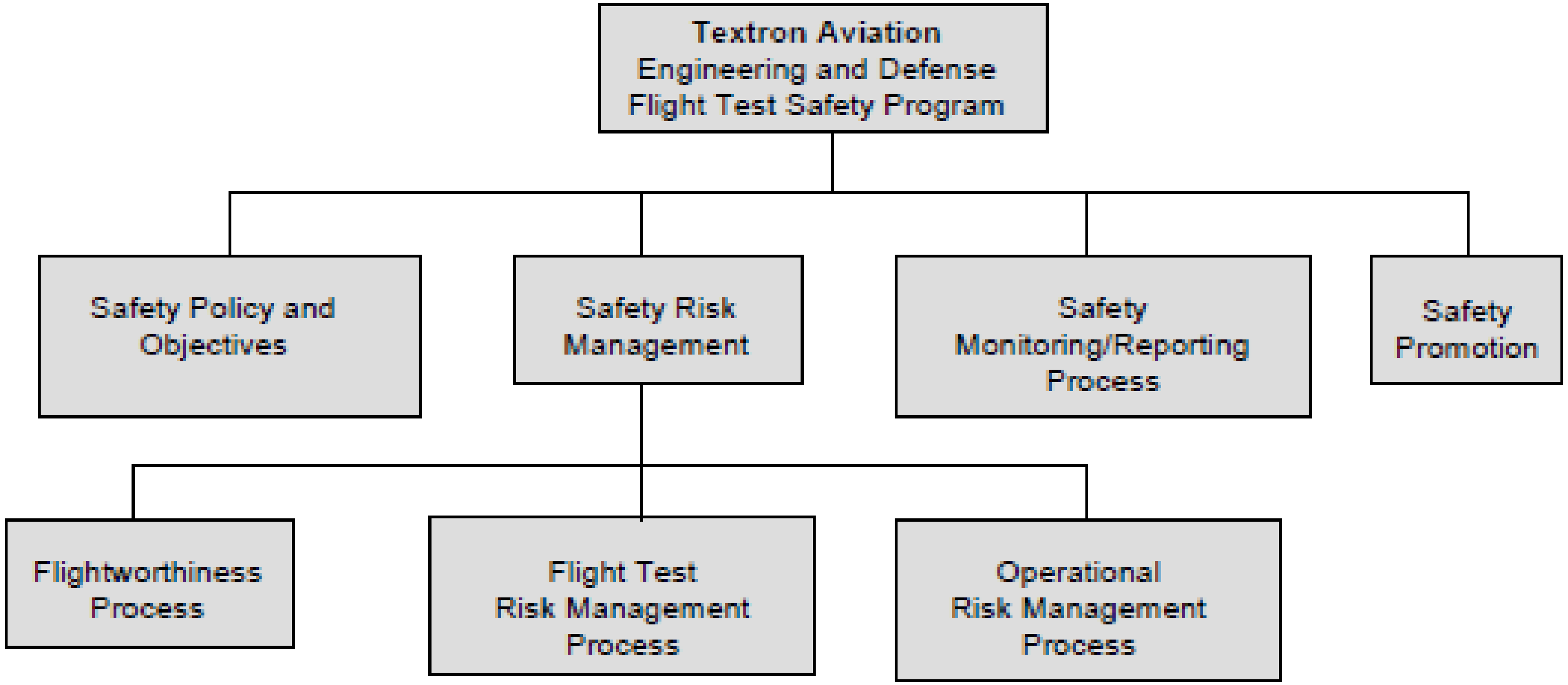
Engineering Flight Test
Report No: FT000-203
POLICY AND PROCEDURES ENGINEERING FLIGHT TEST
SAFETY PROGRAM

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

	ITEM	LOW	SCORE	MODERATE	SCORE	HIGH	SCORE	SCO
MISSION	Planned Risk	Transport, Training, Low Risk Test	0	Demo, Med Risk Test	3	High Risk Test	6	0
	Flight Location	Local incl Roswell	0	Offsite, but simple or known location (Continental US)	2	Offsite / International	5	0
	Mission Plan Changes (incl. Redlines)	Minor	0	Several	2	Significant	5	0
	Mission Complexity (number of conditions/tasks, variations in flight test techniques, complexity of maneuvers)	Simple profile and/or tasks	0	Complicated (Multiple condition types/tasks and flight test techniques)	2	Challenging (Extensive condition types/tasks, coordination, and flight test techniques)	5	0
	Formation	None	0	1 additional aircraft	2	>1 additional aircraft	5	0
	Planned Weapons Delivery	Not applicable	0	Simulated Employment	2	Actual Employment	5	0
	Mission Delays	None	0	< 4 hours	2	> 4 hours	5	0
							MISSION Total	0

ORM

Risk Category	LOW 0 - 25		MODERATE 26-35		HIGH 35+

Unplanned Moderate or High:	Consider additional mitigations, shorter flight, remove test points
Unplanned High:	Discuss with Chief Pilot

- 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

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Flight Test Risk Management

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

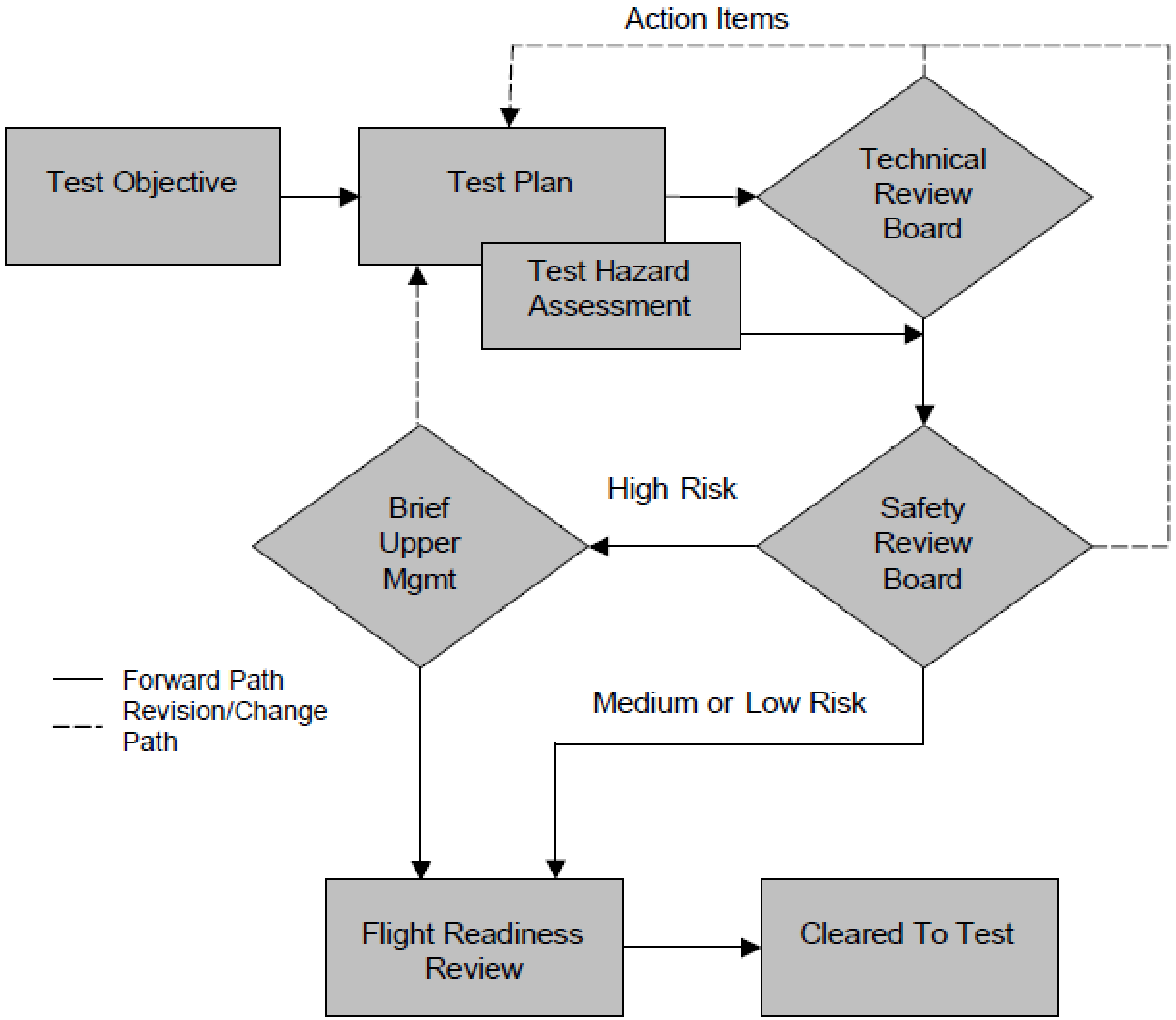
- Test plans are required for **<u>all</u>** ground and flight tests

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

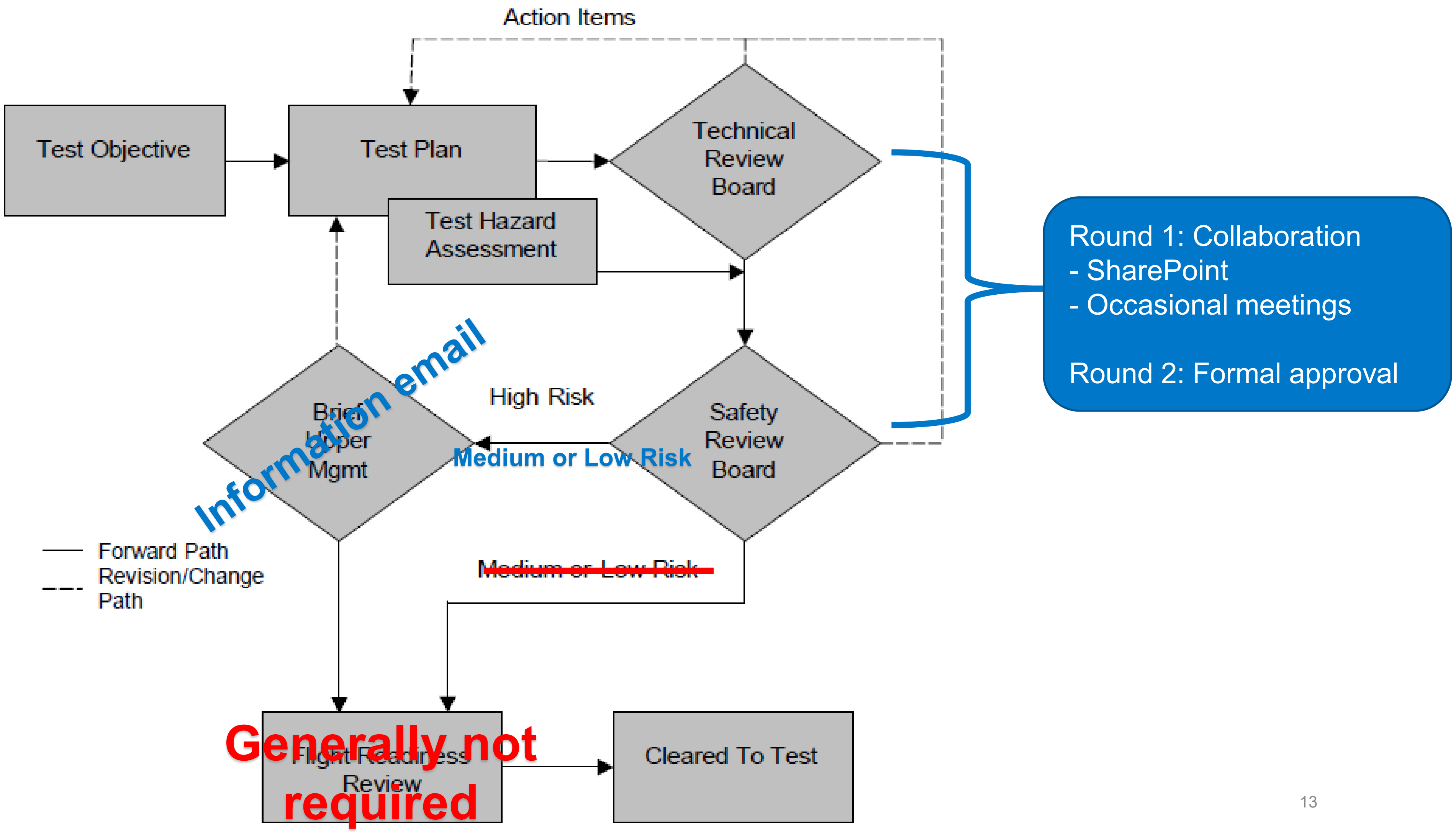
- Both have an electronic approval routing

- Recent challenges
  - Vendor provided test plans
  - SILs

Formal Test Planning Process



Normal Test Planning Process



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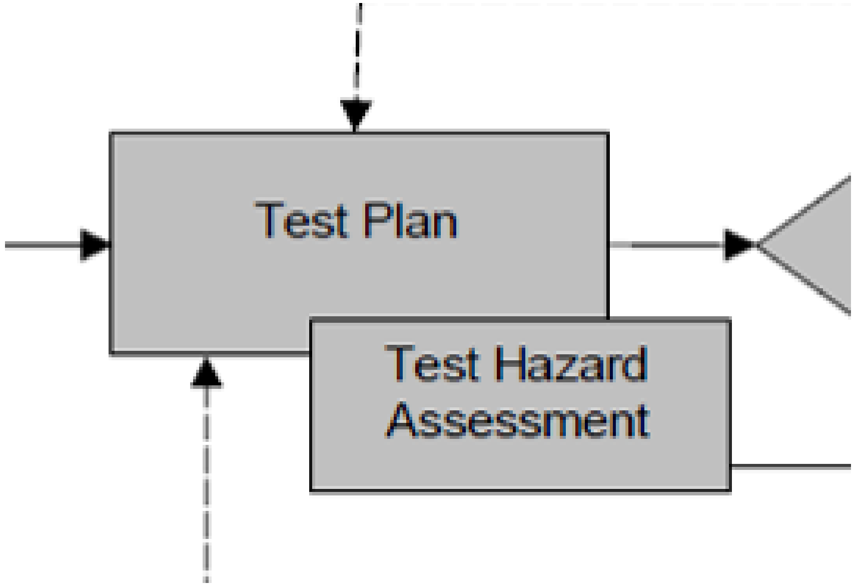
Test Hazard Analysis Worksheets



Test Plan	FTXXX-XX-X (Title of Test Plan)	THA Number	
Test	Usually the title of the section from the test plan		
Hazard	Unplanned or undesired event as a result of performing the test		
Cause	Why the event occurred		
Effect	The result of the event occurring (VERY subjective in nature)		
Minimizing Procedure	1. Use this section to list the procedure(s), techniques, limitations that could prevent or m of the hazard identified above. 2. Generally list in order of occurrent (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 hazard unique items to safely recover from the event and return to land. 4. If a controllability check (per in-flight guide) is specified, the configuration and landing procedures are contained therin 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.		

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 "effect" above.

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

Aircraft Damage Risk Assessment

Catastrophic: Damaged beyond repair	Low	Medium	High	High	Extreme/Avoid
Major Damage: Greater than 2 weeks to repair	Low	Low	Medium	High	High
Minor Damage: 2 weeks or less to repair	Low	Low	Medium	Medium	Medium
Negligible Damage: Repairable within 3 days	Low	Low	Low	Low	Low
No Safety Effect: Damage not likely	Low	Low	Low	Low	Low
Severity / Probability	Improbable	Remote	Occasional	Probable	Frequent

Personal Injury Risk Assessment

Catastrophic: Loss of life.	Low	Medium	High	Extreme/Avoid	Extreme/Avoid
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 does not impact work capability	Low	Low	Low	Medium	Medium
No Safety Effect: Injury not likely	Low	Low	Low	Low	Low
Severity / Probability	Improbable	Remote	Occasional	Probable	Frequent

Overall Risk	Aircraft Chutes	Min Crew	TM	Personal Chutes	Helmets	Escape Hatch	GESE	Chase

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"

THA Summary Table

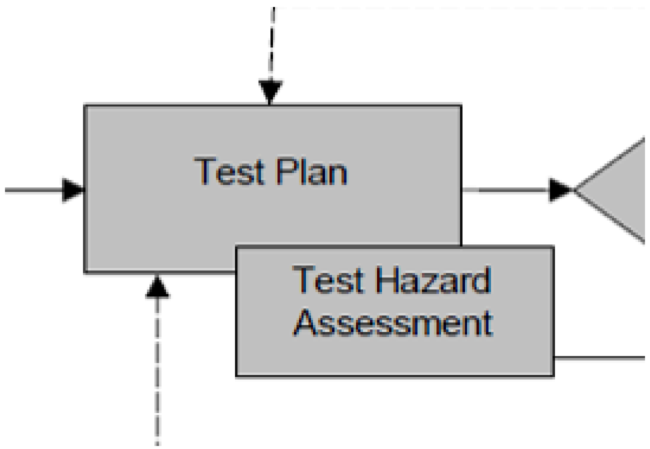
No Safety Effect: Injury not likely	Low	Low	Low	Low	Low
Severity Probability	Improbable	Remote	Occasional	Probable	Frequent

Overall Risk	Aircraft Chutes	Min Crew	TM	Personal Chutes	Helmets	Escape Hatch	GESE	Chase

- "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

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

Abnormal Rotation During Takeoff.docx	2/24/2022 11:05 AM
Aircraft Recovery Chutes Ground Test.docx	4/17/2017 8:39 AM
Airplane Pilot Coupling.docx	9/1/2016 2:54 PM
Alternator or Generator Cooling.docx	1/31/2022 1:57 PM
Anti-Ice Dry Air Testing.docx	9/1/2016 2:54 PM
AP Trim System and Monitor Testing.docx	9/28/2020 1:45 PM
Asymmetric Thrust.docx	4/29/2021 3:33 PM
AT Initial Testing.docx	5/17/2022 9:10 AM
AT Retard without Landing.docx	8/3/2021 9:40 AM
Avionics First Flights.docx	11/16/2020 10:31 AM
Baggage Smoke Detection.docx	9/1/2016 2:56 PM
Bird Strike.docx	3/1/2022 9:22 AM
Captive Carriage.docx	9/25/2017 1:02 PM
Cockpit Defog.docx	8/25/2016 10:58 AM
Cold Wx Ops (Cold Wx Testing).docx	9/13/2022 11:02 AM
Cold Wx Ops (Indoor Engine Runs).docx	9/13/2022 11:02 AM
Contaminated Fuel (Icing).docx	9/17/2018 11:44 AM
Dynamic Engine Cuts (VMCG).docx	2/5/2020 10:49 AM
Dynamic Engine Cuts.docx	11/13/2019 3:00 PM
Emergency Descent Mode.docx	9/1/2016 3:18 PM
Emergency Descent.docx	8/25/2016 11:11 AM
Envelope Expansion.docx	6/1/2020 8:49 AM
Excessive Tail Loads.docx	3/31/2022 4:58 PM
Flammable Fluid Drainage (Glycol Ingestion).docx	1/6/2022 2:26 PM
Flammable Fluid Drainage.docx	9/1/2016 3:19 PM
Flight Loads Expansion.docx	9/25/2017 1:02 PM
Flight Near Severe Weather.docx	3/1/2022 9:30 AM
Formation Flight.docx	3/21/2022 1:57 PM
FTXXX-2 Safety Section.docx	7/18/2013 9:05 AM
Generator Cooling (Heat Stroke).docx	12/3/2021 11:04 AM
GIA Guidance or FD Failure.docx	8/24/2022 4:46 PM

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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

Test Plan	Doc Num (Doc Title)	THA Number	
Test	Runway Performance (Accelerate-Stop, Takeoff, Landing)		
Hazard	Departing end of runway.		
Cause	Improper pilot technique, system failure or unexpected aircraft response.		
Effect	Aircraft damage and crew injury.		
	1. Predicted and/or development aircraft performance data should be reviewed before flight.		

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.

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 – Vmcg 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

Test	Single Engine WAT Limited Takeoff
Hazard	Inability to climb or accelerate leading to impact with ground
Cause	Inaccurate predicted aircraft performance.
Effect	Loss of aircraft and crew.

Minimizing Procedure	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

Test	Large (> 1 ball) Sustained Sideslip
Hazard	Fuel Starvation
Cause	Sustained Large Sideslip (> 1 ball) empties hopper tank
Effect	Loss of thrust to one engine
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?