



**TEXTRON** AIRLAND

# Flight Test Risk Reduction and Lessons Learned from the “Scorpion” Aircraft Development Program

**Dave Sitz**  
**Flight Test Engineer/Pilot**  
**Textron Aviation**

**SETP Flight Test Safety Workshop**  
**May 2015**

**Company Confidential and Competition Sensitive**

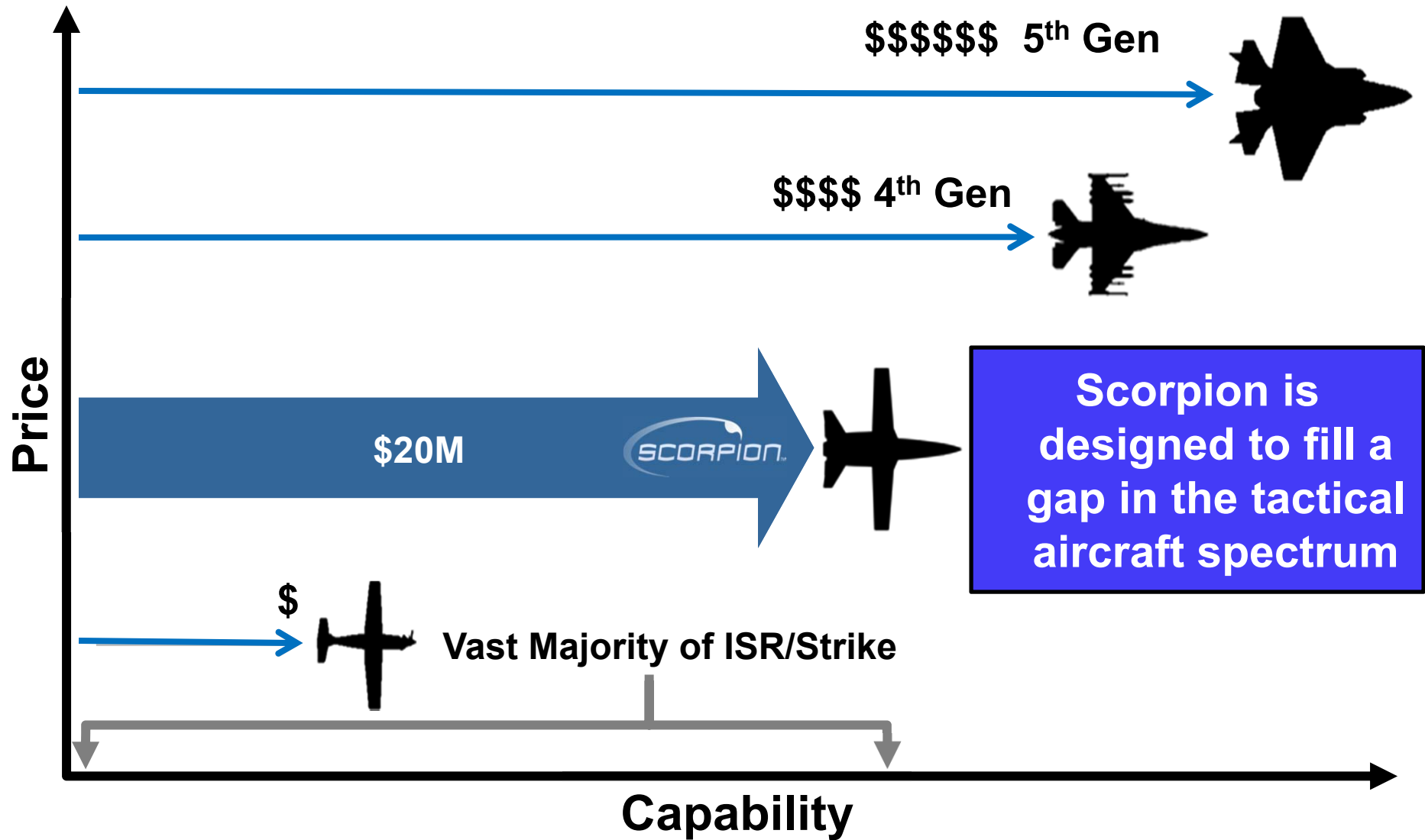
**SCORPION**

## Overview

---

- What is the Scorpion Program?
- Aircraft Description
- Risk Reduction/Lessons Learned from 3 Scenarios:
  - Preparation for First Flight
    - Spin Chute Taxi Test
  - Initial Landing Gear Operations
- Conclusion
  - Condense our experiences into one unified safety approach or theme

# The Scorpion Program



# Aircraft Description

**DIMENSIONS**  
Wingspan: **47.3** Feet  
Length: **43.5** Feet

**AIRFRAME**  
Composite Structure and Skin

**ELECTRONIC SYSTEMS**  
Modular Architecture

**EXTERNAL STORES**  
Scalable, Precision Munitions

**RADAR**  
Weather, Growth Space

**ENGINES**  
2 x Turbofans

**SENSOR**  
EO/IR Ball, Laser Designator

**PAYLOAD BAY**  
Sensors and Comms

Standard Empty Weight	<b>11,800</b>	lbs
Max Takeoff Weight	<b>21,250</b>	lbs
Max Internal Fuel Load	<b>6,000</b>	lbs
Max Internal Payload	<b>3,000</b>	lbs
Max External Stores	<b>6,100</b>	lbs
Thrust	<b>&gt;8,000</b>	lbs
Maximum Speed	<b>450</b>	KTAS
Service Ceiling	<b>45,000</b>	ft
Ferry Range	<b>2,400</b>	NM

\* Design Targets

# Aircraft Description

**Insert EXTRA  
LARGE Flight Test  
Instrumentation  
Package HERE**



<b>Communications</b>	SAT, Network, UHF, VHF, HF	Hotspot, Air-Ground, Air-Air, Air-First Responders
<b>Sensors</b>	EO/IR Ball	Passive
<b>Fuel</b>	3,000 lbs	Auxiliary

# Aircraft Description

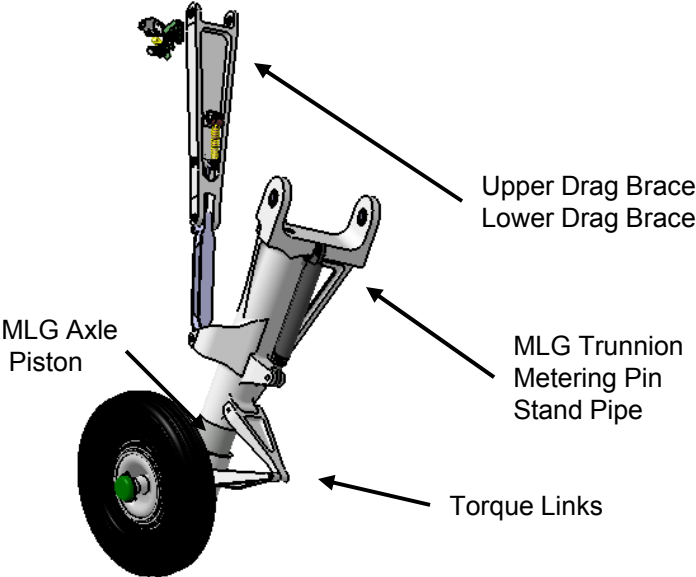
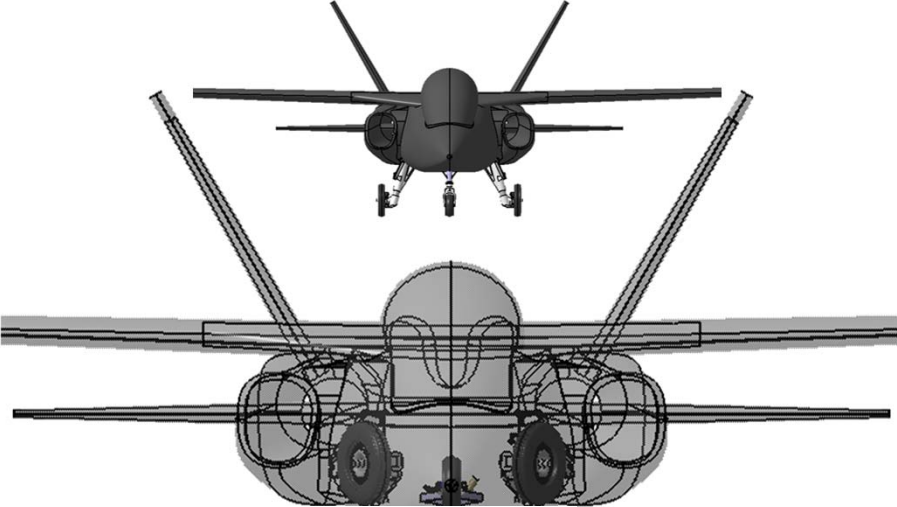
- Aircraft Design

- Maximum Use of Existing Systems
  - Engines
  - Avionics
  - Ejection Seats
  - Sub-Systems: Hydraulics, Electrical, Fuel, OBOGS, ECS, Flight Controls
  
- New Composite Airframe
  - New Main Landing Gear Struts
  - Engine Inlet



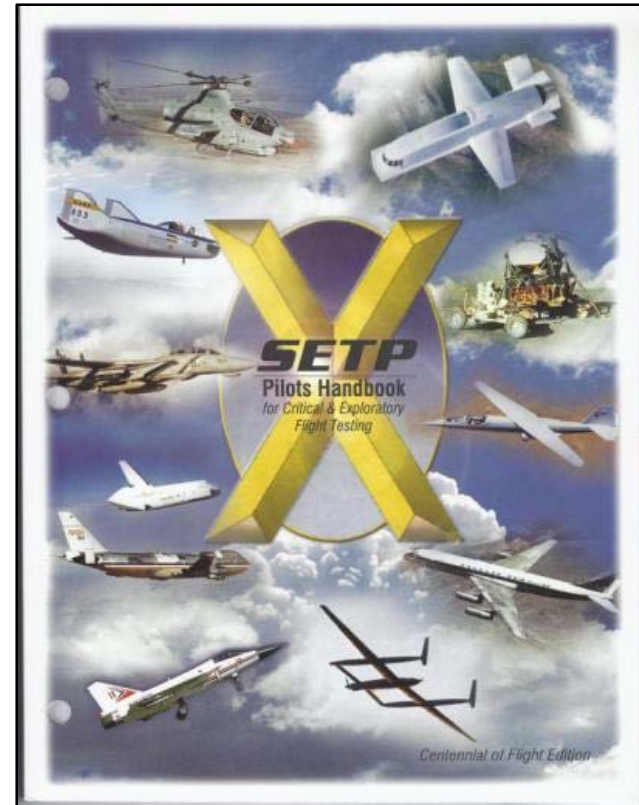
**Airframe structure, and the main landing gear struts, are the only completely original parts**

# Aircraft Description



## Risk Reduction/Lessons Learned

- Preparation for First Flight – At a “Macro” Level
  - “Where Do You Even Start?”
  - Cessna Engineering Flight Test Processes and Procedures
    - Quality/Configuration Control
    - Test Planning
    - Independent Safety Reviews
    - Flight Readiness Reviews
    - Special Inspection (Pre-First Flight)
  - SETP Pilots Handbook



**Resources, processes, and procedures existed to guide macro-level planning**



## Risk Reduction/Lessons Learned

- Preparation for First Flight – At a “Micro” Level
  - Aircrew involved in design process for over 1½ years before first flight
  - Where are the “booby traps” due to unique configurations/interactions?
  - The 4 Forces of Flight (what’s really important?):



**Flight Test had the time to identify and mitigate potential aircraft-unique “booby traps”**

## Event 1 - Preparation for First Flight

---

- First Engine Run – September 2013



## Event 1 - Preparation for First Flight

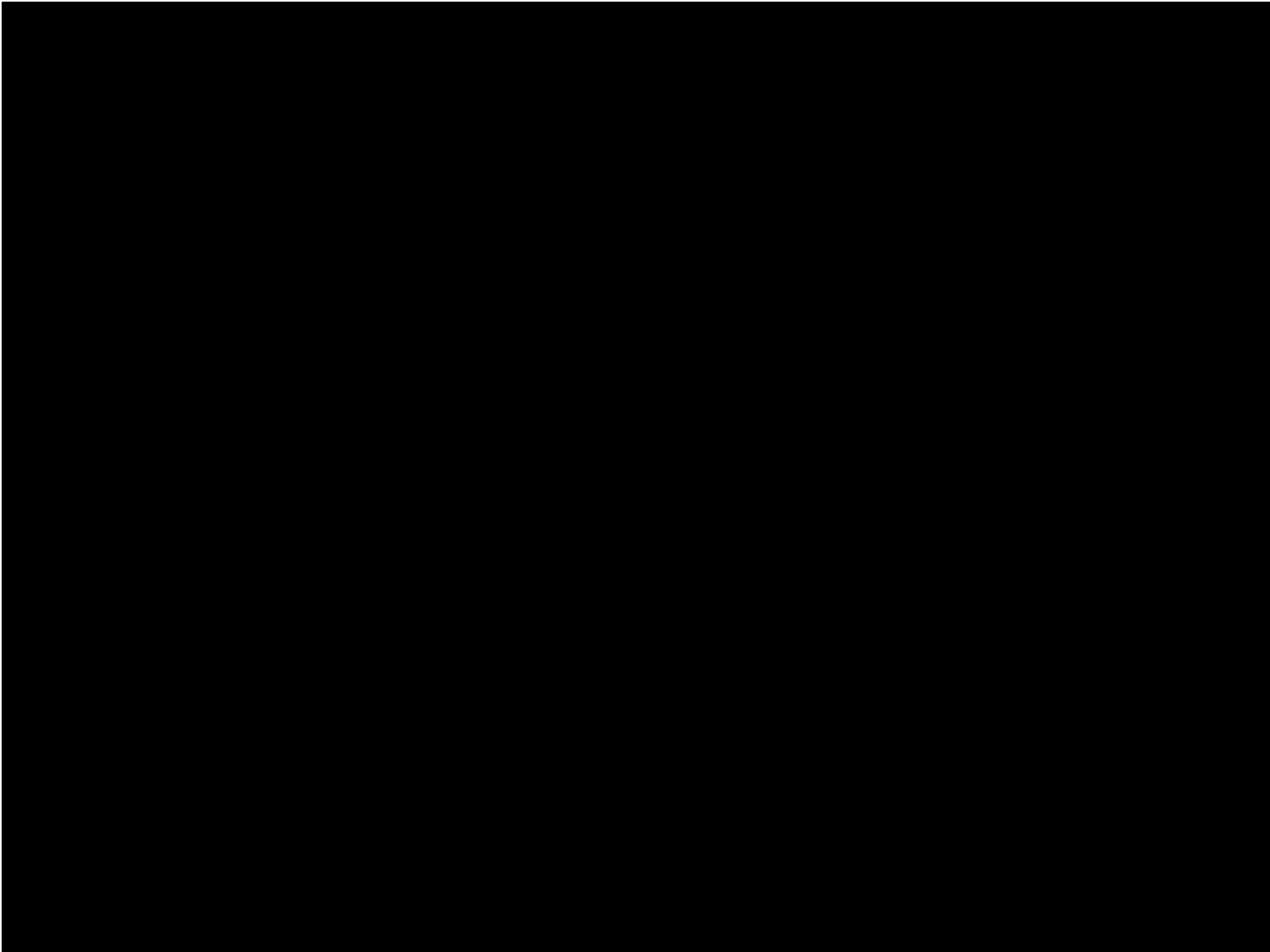
---

- Inlet: Aerodynamics and Airframe Location (behind Gear Doors)



# Event 1 - Preparation for First Flight

---



## Event 1 - Preparation for First Flight

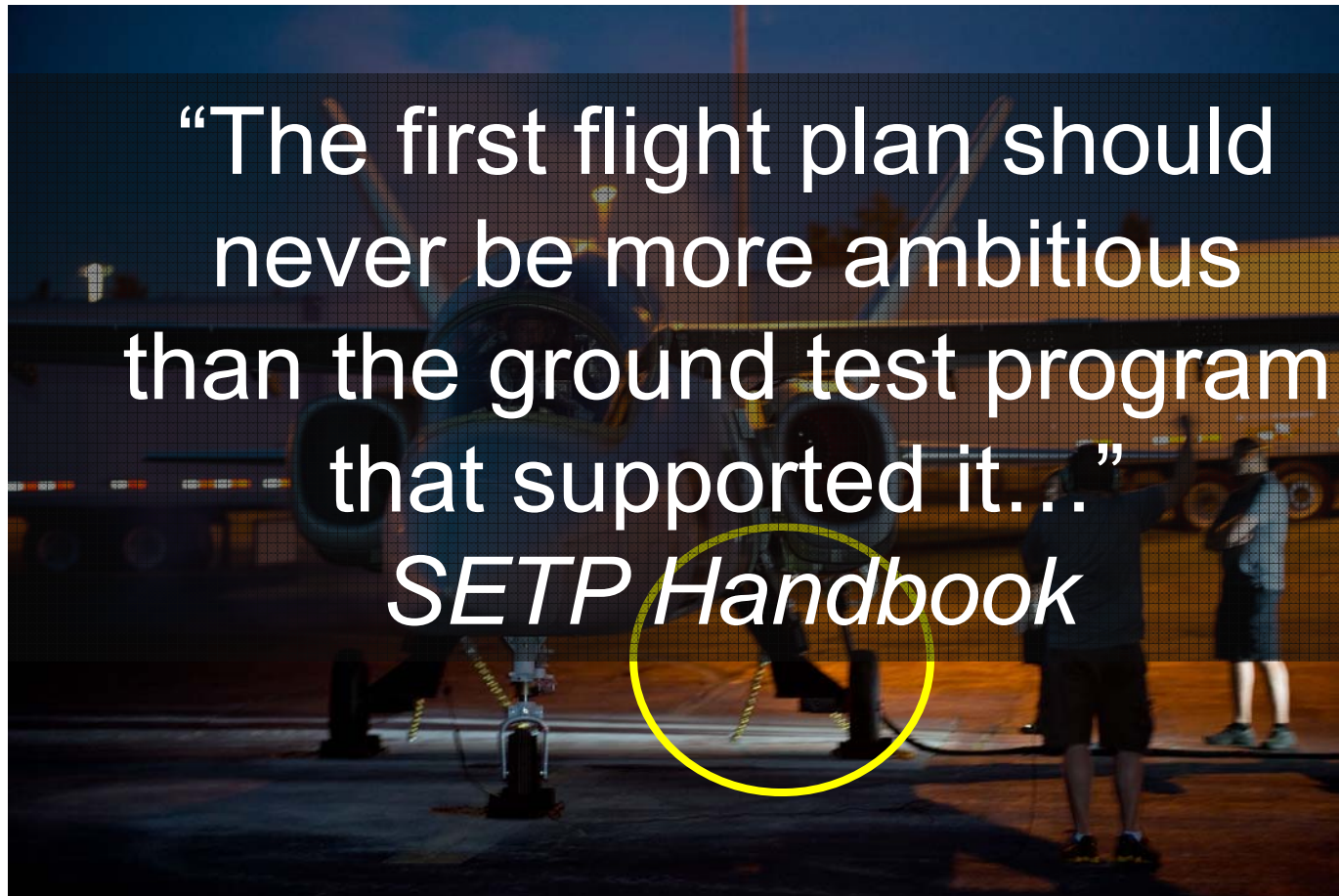
---

- Inlet Risk Reduction
  - “What Can You Do to Reduce Risk?”
  - Pre-Flight Taxi: Test “Worst-Case” Gear Door Configuration



## Event 1 - Preparation for First Flight

- Landing Gear Availability
  - “What Can You Do to Reduce Risk?”



## Event 1 - Preparation for First Flight

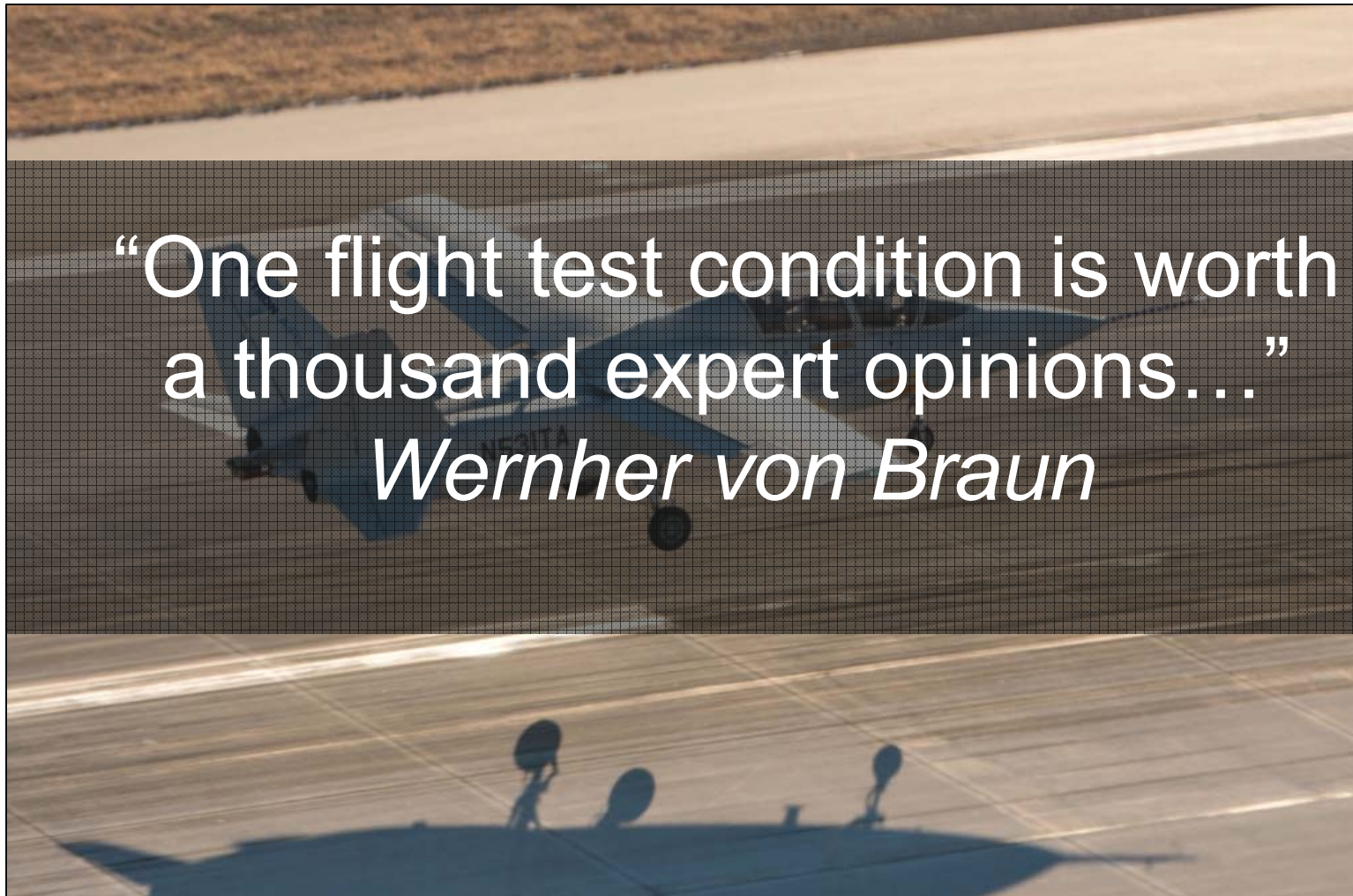


“The primary purpose of a First Flight  
is to make a successful landing...”  
*SETP Handbook*

## Event 1 - Preparation for First Flight

---

- December 12, 2013





## Event 1 - Preparation for First Flight

- Acknowledging the Team's Efforts



“Share the pilot’s exhilaration of a First Flight with the ground team. It is probably the only good thing that has happened to them in the last 6 months...” *SETP Handbook*

## Event 2 - Spin Chute Taxi Test

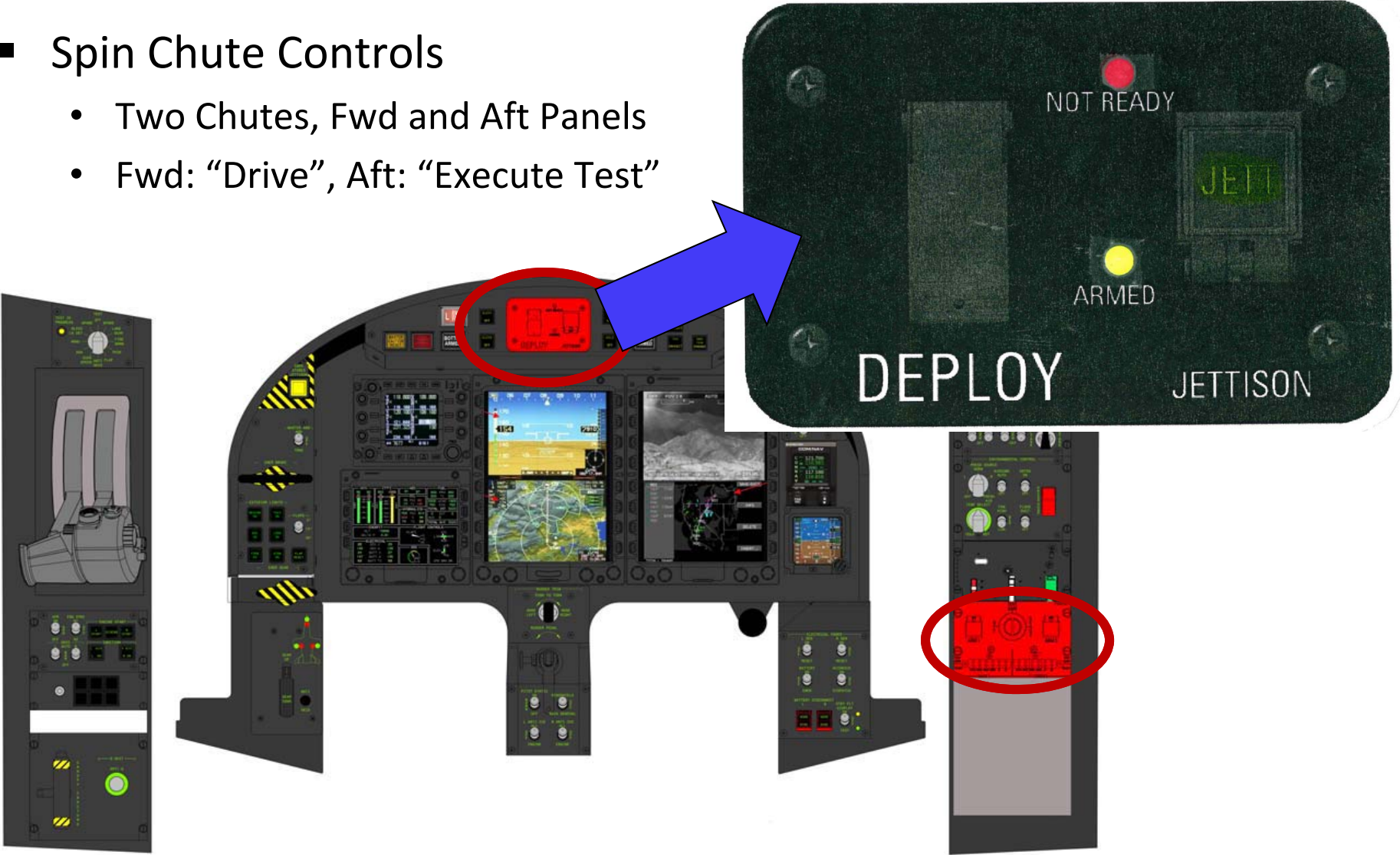
---

- Pre-Flight Taxi Testing
  - Brakes/Steering
  - Low/Moderate Speed Taxi Testing
  - Elevator Control Power Evaluation (Aerodynamics: Rotation and Flare)
  - Spin Chute Operational Test (Deploy/Jettison)
  - Last-Minute Aircraft Squawk
  - “Were We Ready?”



# Event 2 - Spin Chute Taxi Test

- Spin Chute Controls
  - Two Chutes, Fwd and Aft Panels
  - Fwd: "Drive", Aft: "Execute Test"



## Event 2 - Spin Chute Taxi Test

---

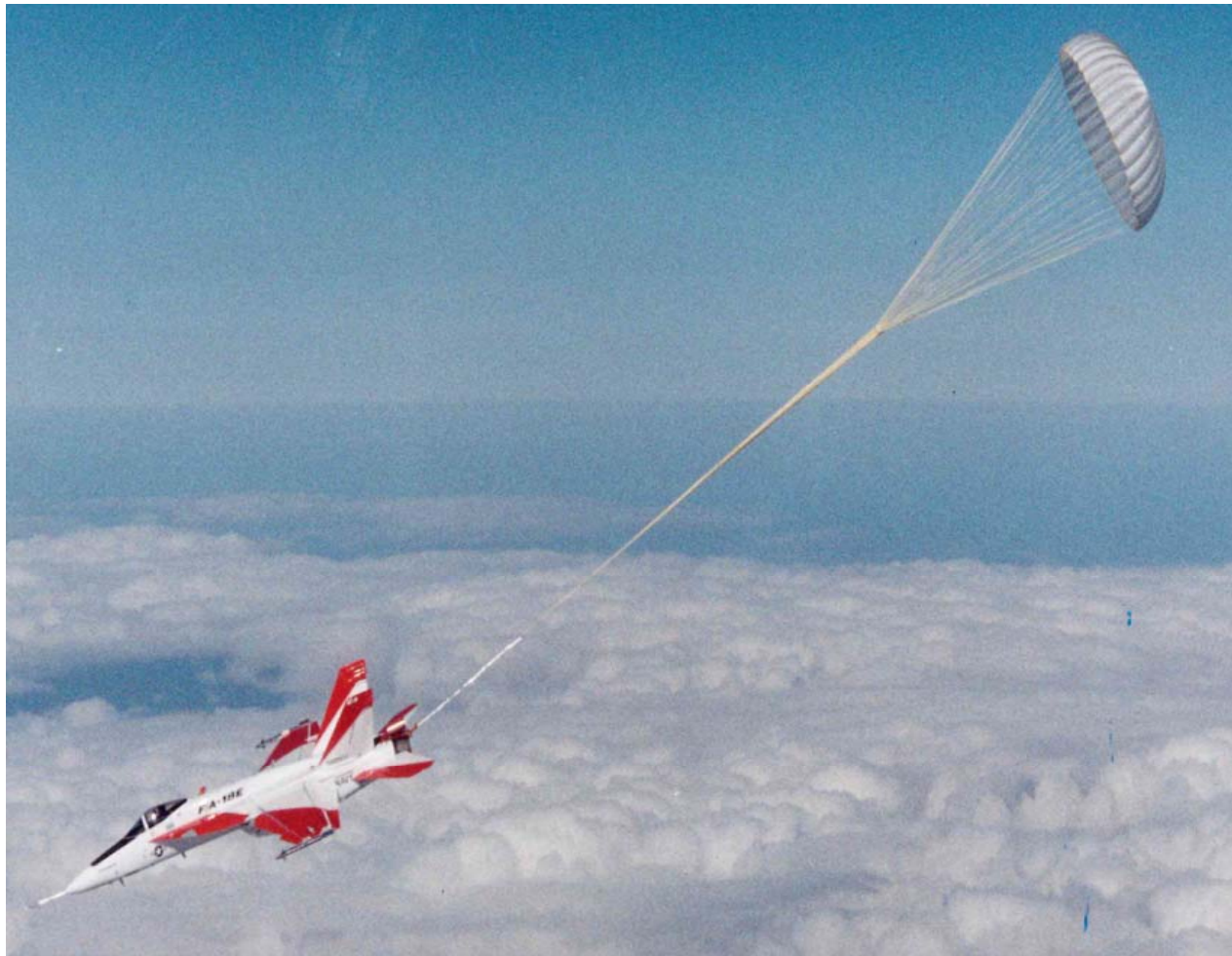
- Crew Resource Management in Action



## Event 2 - Spin Chute Taxi Test

---

- Was my “experience” working against me?



## Event 2 - Spin Chute Taxi Test

---

What I expected:

**“Deploy Confirmed” –or-  
“No Chute, No Chute”**

**Mortar Fire Noise**

**Kinesthetic (Seat of Pants)**

**Visual**

**Control Panel**

## Event 2 - Spin Chute Taxi Test

---

What I expected:

**“Deploy Confirmed” –or-  
“No Chute, No Chute”**



**Nothing (Com blocked)**

**Mortar Fire Noise**



**Nothing (Com blocked)**

**Kinesthetic (Seat of Pants)**



**Nothing**

**Visual**



**Nothing**

**Control Panel**



**No Change**

**My Conclusion: Failed Chute Deployment**

## Event 2 - Spin Chute Taxi Test

---

What I expected:

**“Deploy Confirmed” –or-  
“No Chute, No Chute”**



**Nothing (Com blocked)**

**Mortar Fire Noise**



**Heard Mortar Fire**

**Kinesthetic (Seat of Pants)**



**Nothing**

**Visual**



**Nothing**

**Control Panel**



**No Change**

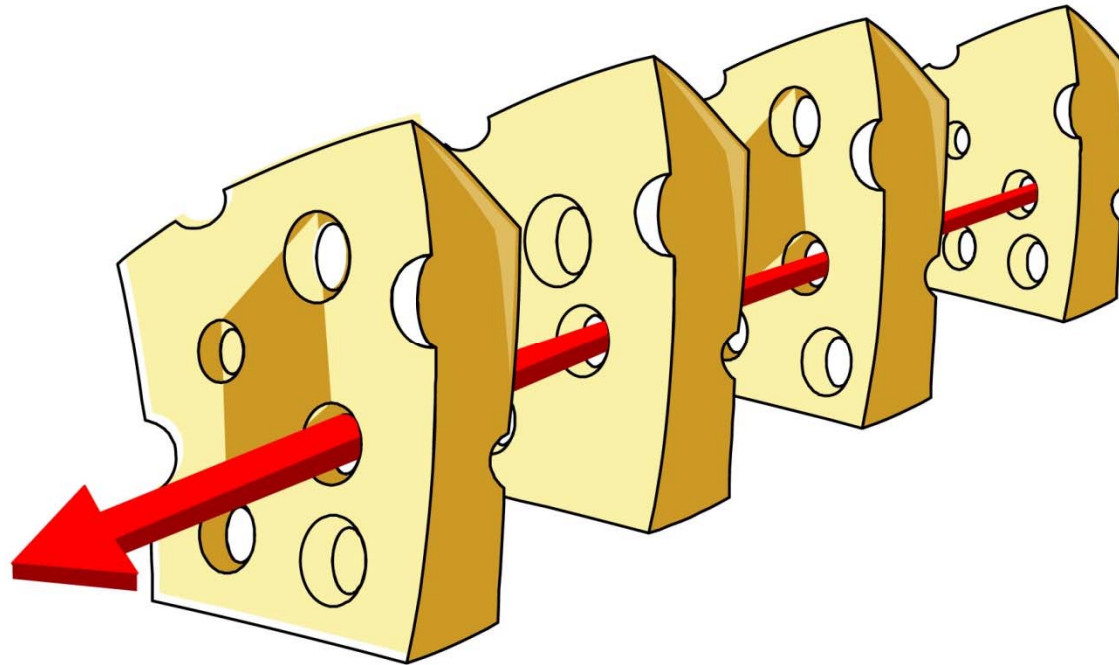
**Pilot Conclusion: Jettison Chute**



## Event 2 - Spin Chute Taxi Test

---

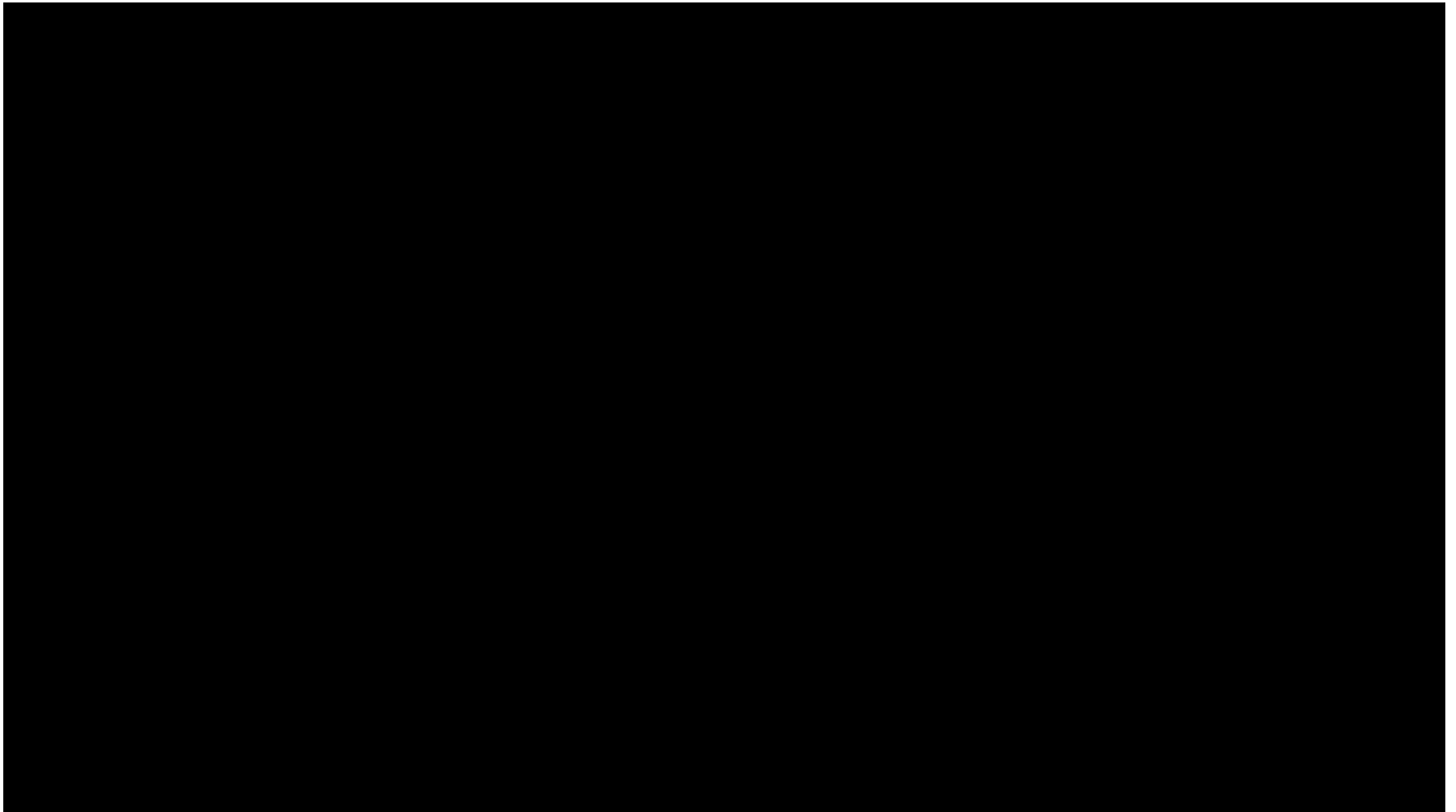
- Inadequate/misleading feedback led to delayed chute jettison
  - Aircrew CRM saved the day
  - Fortunately, the only consequence was a few extra thousand feet of FOD walk for ground crew...



## Event 3 - Initial Landing Gear Operations

---

- Initial Gear Ops – Gear Up Attempt



## Event 3 - Initial Landing Gear Operations

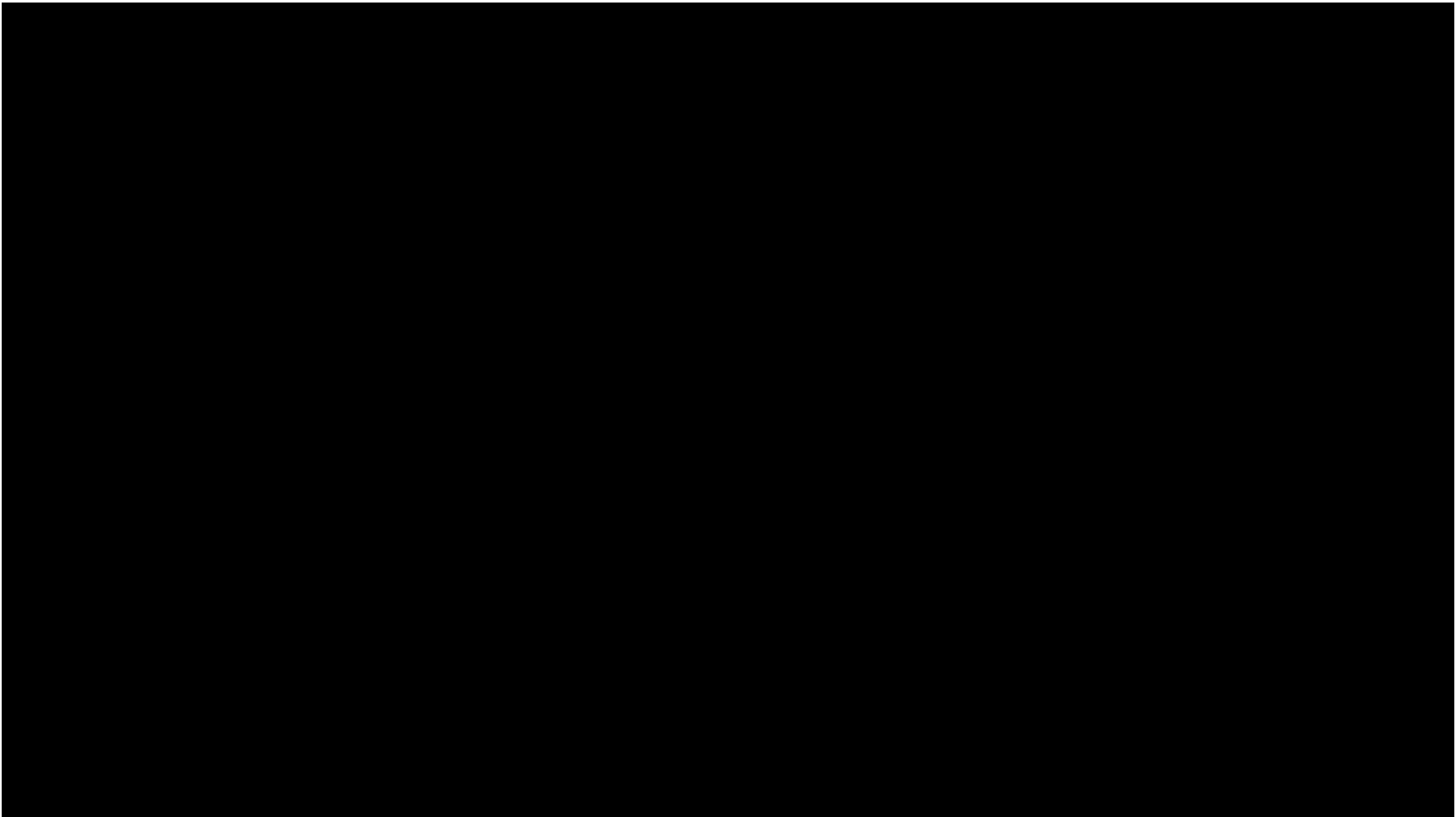
- Under airloads, NLG doors overlapped
  - MLG retract sequence did not complete
    - Notice where MLG doors are...



## Event 3 - Initial Landing Gear Operations

---

- Initial Gear Ops – Gear Down Attempt (the one that counts...)



## Event 3 - Initial Landing Gear Operations

---

- Gear Down
  - “What Would You Report?”



## Event 3 - Initial Landing Gear Operations

- Gear Down – Cockpit Indications



## Event 3 - Initial Landing Gear Operations

---

- Chase reported “apparent down and locked”
  - No MLG “greens” due to incomplete sequence?
- We did NOT declare an in-flight emergency
  - We were doing gear testing, after all
  - Experimental License dictates initial takeoffs/landings from home field
- Emergency Gear Extension?
  - Booby Trap: Continuous 3000 psi hydraulics vs. one-shot pneumatics
  
- Airloads on MLG Drag Brace higher than anticipated
  - Did not quite reach over-center
  - Gear locked over-center during landing rollout

## Event 3 - Initial Landing Gear Operations

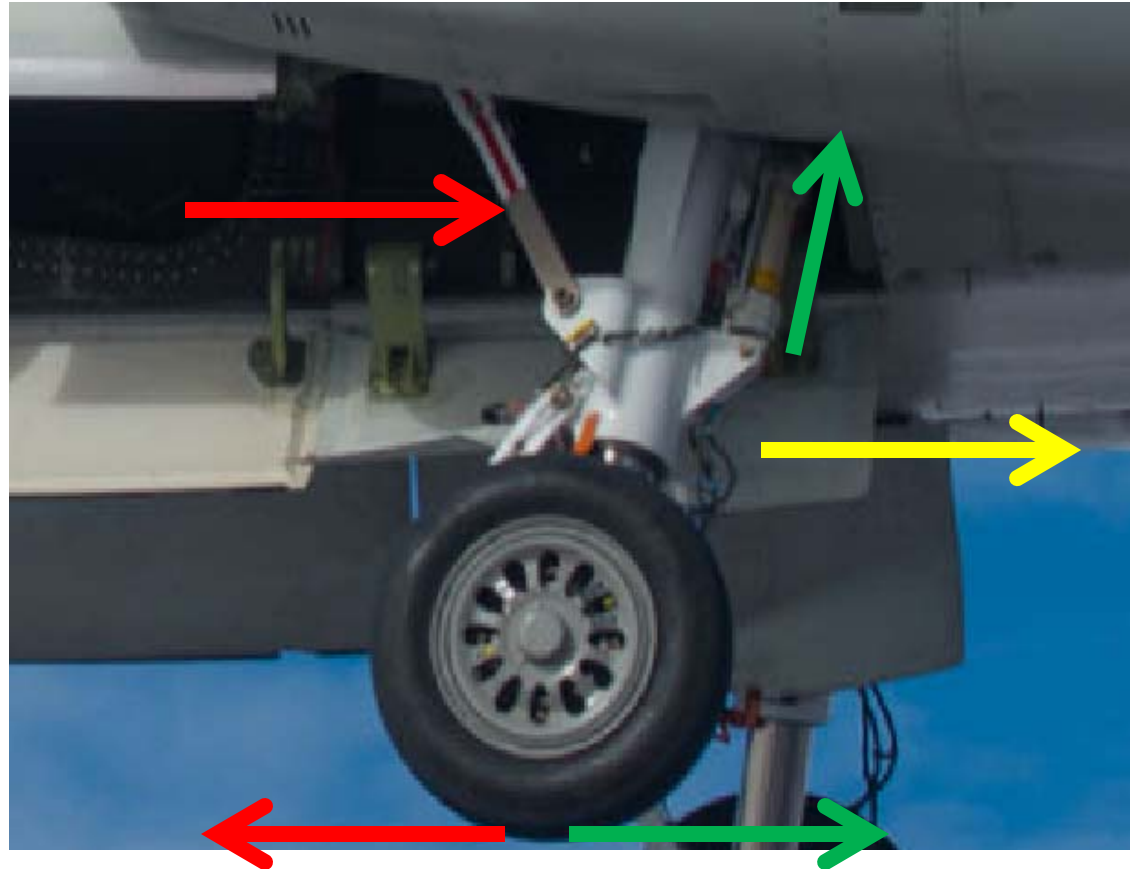
- Gear Down – After Landing





## Event 3 - Initial Landing Gear Operations

- $\Sigma$  MLG Forces



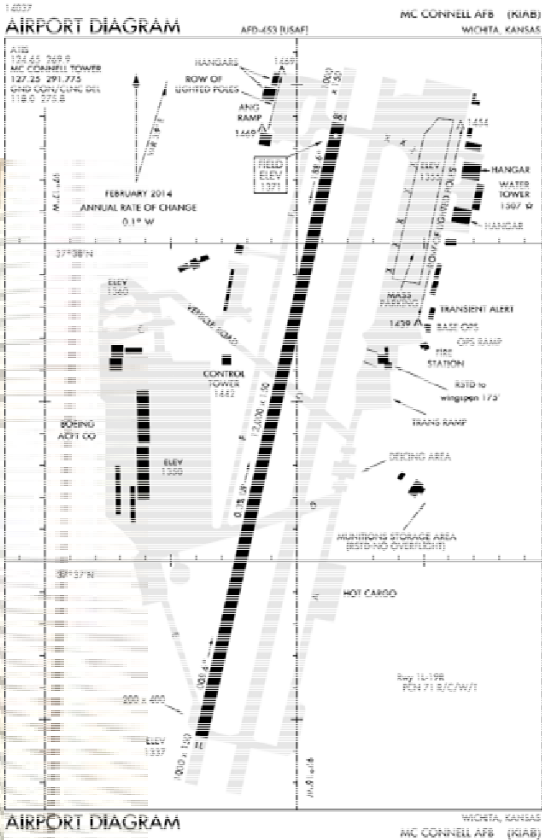
## Event 3 - Initial Landing Gear Operations

---

- Troubleshooting and Changes
  - For Gear Up: Adjust NLG Doors
  - For Gear Down: Alleviate MLG Drag Loads
    - Positive G and engine RPM (to assist “mechanical advantage”)
    - Adjust airspeed (to reduce airload on MLG drag brace)
    - Sideslip (to change airload direction from aft gear doors; “air dam” effect)
    - Pulse braking on rollout to ensure load assists over-center locking
  - Additional Instrumentation
  
- Next Attempt
  - NLG closed but mains still didn’t completely lock over-center
  - This time we DID declare an emergency with McConnell Tower...

# Event 3 - Initial Landing Gear Operations

- Declaring an Emergency...
  - We were “called to the principal’s office...”



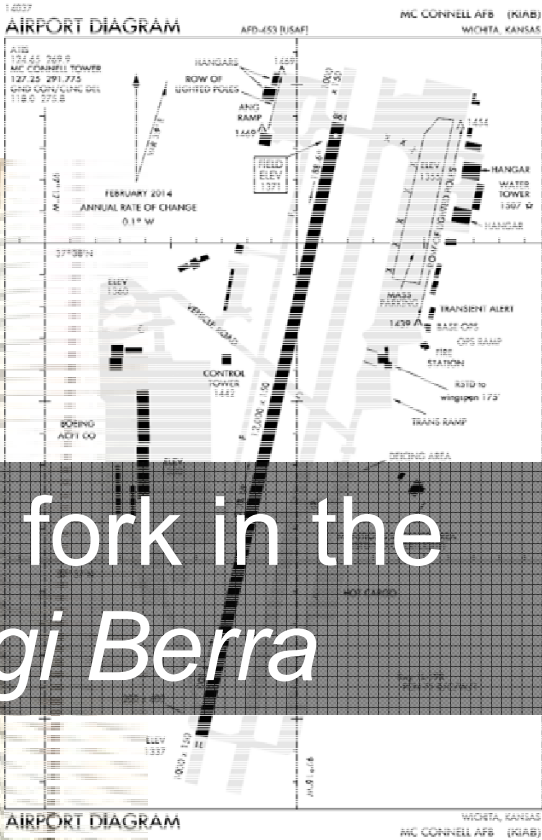
# Event 3 - Initial Landing Gear Operations

- Declaring an Emergency...
  - We were “called to the principal’s office...”



“When you come to a fork in the road, take it...” *Yogi Berra*

We did, but were “wrong” because...



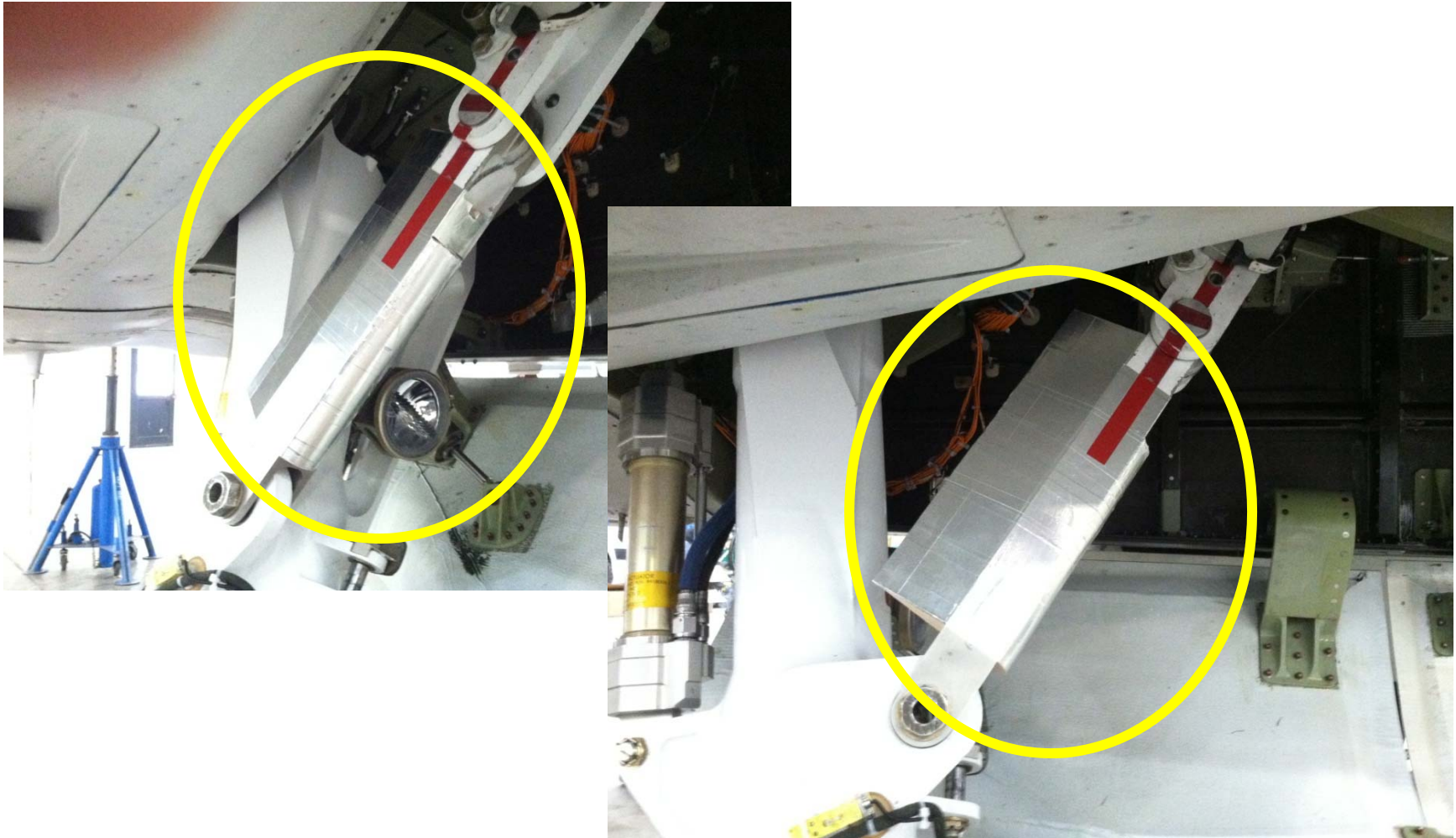
## Event 3 - Initial Landing Gear Operations

---

- More Troubleshooting and Changes
  - Engineering “Tiger Team”
  - More NLG Door adjustments, and new actuator
  - Aerodynamic Fairing to reduce MLG Drag Loads
  - New MLG actuator
  
- Final Success
  - Aircraft-unique changes worked
  - Procedural Lessons Learned
  - Follow-on improvements made

## Event 3 - Initial Landing Gear Operations

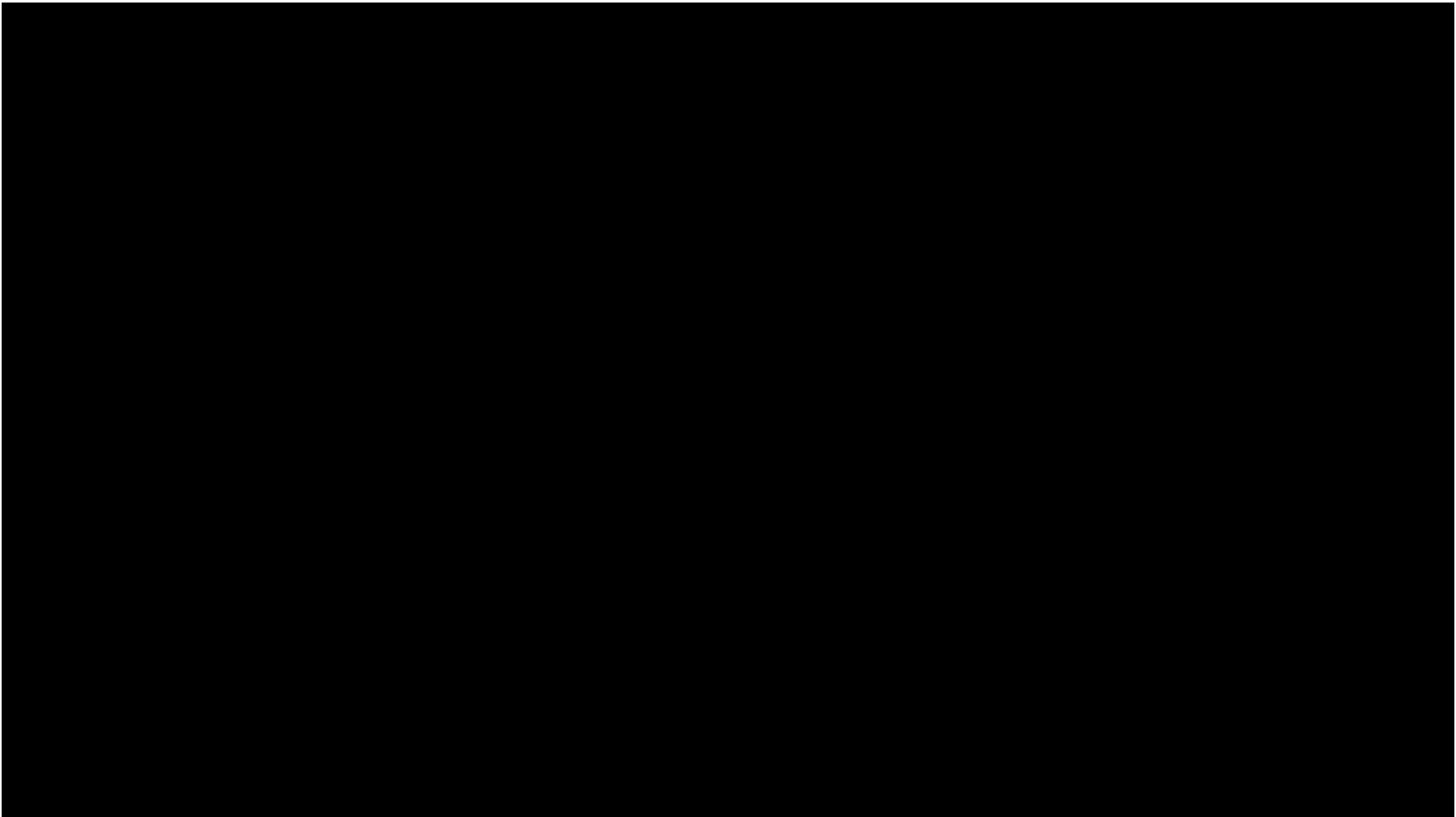
- Drag Brace Aerodynamic Fairing



## Event 3 - Initial Landing Gear Operations

---

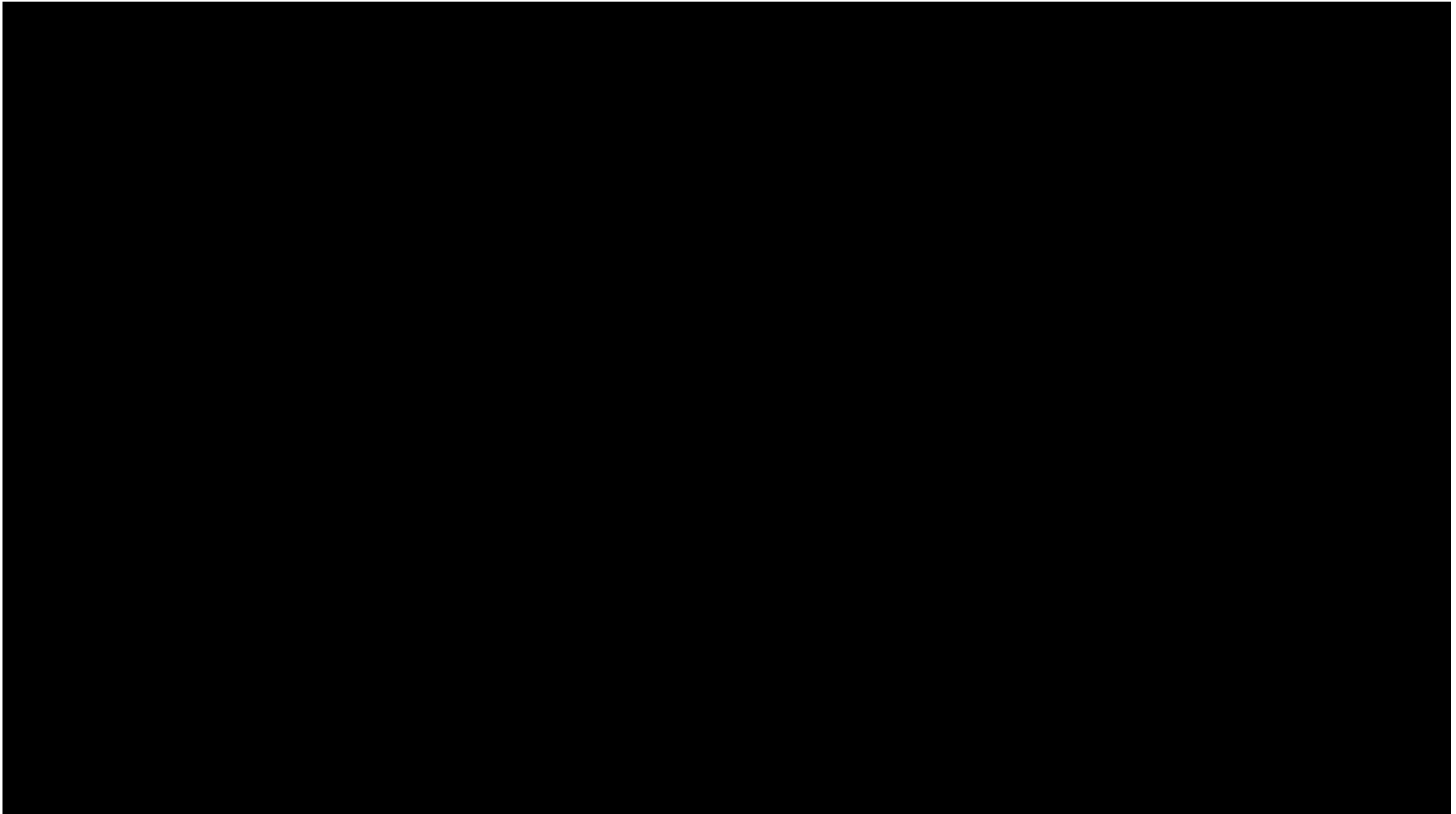
- Final Gear Ops – Gear Up (watch for “special” signal...)



## Event 3 - Initial Landing Gear Operations

---

- Final Gear Ops – Gear Down





## Event 3 - Initial Landing Gear Operations

- Final Drag Brace Downlock Spring



## Conclusion

---

- “The (Flight Test Safety) Theory of Everything”

**There isn't one (yet...)**

- **MACRO: Proven Processes and Procedures**
  - Use of Cessna’s Established Methods
  - SETP Guidance
  - Practice Good CRM
  - Ground Test before Flight Test
  
- **MICRO: Integration with Design; aircraft-unique “Booby Traps”**
  - Inlet Risk Reduction
  - Elevator Control Power Evaluation
  - Initial Landing Gear Operations

Questions?



Dave Sitz  
Flight Test Pilot  
Textron Aviation  
(316) 831-4252  
dsitz@txtav.com  
[www.ScorpionJet.com](http://www.ScorpionJet.com)



























Questions?



Dave Sitz  
Flight Test Pilot  
Textron Aviation  
(316) 831-4252  
dsitz@txtav.com  
[www.ScorpionJet.com](http://www.ScorpionJet.com)