

Flight Test Safety Workshop

12-15 May, 2014

Savannah



USNTPS

C-12 Gear Malfunction Incident



Mr. Michael Wagner

Mr. Tom Huff

FTSW Savannah May 2014



Background

- “Routine” Instrument Competency Check
- Plan
 - IFR Preferred Route to Dover AFB
 - Approaches at DOV
 - Additional Approaches at SBY
- Brief and Initial Operations Normal





The Event

- First Approach – VOR at DOV
 - Gear lowered prior to FAF
 - Green lights for nose and right main gear
 - No light for left main gear
 - No light in gear handle
- RTB to NAS Pax
 - Started working checklist
 - Contacted base...



▶ Meanwhile, Back at Base...

- High Traffic Ready Room
- Student Duty Officer on Watch – Duties Include:
 - Schedule Execution
 - Communication Interface with Operations
 - Emergency Response
- Crisis Protocol:
 - Run Response Checklist
 - Get Staff Help...





The Checklist

- **LANDING GEAR UNSAFE INDICATION**
(Note: 1 EP for all gear malfunctions)
 - 1) **LDG GEAR CONTR** switch – **DN**.
 - 2) **LANDING GEAR RELAY** and **LANDING GEAR IND** circuit breakers – Check in.
 - 3) **GEAR DOWN** lights – Check.

IF INDICATOR REMAINS UNSAFE:

 - 4) Landing gear emergency extension – Perform.



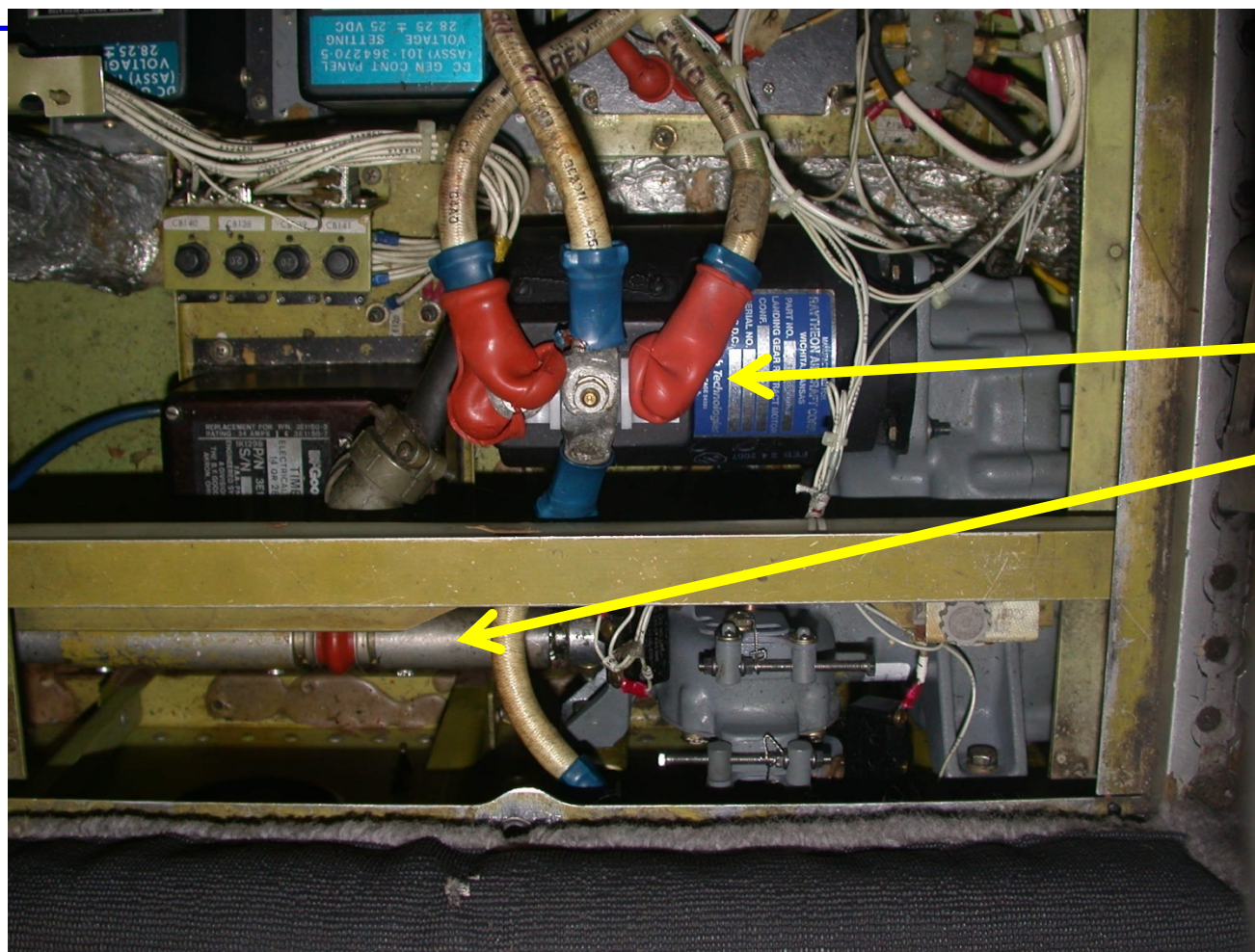
The Diagnosis

- Emergency gear extension
 - Mechanical override to an electrical malfunction
 - Disengages the motor
 - Uses same mechanical linkages
 - Does not help if electrical system is functioning normally

No Procedures that Differentiate Between Electrical or Mechanical Malfunctions



Fwd



Landing Gear
Actuation thru
Electric Motor,
Gear
Reduction and
Torque Tubes

Aft



▶ Finding Refuge...Seeking Help..

- Back at NAS Pax 3000 foot delta pattern
- T-6 Chase
- “Essential Only” in Ready Room
 - Troubleshooting Team
 - Checklist Execution
 - System Study – Previous FA-18 Asymmetric Landing
 - Airport Response Team
 - Operational Impact - Recall
 - Runway Prep
 - Evacuation



Checklist Results

- Emergency Extension Attempt Failed
- Unfavorable Landing Config
 - Nose and 1 main down; 1 main up
- Retract Gear
 - Gear Up Landing Checklist Failed
 - Binding Actuator due to Emergency Extension?
 - Motor disengaged?
 - No mechanical-only retraction method



The Checklist to Retract

- **GEAR-UP LANDING (GEAR UP OR UNLOCKED)**
 - Fuel load – Reduce. Personnel emergency briefing – Completed. Loose equipment – Stowed. **BLEED AIR VALVES – ENVIRO OFF. CABIN PRESS switch – DUMP. CABIN SIGNS switch – BOTH.** Cabin emergency hatch – Remove and stow. Seat belts and harnesses – Secured.
 - **Landing gear alternate engage handle – Disengaged.**
 - **Alternate landing gear extension handle – Stowed.**
 - **LANDING GEAR RELAY circuit breaker – In.**
 - **GEAR – UP.**
 - Nonessential electrical equipment – **OFF.** Flaps – As required (**DOWN** for landing). **POWER** levers (runway assured) – **IDLE.** **CONDITION** levers – **FUEL CUTOFF. FIRE PULL** handles – Pull. **MASTER SWITCH – OFF.**



Saving Grace...

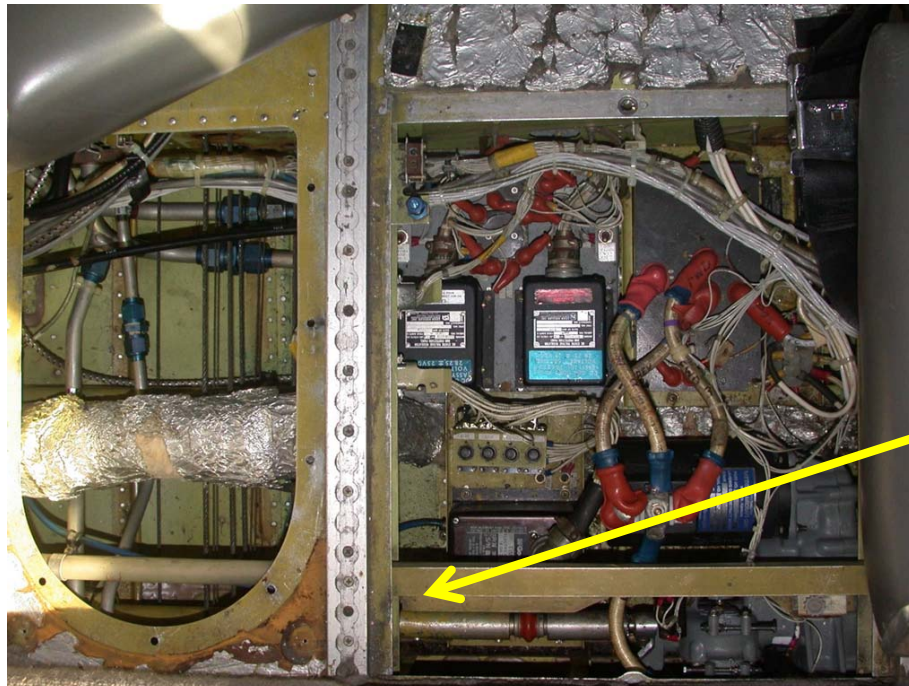
- Contacted [Vacationing] Technician
- Discount Further Electrical Solutions
 - Check CBs and Current Limiters
 - Total Electrical “Reboot “ (not done)
 - Short Current Limiter by MacGyver Method (absolutely not done)

Asymmetric Gear Configuration not Explainable Electrically



The Ah-Hah Moment...

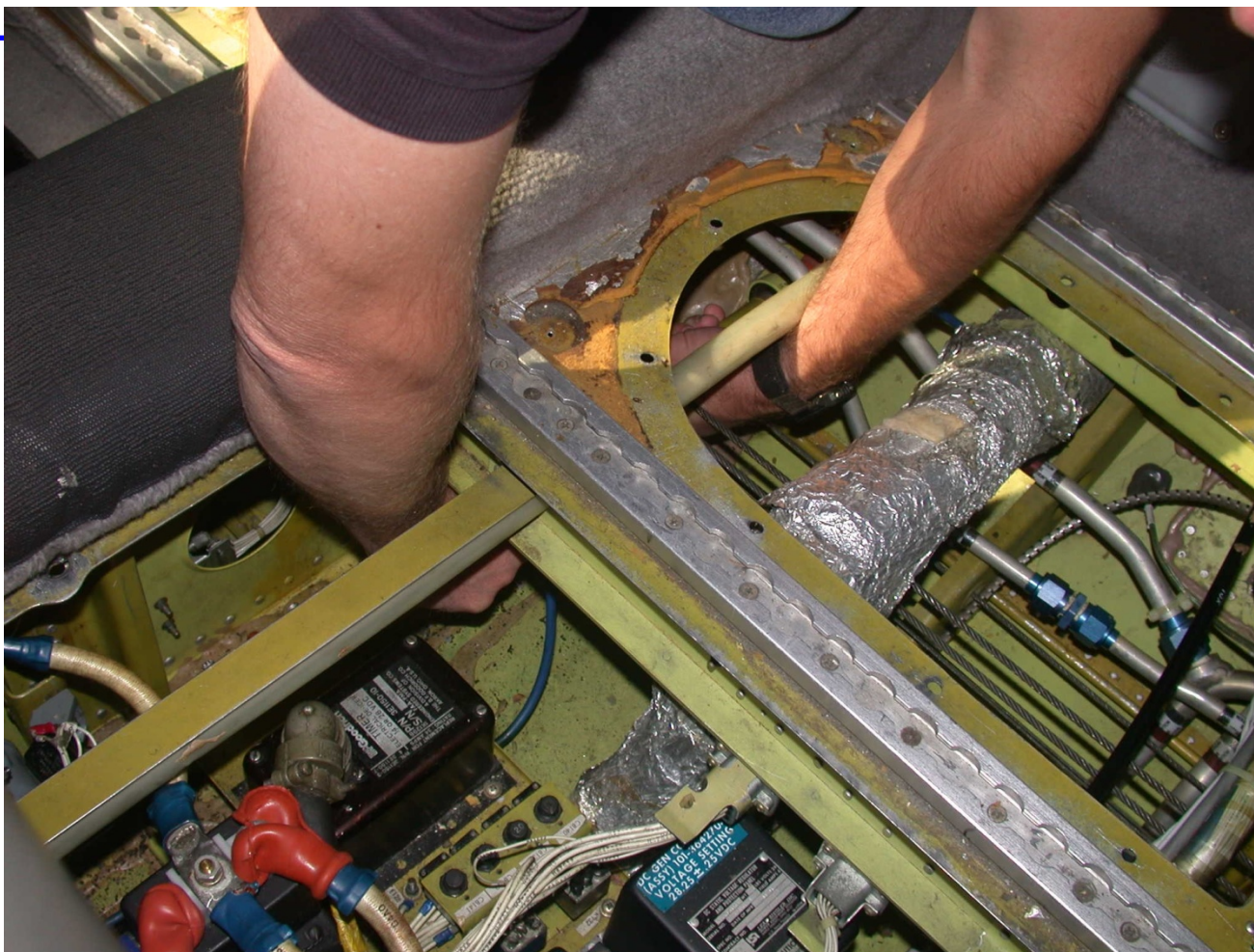
- Think Mechanically – Access Gear Actuator
 - Required Seat, Carpet and Floorboard Removal
 - Swiss Army Knife to the Rescue!
- Discovered Torque Tube Joining Hardware
 - Bolt, Washer, Friction Nut in the Bilge



Torque Tube
Hardware Location



Close-up of Exemplar Torque Tube



Fwd

Hand Positioning To Effect Twisting of Torque Tube



We Have Movement!

- Approximately 300 Rotations Required
- Progress Confirmation via Chase and Nike
- Full 3 Down and Locked Achieved
- Uneventful but Cautious Landing
- Cleared Active for Tow-back



Investigation Findings...

- Cause Began a Month Earlier...
 - Cycled Gear in Mid-Travel
 - Subsequent Maintenance Action Incomplete
 - Insufficient Torque on Retaining Hardware



Self Analysis..

- Checklist Execution
 - Written for Higher Probability Electrical Fault
- Compounded Situation
 - Damaged Gear Actuators
 - Eliminated Retraction Option
 - Preferred Gear UP Landing Config Unobtainable
 - Forced 2 Gear Landing Brainstorming



Lessons Learned



- Take Charge, Identify Team, Solve (off Airwaves)
 - True Crew Resource Management
 - Pilot Flying --- Fly!
 - Pilot Not Flying --- Remediate (Headset Extension)
 - Chase --- Assist with Nav and Comms
 - Ready Room --- Tactful Suggestions
 - Major Mishaps from CRM Pitfalls
 - Eastern Flight 401 – PF/PNF Both Heads Down
 - VMFAT-101 FA-18 – Ready Room Influence

Exploit Available Resources – System SME's!



Translating to Test...

- CRM Knowledge and Practice
 - TM Room / Chase / Test Vehicle Synergy
- Test Planning “What If”
 - Test Result Anomalies vs. Bona fide Emergencies



More Translation to Test

- Minimize the “Failure of Imagination”
 - In All Areas of Design and Test
- Emergency Procedure Development
 - Design Engineers and Aircrew Collaborate to Consider:
 - Unlikely/Atypical System and Subsystem Failure Modes
 - Optimal troubleshooting techniques

Questions??

