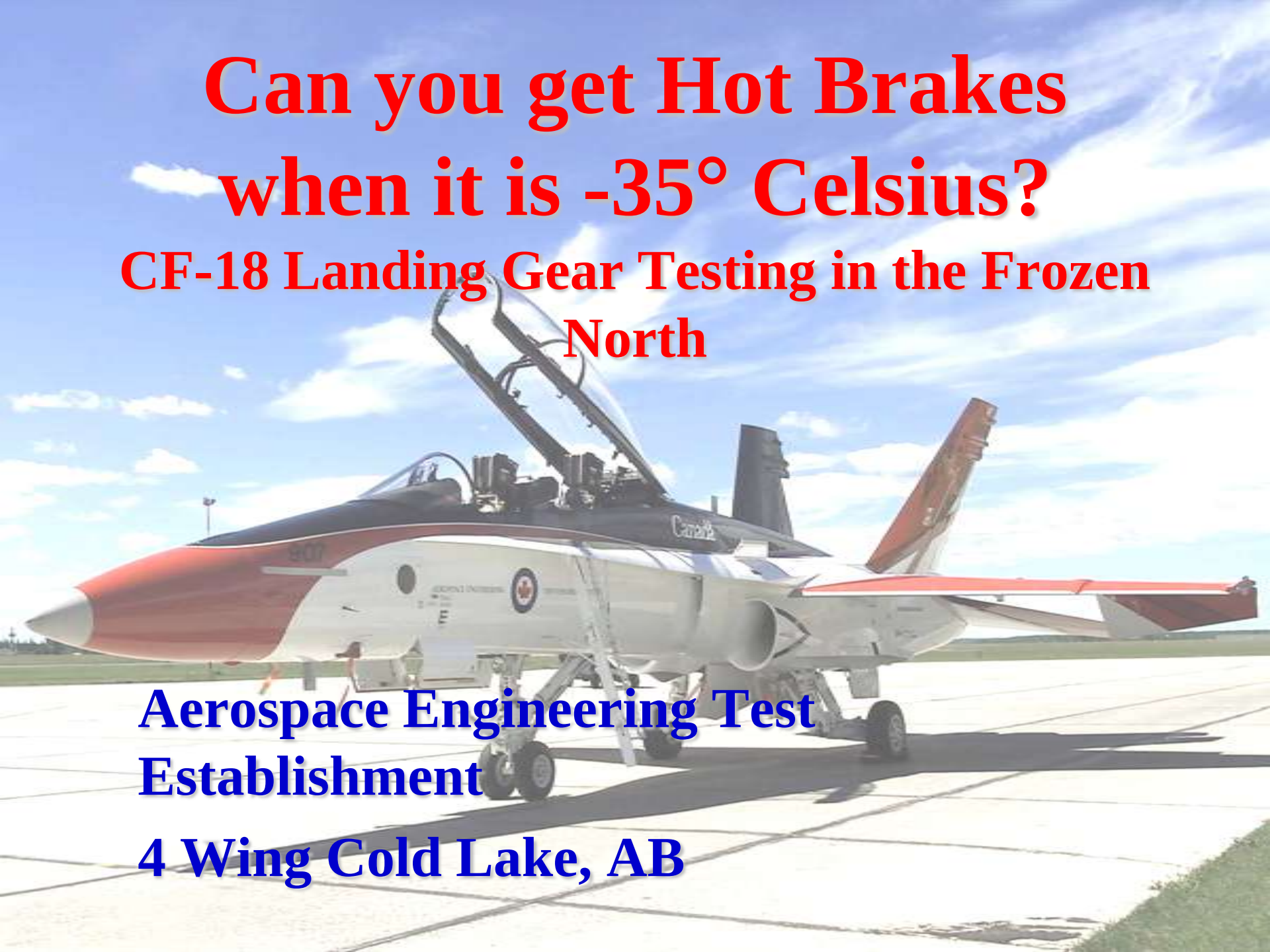
Can you get Hot Brakes when it is -35° Celsius?

CF-18 Landing Gear Testing in the Frozen North



Aerospace Engineering Test Establishment

4 Wing Cold Lake, AB

Introduction

- Major Eric “Kahuna” Grandmont
  - CF-18 Flight Test Engineer
- Major Stuart “Chia” Rogerson
  - CF-18 Test Pilot and Project Officer
- Major Reagh “Rage” Sherwood
  - CF-18 Test Pilot

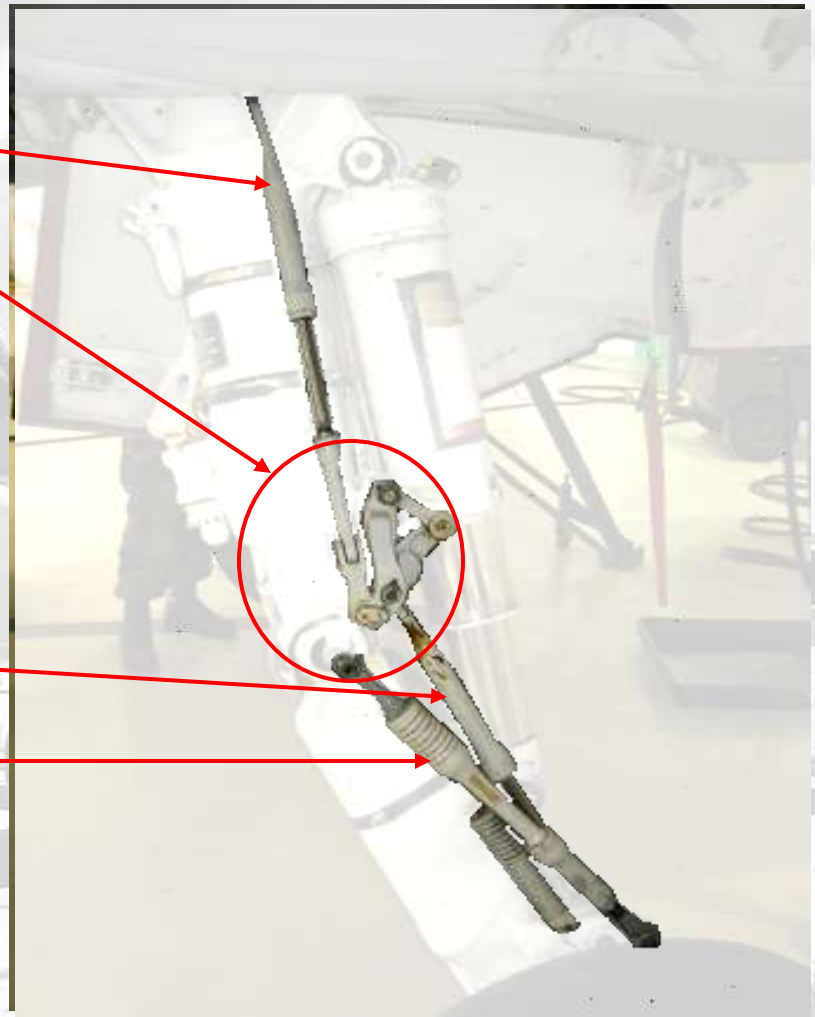
Background

- From YF-17 to F/A-18
  - USN unique requirements
  - Aircraft carrier operation
  - Additional 10,000 lbs
- Planing Mechanism Assembly (PMA)
  - Rotate the wheel
  - Compress shock absorber

PMA Components

PMA Components

- Connecting link
- Bell crank assembly



- Shrink link
- Planing link

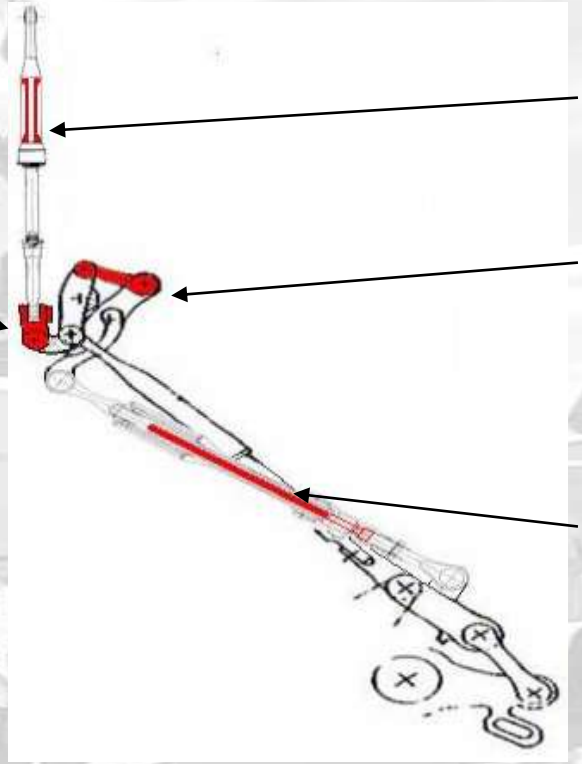
PMA Failures

- Upon landing or shortly thereafter, main wheel deplaned resulting in directional control
  - Associated with buckling of connecting link or planing link
  - Signs of bell crank assembly contact

PMA Failures - Causes

- Servicing, rigging
- Bell crank assembly isolation
- Connecting link buckling
- Planing link bottoming out
- Dynamic unlock of the lock links

Prototype Design



Rigid Connecting Link

Urethane Connecting Link Cartridge

Dogbones

Planing Link Urethane Spring

Project Aim

- Assist NAVAIR and Boeing in validating the proposed CF-18 landing gear modifications by collecting landing gear loads data through flight test

Test Point Requirements

- Four MLG Configs:
  - Baseline
  - Prototype but with production Connecting Link
  - Full Prototype
  - Full Prototype with USN Navy Crank Assembly and Axles
- Matrix consisted of 36 landing test points per config
  - Taxi Tests – Low, Medium and High Speed
  - Descent Rates from <6 fps (360 fpm) to ≤14 fps (840 fpm)
  - Various crab and roll angles at touchdown (±5°)
  - Gross Weight up to 39,000 lbs

Landing Types

Data Requirements

- Instrumented MLG
- AC MUX Bus Parameters
- Tail Hook Imagery
- On Field Cameras
- Instrumentation was recorded on board and TM’d to control room

Weather Limits

- 100% Bare and Dry runway for tail hook camera
- Max crosswind limit of 10 knots (including gusts)
- Max crosswind of 5 knots (including gusts), for the following test points:
  - Roll away from crosswind
  - Crab away from crosswind
  - Crab away combined with roll into crosswind
- Arresting cables were restricted from use below -30°C
- The instrumentation had a temperature limit of -30°C
- Discovered that the rooftop mounted telemetry tracking system had a temperature limit of -20°C

Cold Lake Airfield

Schedule Pressures

- Priority C Project – Flight Safety RA: High
- Senior CF leadership wanted a solution now
  - Very visible project throughout chain of command
- International project with multiple stakeholders
- Significant delays had occurred with instrumentation on aircraft
- Large multinational exercise at Wing was looming around the corner

Risk Assessment

- A total of 13 risks were identified in test plan
- Many of the risks had similar mitigation strategies
- Fleet Aircraft were already operating High Risk
- Able to mitigate to a Test Medium risk
- Non aircraft specific risks as well such as Frostbite and Hypothermia

PMA or Side Brace Failure and Blown Tire

- Used TM to monitor loads data on key MLG components and placed safety limits on them
- Seventh landing was always a full stop for a visual gear inspection by maintenance
- Roll and/or crab ≥7 ° on touch down, full stop required
- Simulator session required for pilots
- Test build up. Low sink rate landings planned prior to high sink rate and all zero roll and crab prior to landing with roll and/or crab
- Approach end cable had to be available
- Review the red page response for Directional Control Problem on Takeoff or Landing

Hot Brakes

- Real problem was not hot brakes, but melting instrumentation 430F vs 200F
- For this reason, installed brake temperature sensors TM'd to control room
- If temp reached 175F, needed to cool to 100F before continuing – easy to do in Cold Lake
- Delayed brake application as much as possible
  - Runway to go markers
  - Became a challenge when test point ate up a lot of the runway

Departing Lateral confines of Runway

- Max crosswind of 10 knots
- Camera personnel located either abeam or behind the arresting cables
- Most landings, land beyond the cable

Departing End of Runway during Taxi Tests

- Assumed you were going flying
- Departure end cable on test runway
- Had to conduct High speed tests at beginning of runway
- High speed tests on Inner only (12K’)
- Set a Go/No Go of 6000’

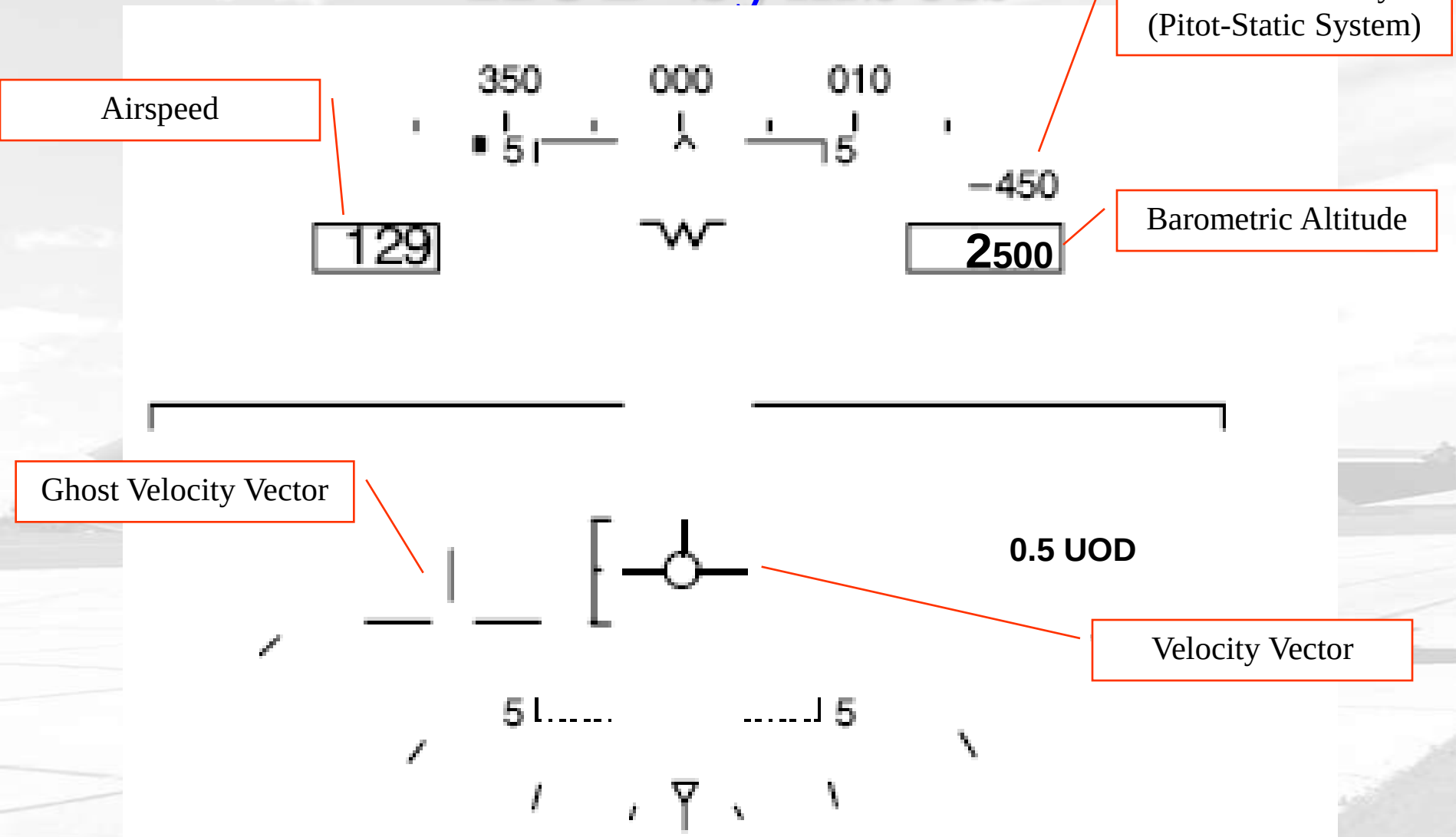
Aircraft and/or Arresting Hook Touching Down Prior to Runway Threshold

- Arresting cables at Cold Lake are located between 1300 and 1500 feet from the runway threshold. For all low sink speed touch and go landings, the touchdown aim point was beyond the arresting cable
- For a one-degree glide path the arresting hook will touchdown 900 feet before the VV aimpoint – deleted low sink rate arrested landing from matrix

Camera Personnel being struck by arresting cable

- Planned touchdown point for the majority of the test points will be beyond the arresting cable.
- Danger area from a cable snap is down the runway from the cable location
  - IDS personnel will be located either abeam or behind the arresting cable for all landings
  - Need to ensure this for normal airfield operations as well

HUD Symbols


Airspeed
Vertical Velocity
(Pitot-Static System)
350
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129
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Barometric Altitude
Ghost Velocity Vector
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Velocity Vector
5
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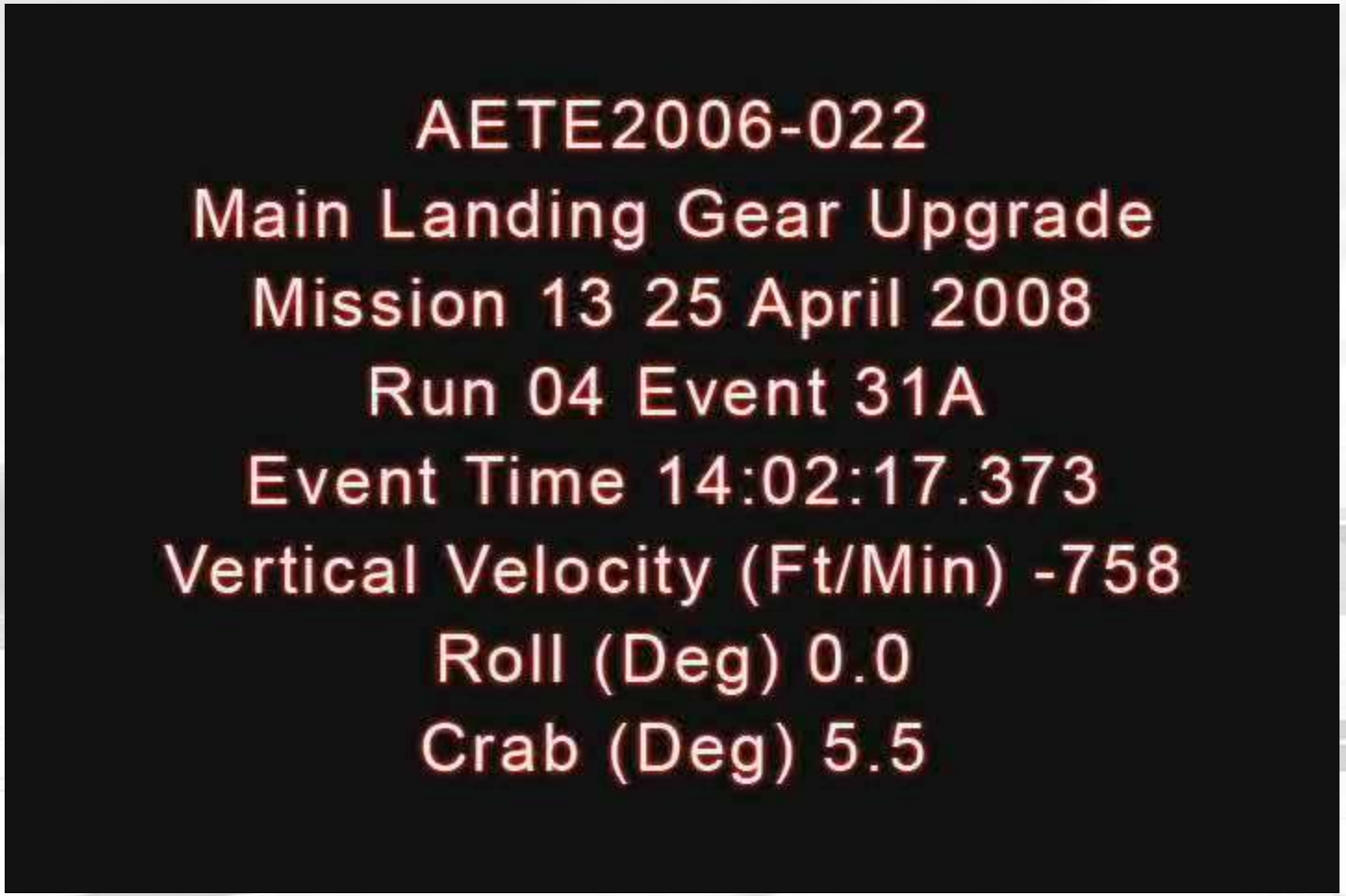
Landings – HUD

Produced by AETE IDS, May 08



Rate of Descent

- Tolerance was very challenging
- HUD Pitot-static info was unreliable
- Eventually adopted INS Z Velocity data
  - FTCR had good data
  - Pilot had 1kt resolution or A1F63B (Hex code)
- Compensated with pilot technique and a bit of luck

TM Drop Out

- TM was often unreliable at touchdown
  - frequent drop outs.
  - Noise would spike safety parameters
- “Standby, Red Latches” call
  - Gear stayed down
  - 10-15 seconds to review data
  - “Clear” call

Cable Status

- Operational base
  - Cables on scheduled maintenance (not notified)
  - Need to rationalize test efficiency with safety
  - We normally operate with cables, but do we need them?
  - Based on wind limits, approach end cable was always available
- New risk assessment item to define when departure cable must be available on the test runway
  - All takeoffs
  - All taxi tests
  - All non-arrested full stop landings

Bent Connecting Link

- During configuration change from #2 to #3, discovered connecting link had a 1° bend
- Probably two flights on this bent link without knowing it
- Expected load limit of connecting link was 9000 lbs and safety limit was 6000 lbs
- Load limit exceeded 5000 lbs during some landings in config #2, but never 6000 lbs

Bent Connecting Link cont…

- Created an interesting debate
  - Stop the program…, we damaged a component
  - But in reality, project wouldn't exist if the engineers truly understood the dynamic loads in the PMA – this was great data!
  - Real issue was that the bent link was missed for at least two flights
    - Incorporated a lower safety load limit on the connecting link and a new tool to assess straightness during all inspections (now adopted fleet wide)

Descent Rate Data

- During post project data reduction, discovered that multiple landings that were repeated because they did not fall within the desired descent window as analyzed from real time TM data were in fact valid
- Better real time processing would have eliminated repeat test points, making the program more efficient, but more importantly exposing program to less risk
- Even processing between flights would have reduced repeat test points

Better Solutions

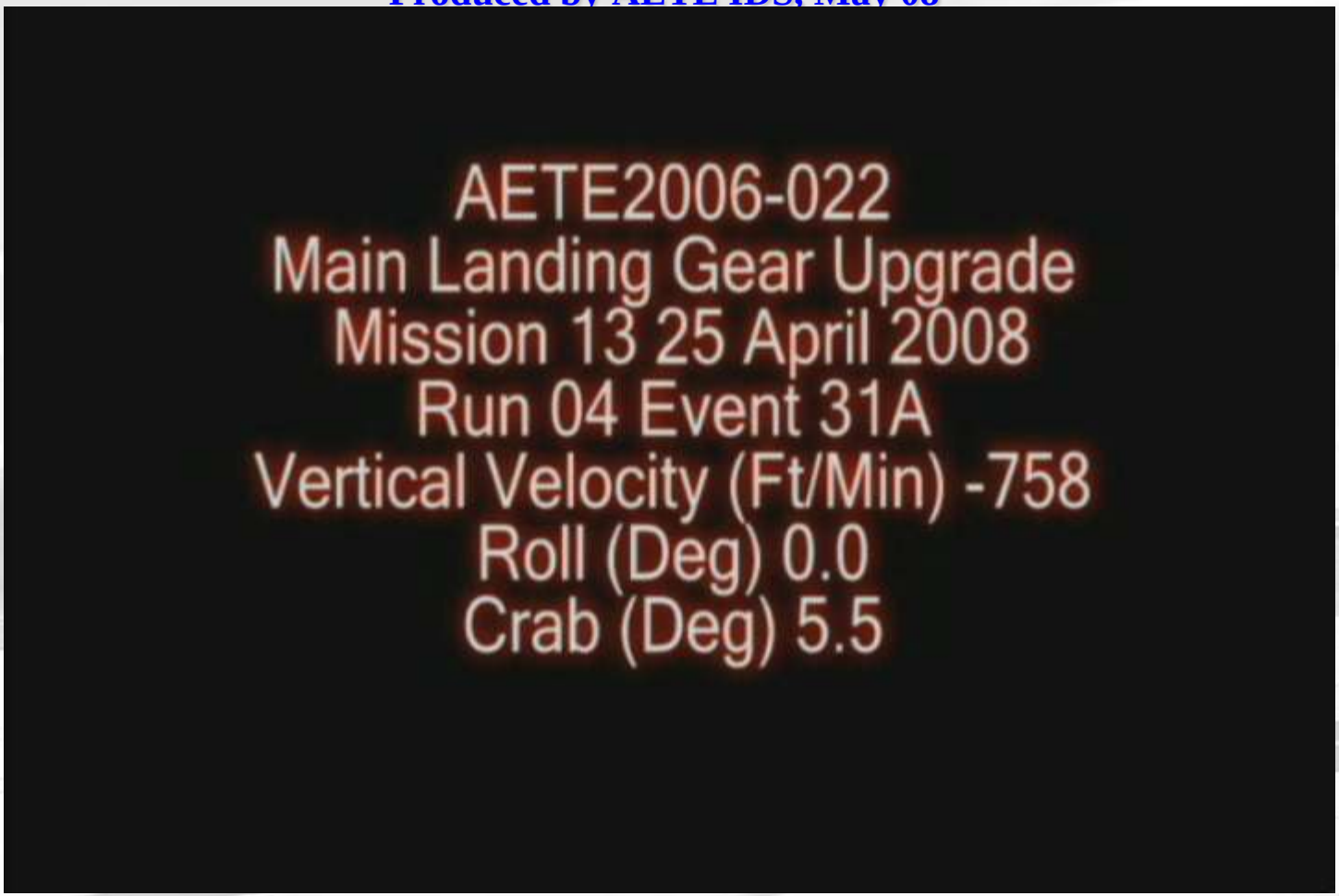
- CF-18 can display video in-cockpit
- Intended for weapons and FLIR pods
- Use a PC to capture bus traffic (INS descent rates)
- Use weapon video as the “monitor”

Project Summary

- Flew 17 sorties for a total of 26.7 hours with 271 landings over a span of four months. Provided 132 valid test points.
- It is expected that this DT&E effort will result in an ECP to the F/A-18 MLG to reduce PMA failures for all Hornet users throughout the world

Landings – Tail Hook

Produced by AETE IDS, May 08



Sometimes your best data is the unexpected results…

- Questions?