Using

Predictive Maintenance

concepts for structure integrity in the IAF

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Presentation Outline

- **IAF & ASIP overview**
- **What is predictive maintenance?**
- **PdM and ASIP**
- **Embedded sensors**
- **Usage DB**
- **Summary**

Background
IAF, ASIP

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F-15

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F-16

C-130

CH-53

UH-60

A-4

Zukit

AH - 64

AH-1

UH-1N

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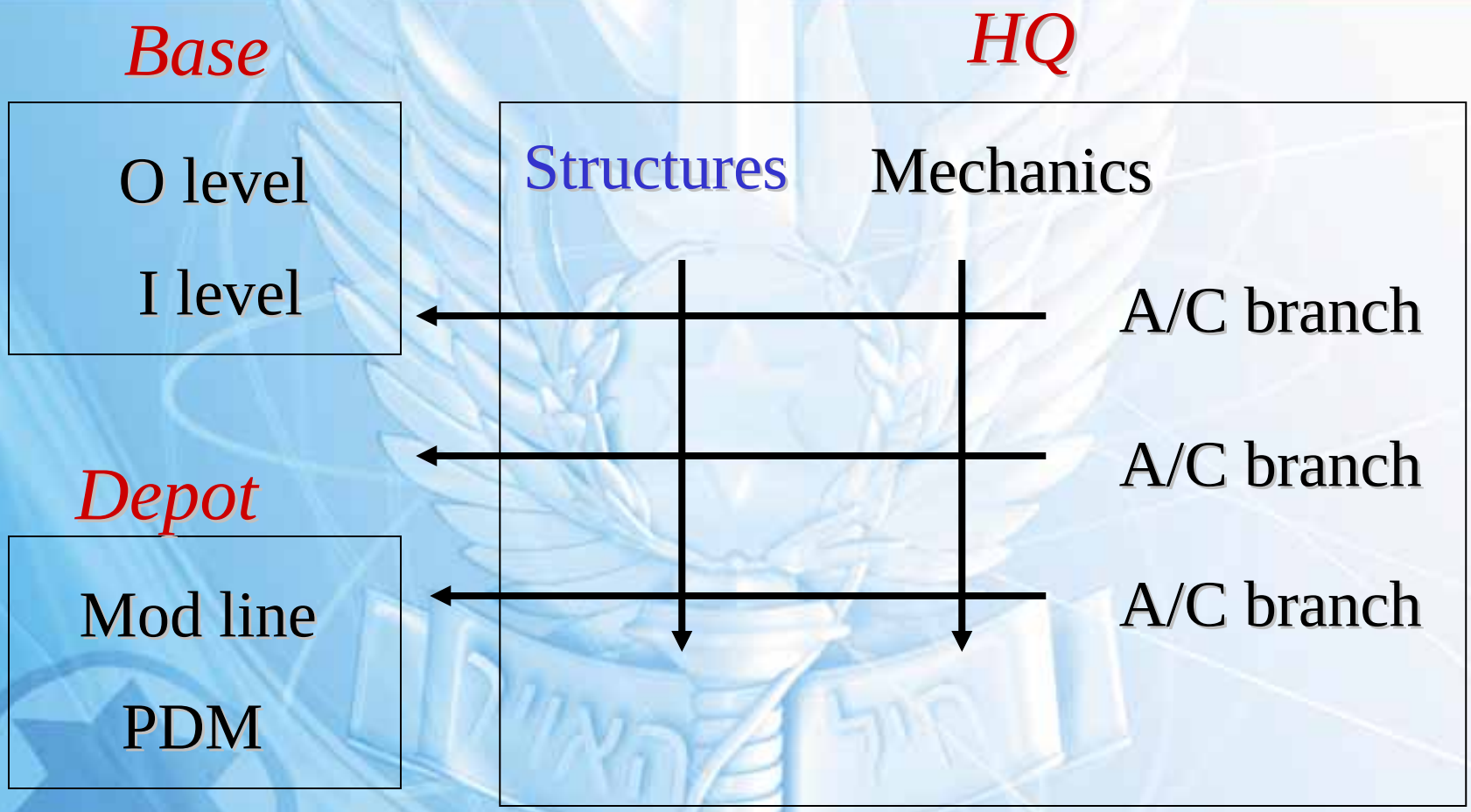
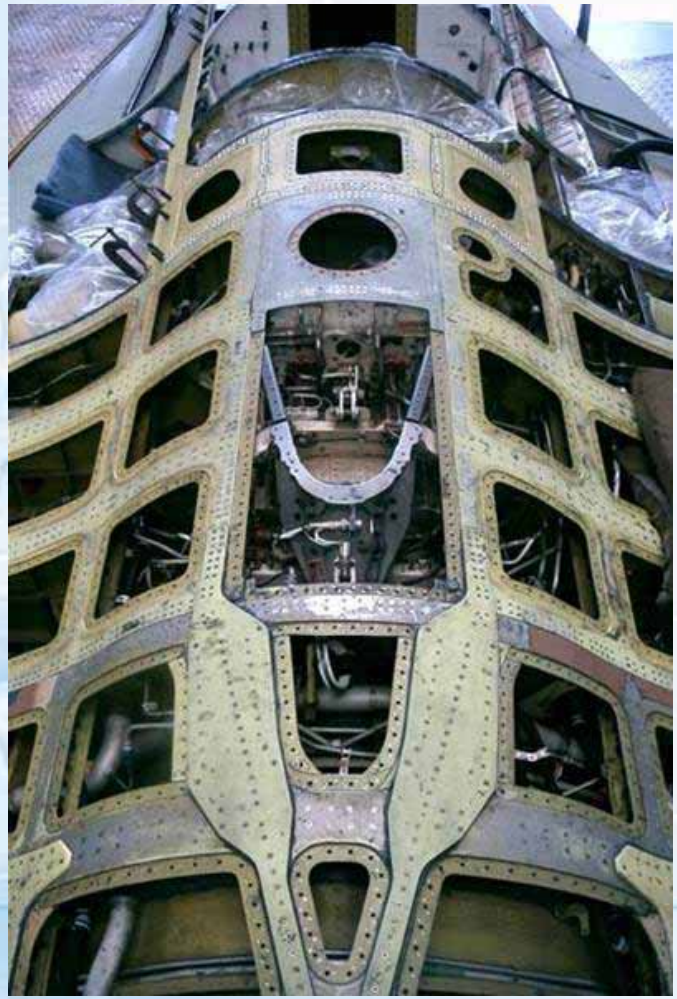
IAF ASIP Implementation



Structures branch

- Structure Branch groups
  - NDI
  - Fatigue and DT
  - Tools
  - Materials
  - Technology



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Fatigue and DT group

- Structures and mechanical fatigue critical parts
- Usage survey (LESS) and individual aircraft tracking (IAT)
  - Processing and reporting
- Fatigue substantiation programs
- IAF FSMP
- Analytical capabilities
  - FEM, crack growth, crack initiation, risk, fatigue test lab
- Failure investigations

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What is Predictive Maintenance?

What is predictive maintenance?

Predictive maintenance is a ***condition based maintenance*** *program*

Instead of relying on average life statistics to schedule maintenance activities, predictive maintenance uses ***direct monitoring*** *of the mechanical condition*

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What is Predictive Maintenance?

For ASIP

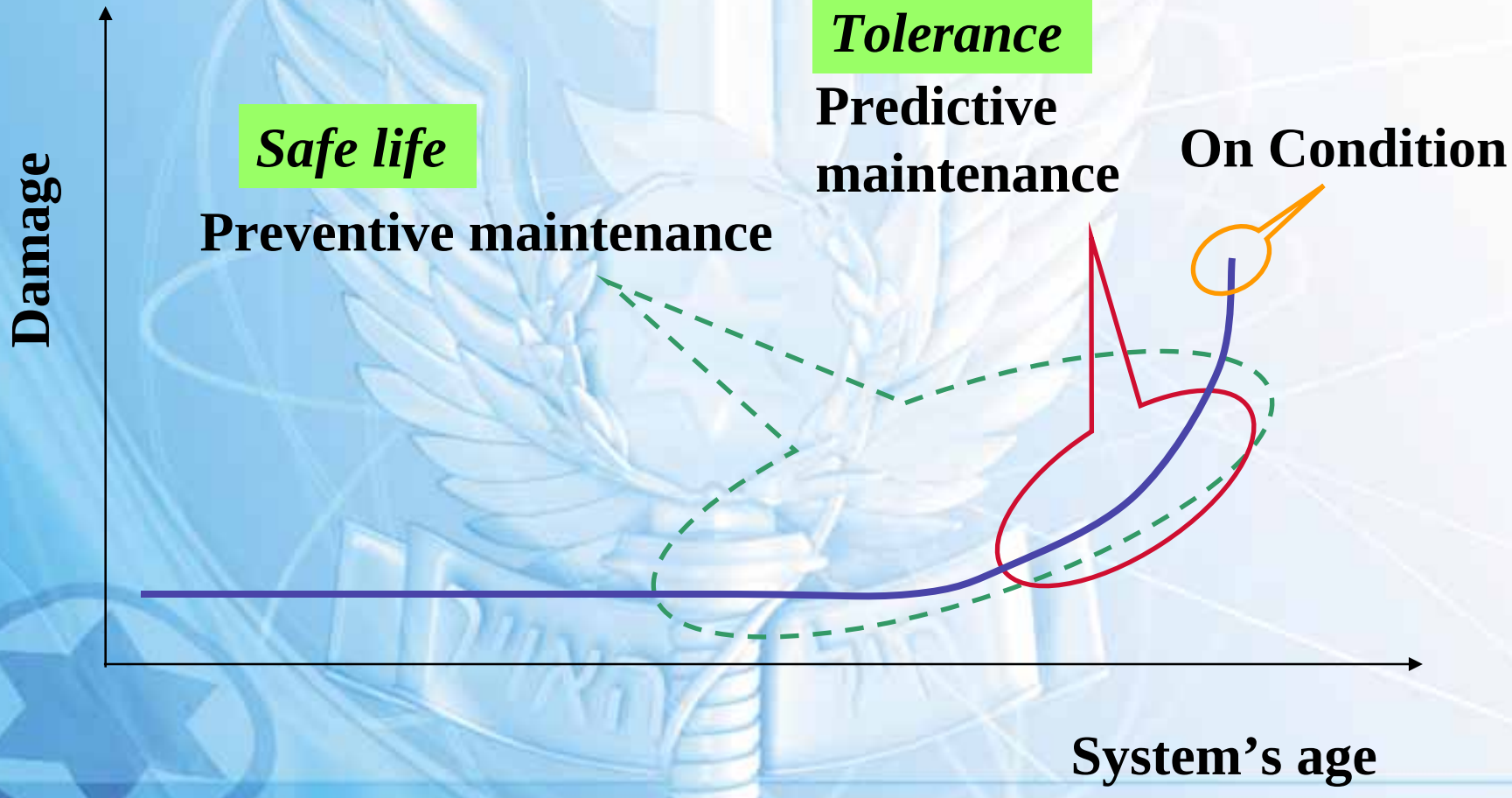
Damage Tolerance

Predictive maintenance

On Condition

Safe life

Preventive maintenance



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Predictive maintenance activities

For ASIP

Use recorded flight data

Install new sensors

Increase use of recorded flight data

Embedded structural sensors

Can we predict failure using this data?

Test and analyze

Implement predictive maintenance

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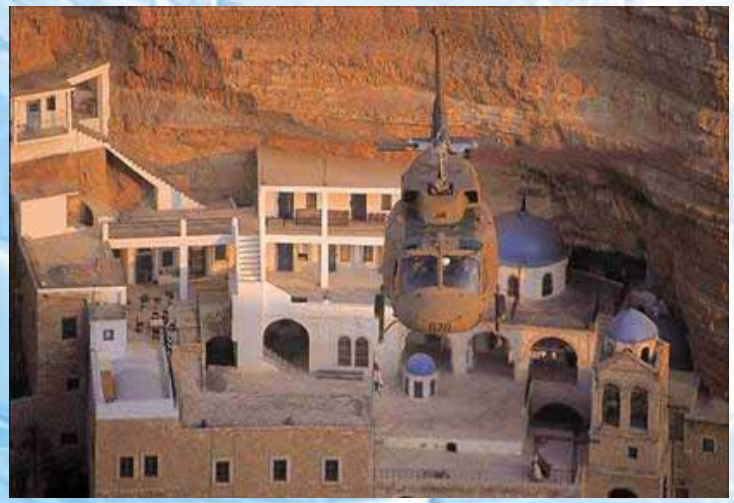
IAF activities

IAF initiated two activities:

- Embedded structural sensors
- Usage Data Base

“Low hanging fruits”

Embedded sensors



Embedded sensors

MWM sensors

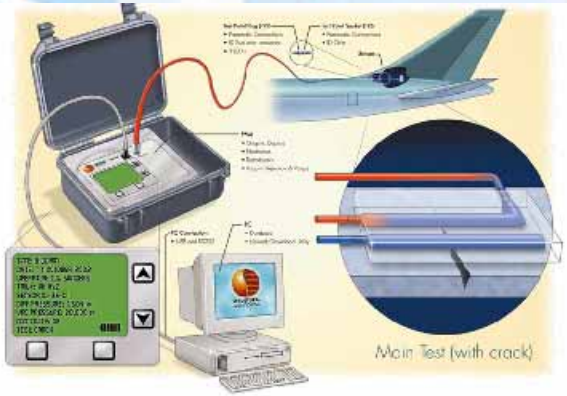


Figure 4: Crack Detection Via CVM System and Aircraft Test Installations of Sensors

VCM sensors

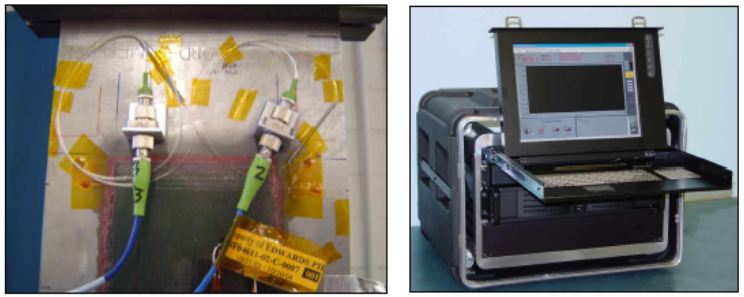


Figure 22: Fiber Optic Sensors in Adhesive Bondline and FO Monitoring Equipment

Fiber optic sensors

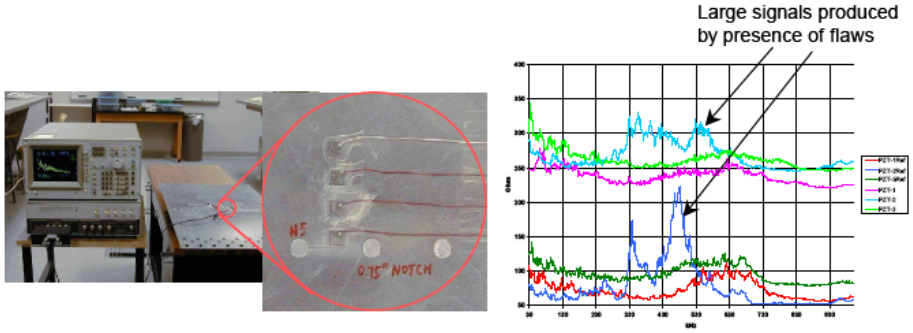


Figure 7: Piezoelectric Sensors on an Aircraft Panel Containing Crack and Corrosion Damage (left). Results Obtained with the E/M Impedance Technique Using Active Sensors (right)

Piezoelectric sensors

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Embedded sensors advantages

- One disassemble – save disassembles cost and damage
- Inspection repeatability
- Higher POD and sensitivity
- Less training

Goal:
Higher safety - Lower cost

Embedded sensors - Status

- FAA: "*The use of in-situ sensors for ~~real time~~ health monitoring of aircraft structure appears to be a viable option in the ~~near future~~.*" *(FAA airworthiness assurance center 2006 – ~~presented at~~ ageing aircraft conf.).*

Not in our program

Now

- Army: Condition Based Maintenance (CBM) project.
- Many tests – in lab and some on aircraft. Sensors includes: Comparative Vacuum Monitoring (CVM), Piezoelectric Transducers (PZT), Fiber optics, Remote Field Eddy Current (RFEC), Meandering Winding Magnetometer Probes (MWM) and others .

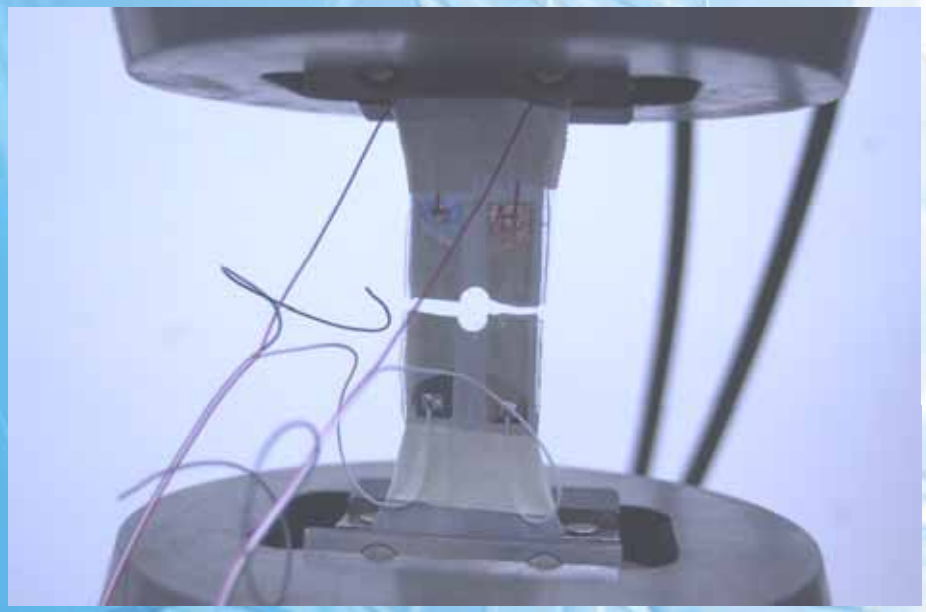
Embedded sensors - Status

Although technology seems mature and advantages are clear, there is no structural embedded sensor in any IAF aircraft

Crack detection/propagation sensors

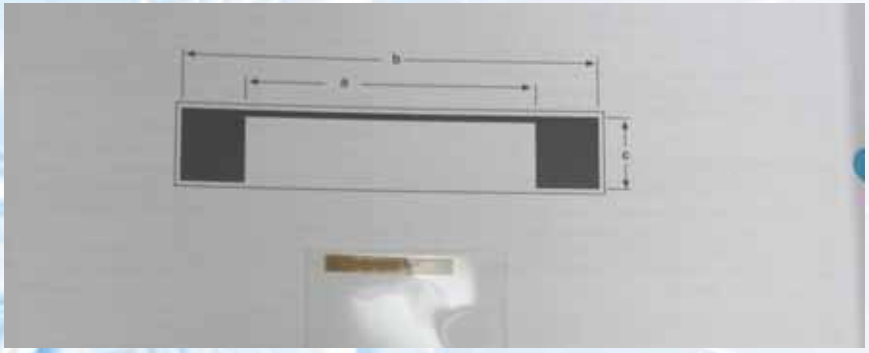
- Crack Detection / Propagation Sensor (CDS / CPS)
  - Crack tears a wire and changes the sensor's resistance
  - Used in lab fatigue tests for many years
  - Was installed under a patch repair of F-16 lower wing skin 15 years ago. Sensor showed good results

Crack detection/propagation sensors



CPS in the Lab

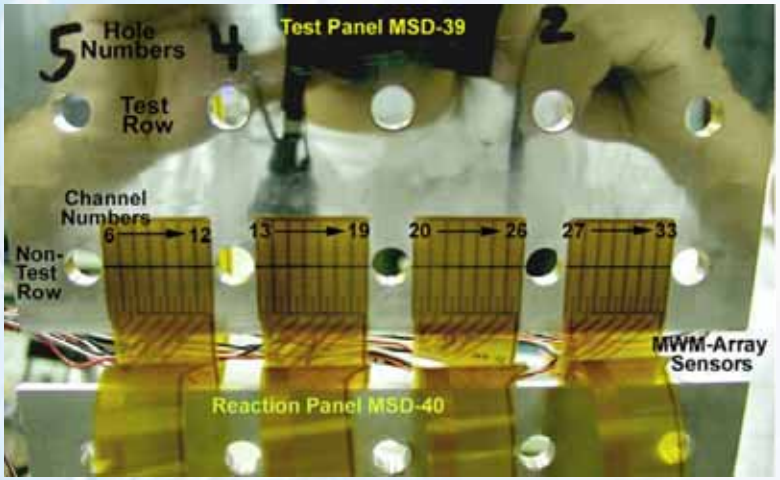
Crack Propagation Sensor (CPS)

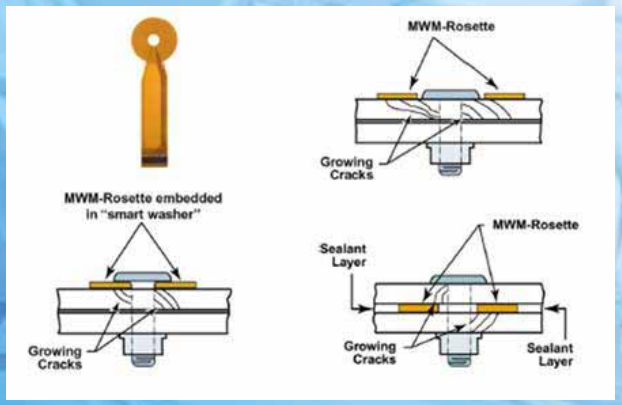


Crack Detection Sensor (CDS)

MWM - Embedded sensors

- MWM embedded sensor
  - Eddy current sensor
  - Proven in lab
  - Use IAF existing equipment





Criteria for sensor location

- Non safety of flight
- Areas that can not be inspected without embedded sensors or hard to inspect
- Assemble and disassemble are costly (man hour or damage)
- Wiring space
- Environmental limitations
- Quick cracking
- Critical crack size – Sensor detection capability

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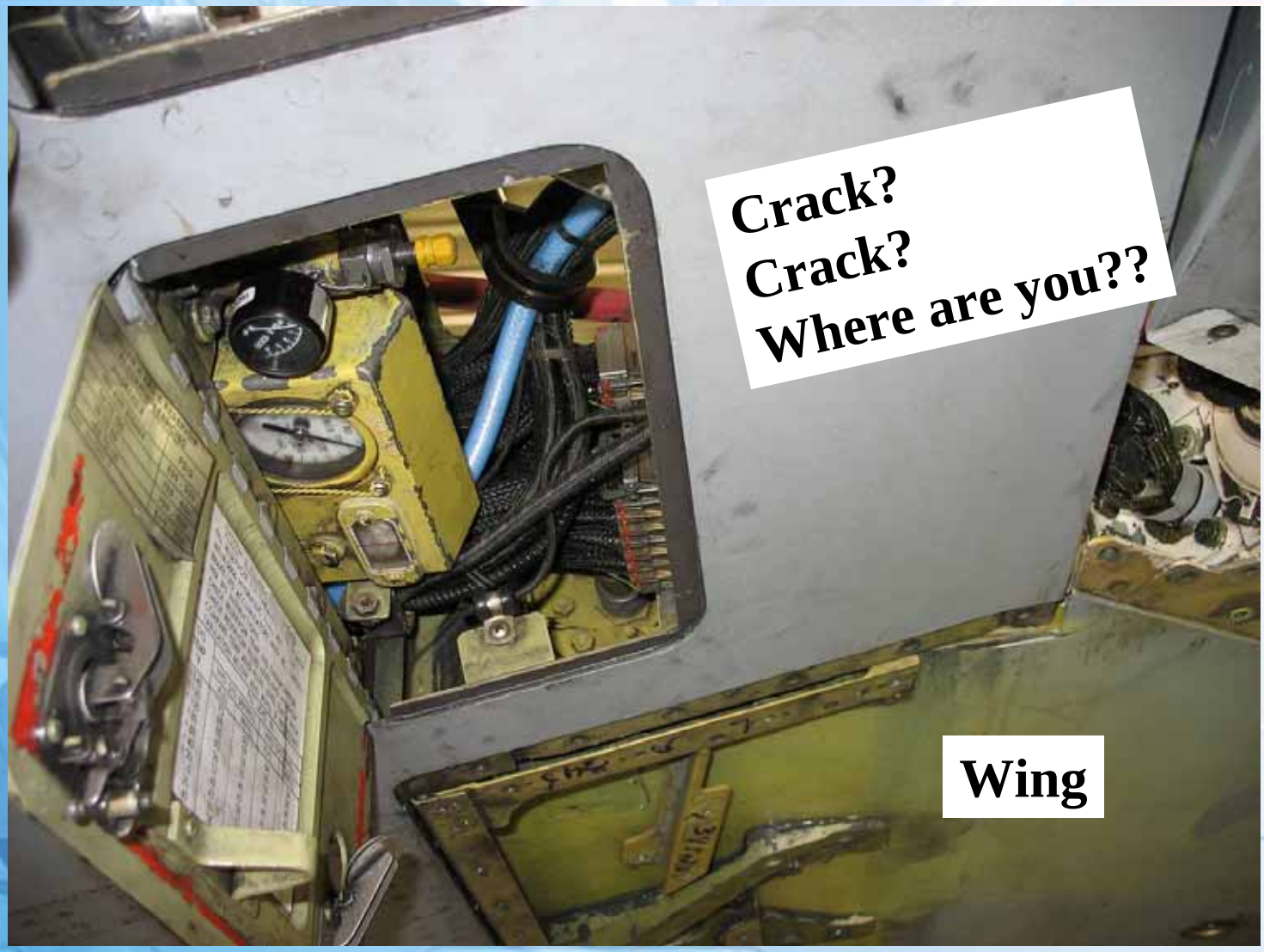
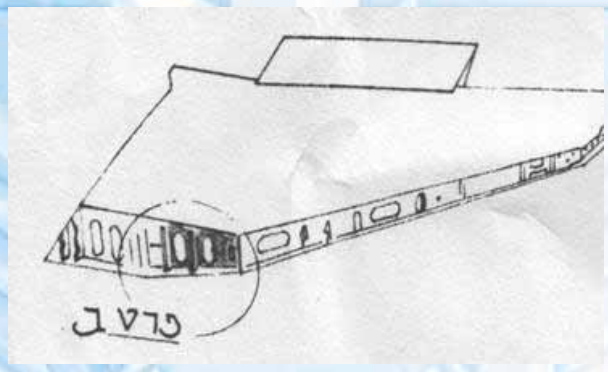
Crack Detection Sensors

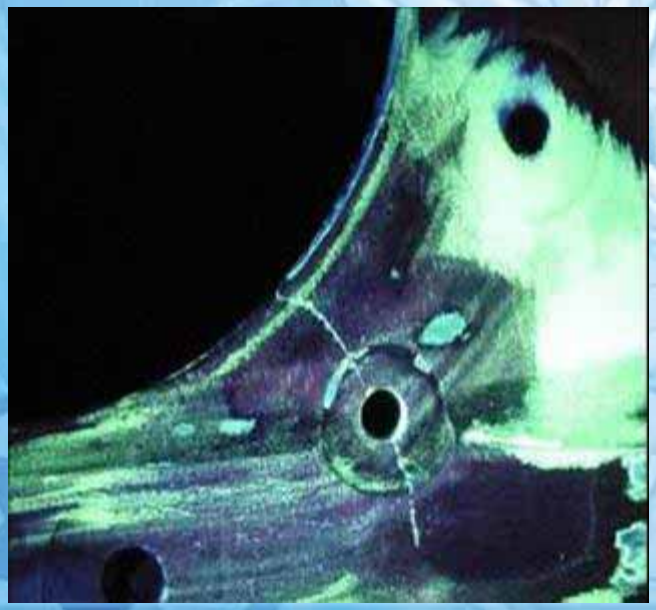
Typical crack locations

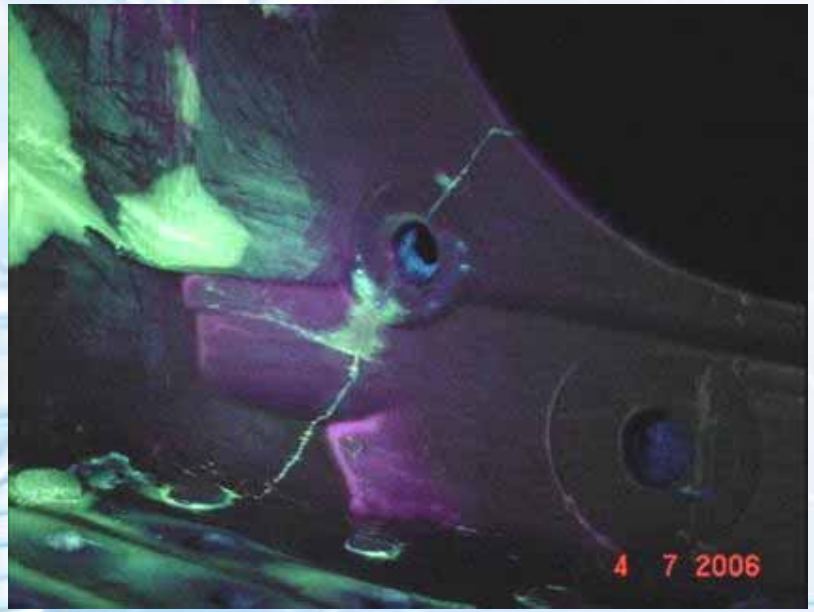
Crack Detection Sensors



MWM embedded sensors



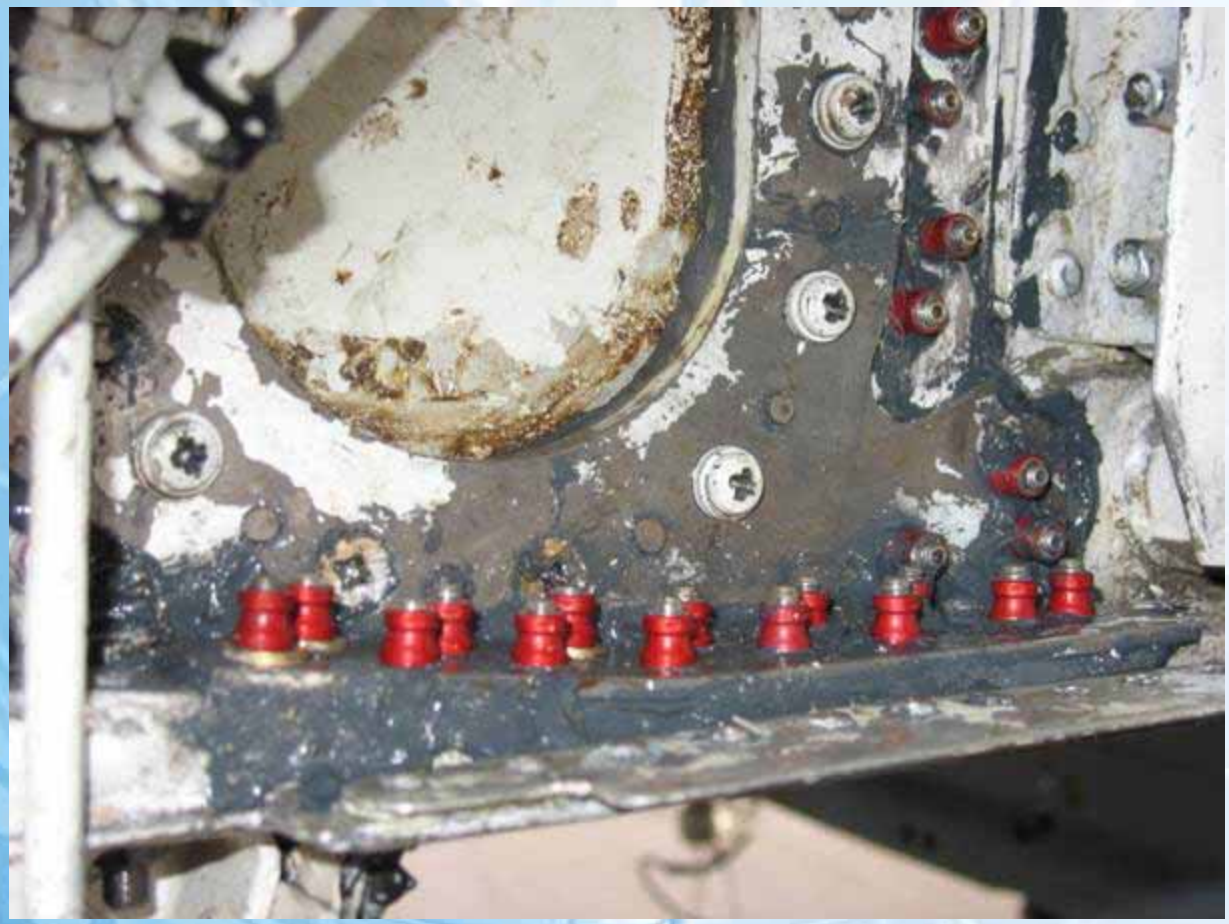




A-4 front spar cracking

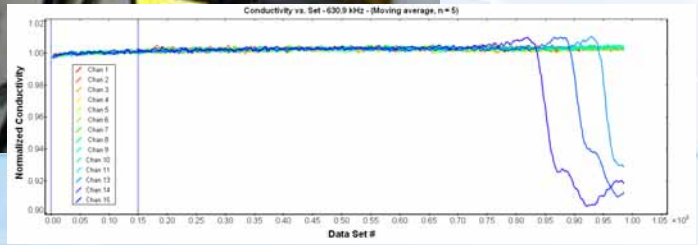
MWM embedded sensors

MWM embedded sensors

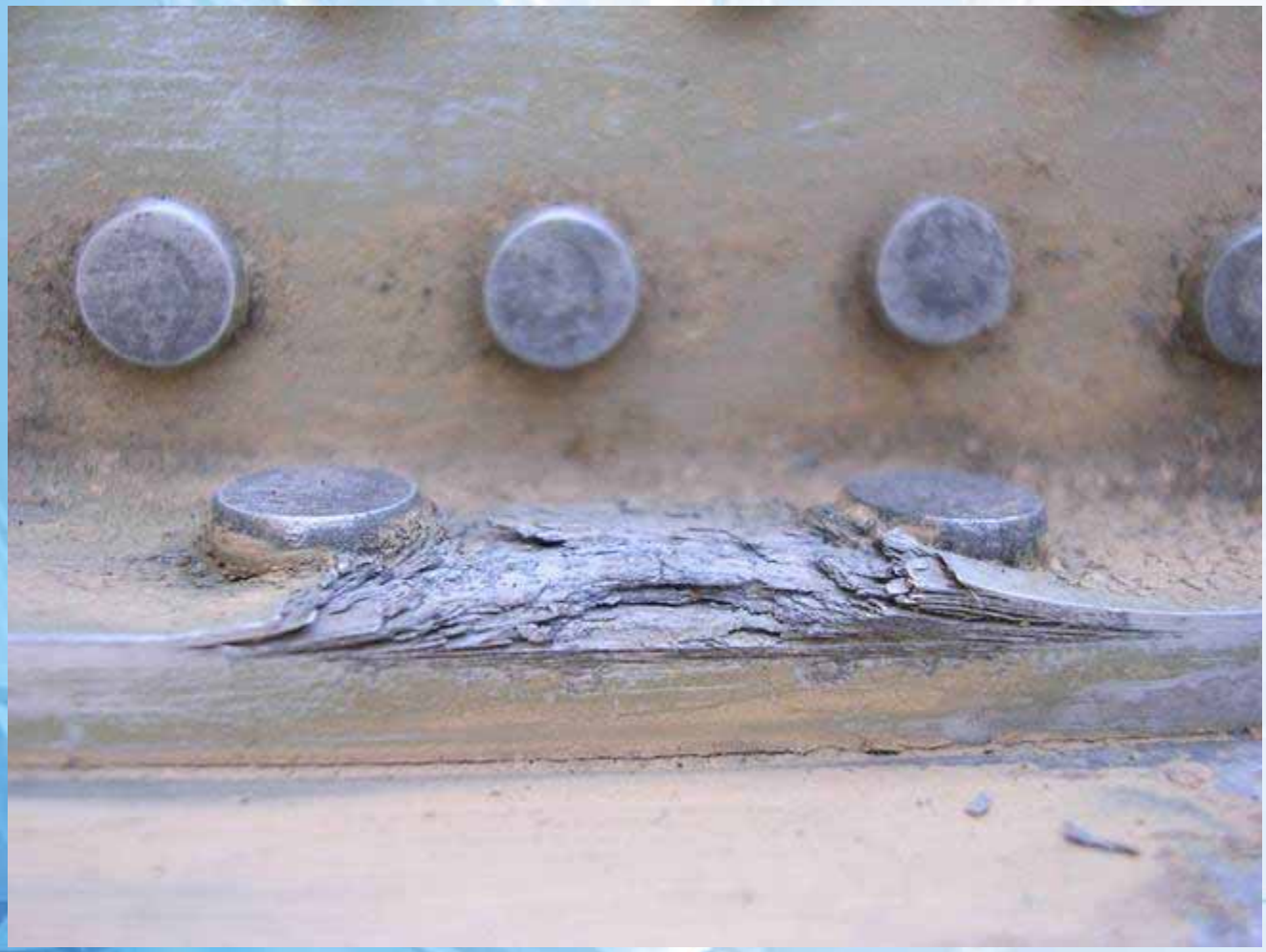


MWM embedded sensors

MWM embedded sensors



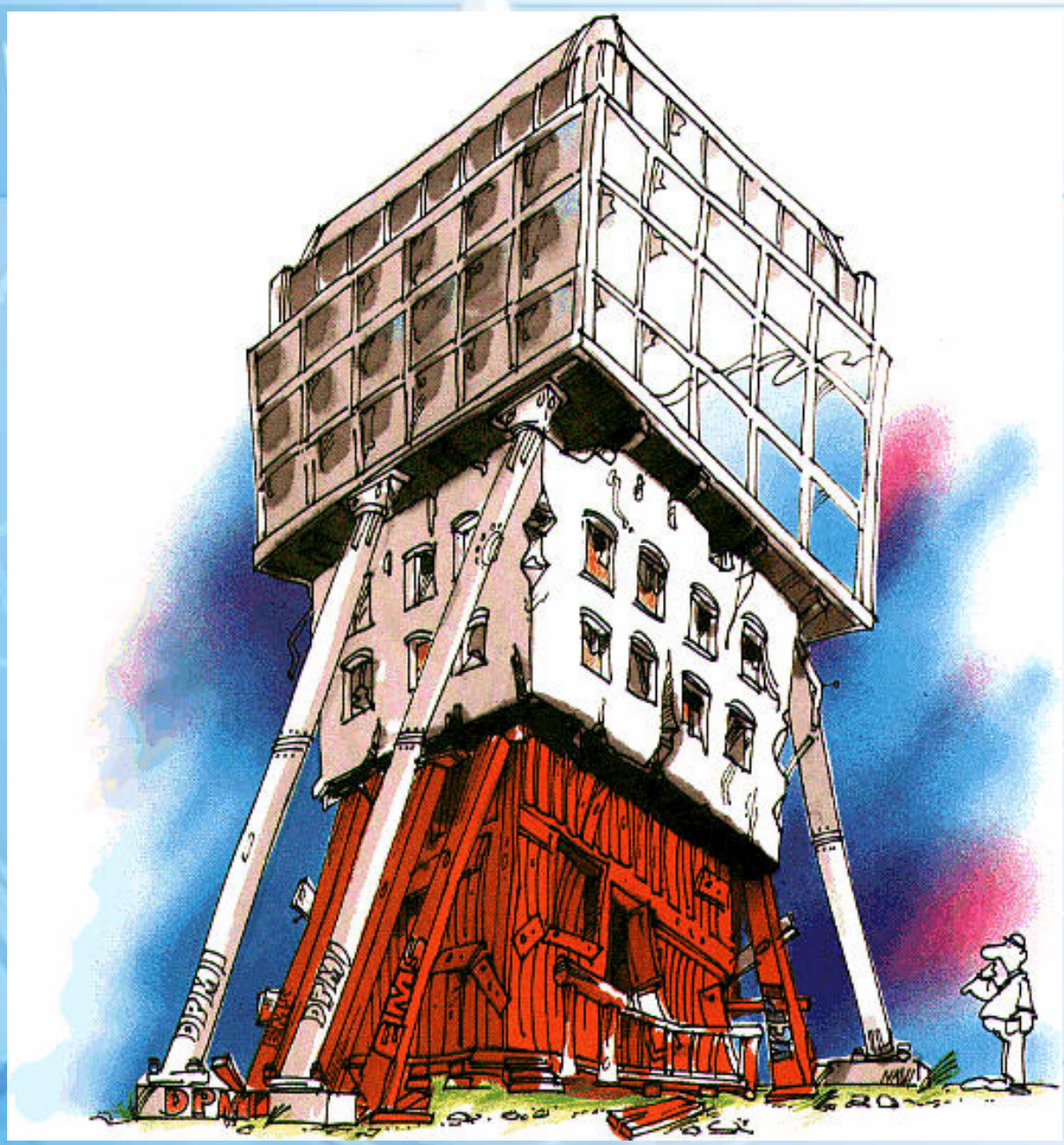
Looking for corrosion detection sensors



Usage database

Usage database

- Some a/c have flight data recorders but do not have LESS/ IAT compatible software
  - Data is used for debriefing or mishap investigations
  - Not stored for usage tracking
- OEM cannot use this data – Use of pilot questionnaire


DPMT
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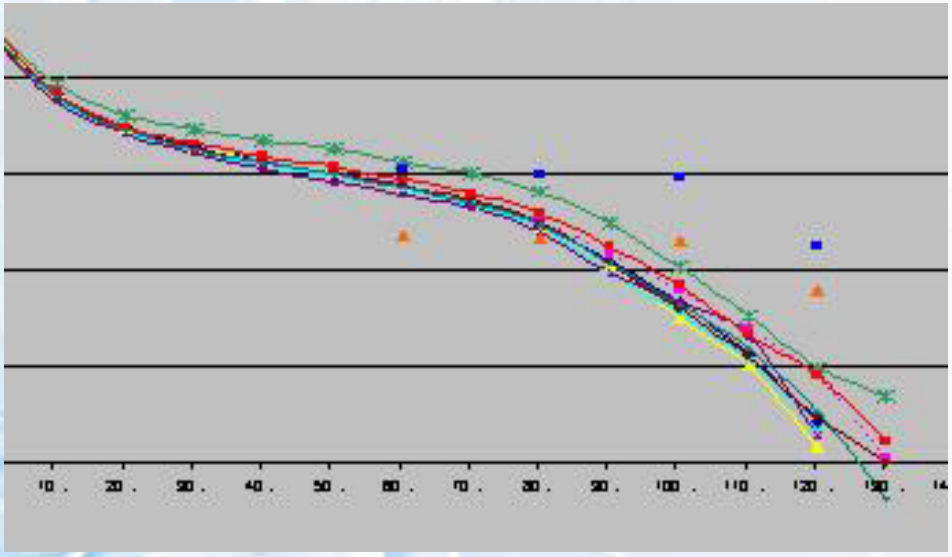
Usage database

Example

Gear failure



Torque exceedances taken from CDR data

Usage database

- Other needs for the flight recorded data:
  - Military Flight Operations Quality Assurance (MFOQA)
  - Pilot debriefing
  - Predictive maintenance for other systems
  - Health Usage Monitoring Systems (HUMS)
- Joining effort helps getting the needed budget and resources

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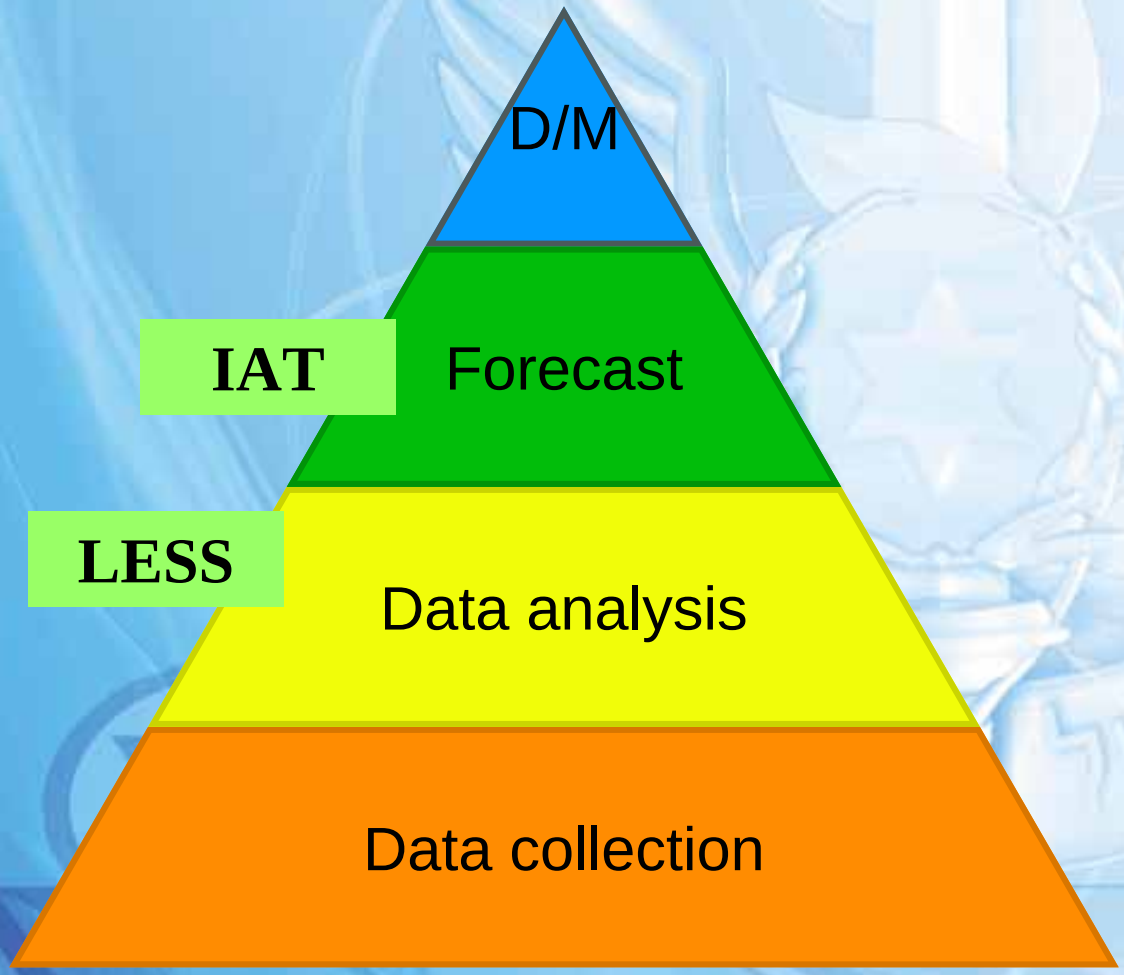
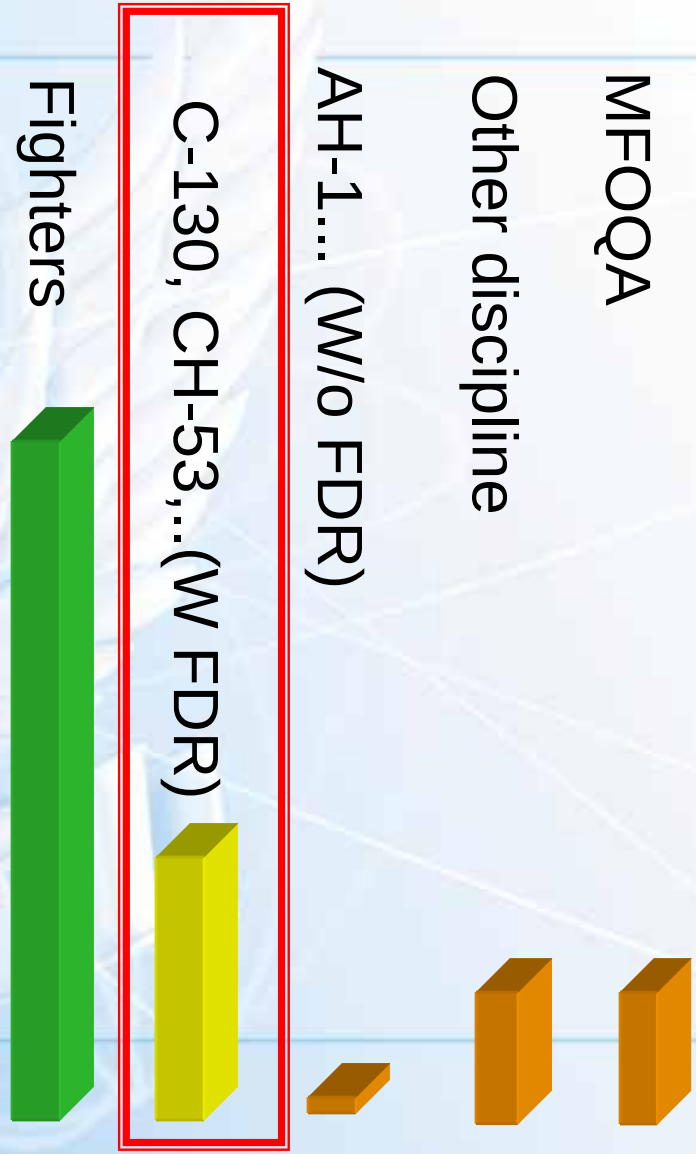
Usage database

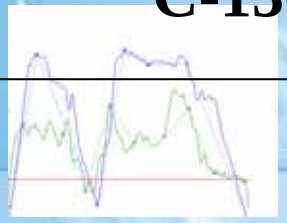
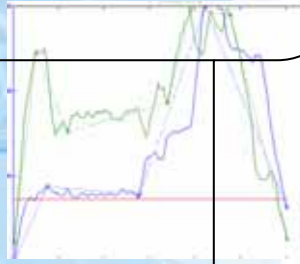
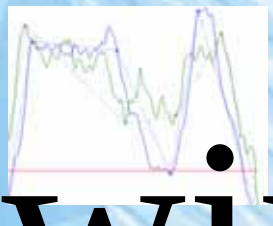
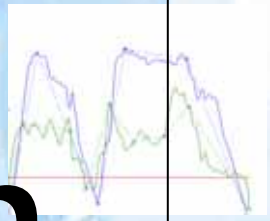
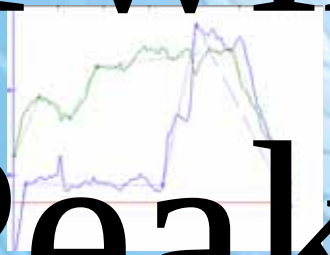
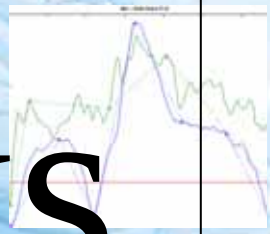
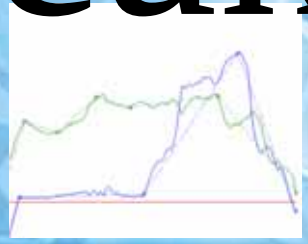
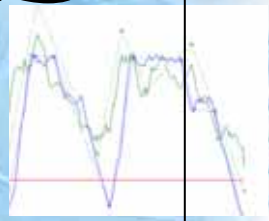


IAT

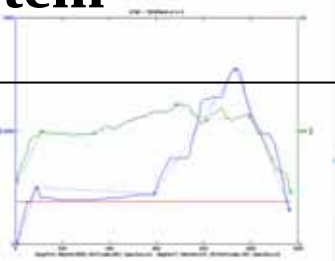
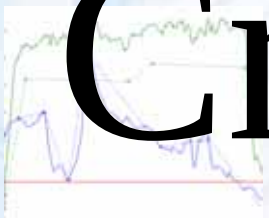
LESS

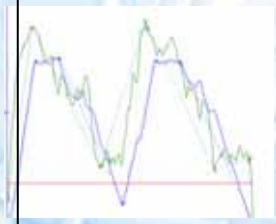


C-130 missions classifying system

Twin Peaks



Cruise & Peak

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DB benefits for ASIP

- Identify usage change
- Compare different groups
- Support mishap investigations
- Limited individual aircraft / components tracking
- Future use

Data base structure

Download

Reports

Validation

Processing, Analysis

data CTH aircraft

data CTH aircraft

data CTH aircraft

data CTH aircraft

Group (Sqn.)

Findings

CTH = Compressed Time History

Data Analysis

- Average flight time
- Alt – Velocity graph
- Nz, RPM exceedance tables
- Weight

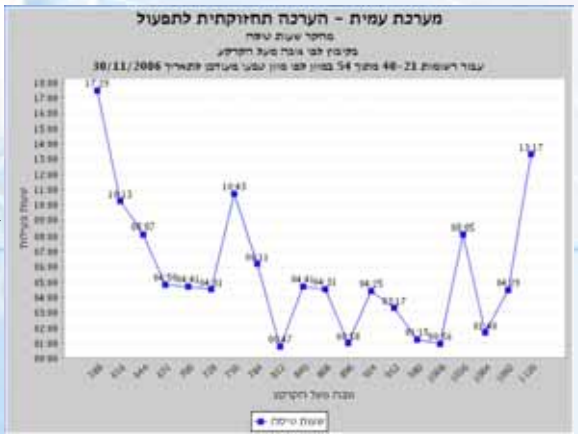
- Mission name
- DB is built in a way that it would be easy to define and implement new analysis on history data (CTH)

The implementation concept

- Based on existing software and hardware (except for HD)
- Almost fully automated process
- A CH-53 DB prototype was established

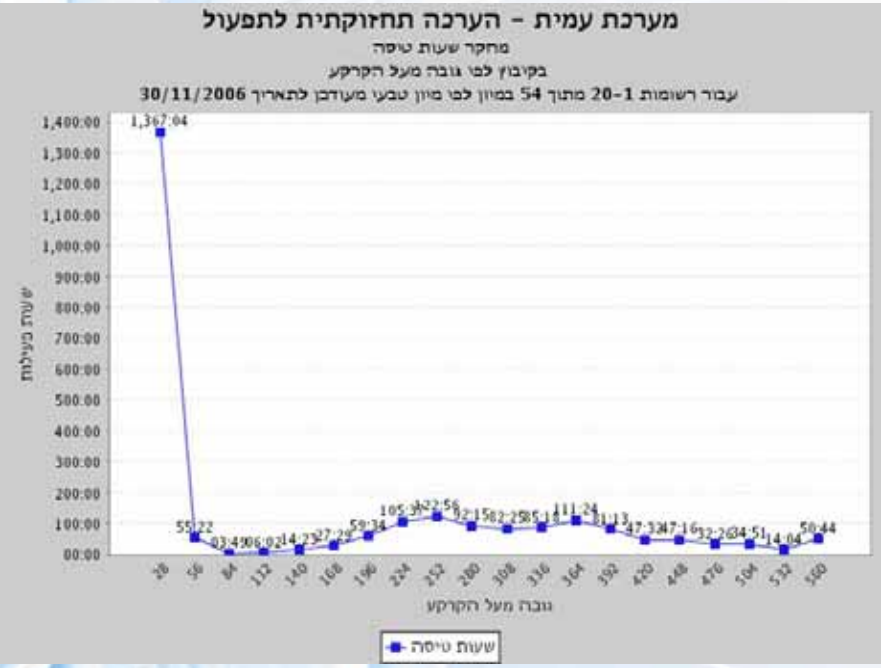
Laptop → Gate to net → Centralized DB server →

Analyze by I/T system



Reports

- Similar to LESS report
- Graphs and tables
  - Compare time intervals
  - Compare groups
  - Available on the IAF net



Summary

- Predictive maintenance (PdM) is a maintenance concept developed in the recent years

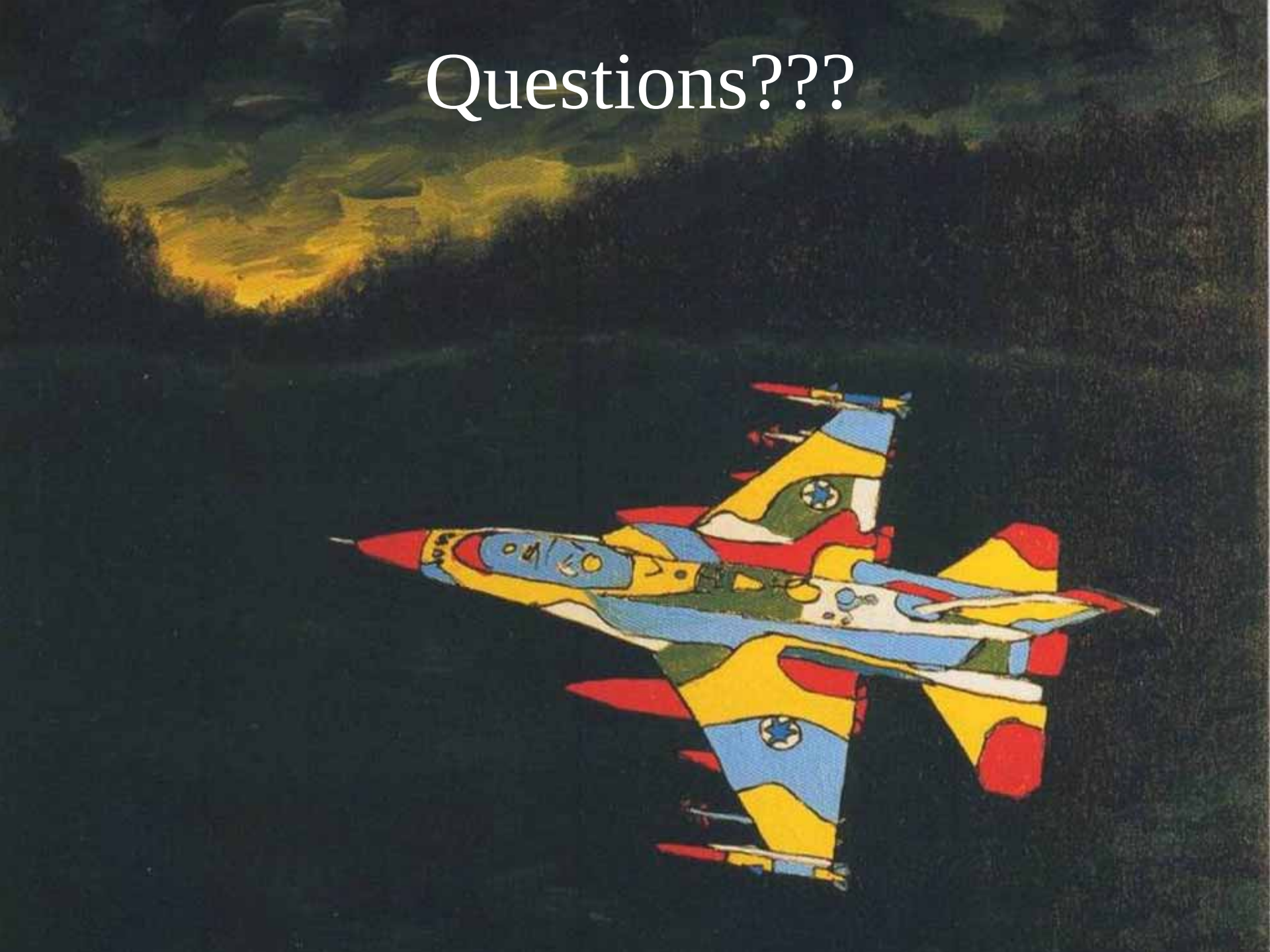
- Increases safety and reduces costs

- PdM and ASIP:
  - Different point of view of ASIP activity
  - Joint vision of future maintenance with other discipline
    - Gain budget and resources

Summary

- As part of PdM activity, structures branch initiated two projects:
  - Embedded sensors
  - Usage database
- Implementation within few months

- Future projects are in plan

- Looking to share ideas and effort

Questions???