

Image Cover Sheet

CLASSIFICATION

SYSTEM NUMBER

511919

UNCLASSIFIED



TITLE

Materials Solutions to the Aging Aircraft Problem

System Number:

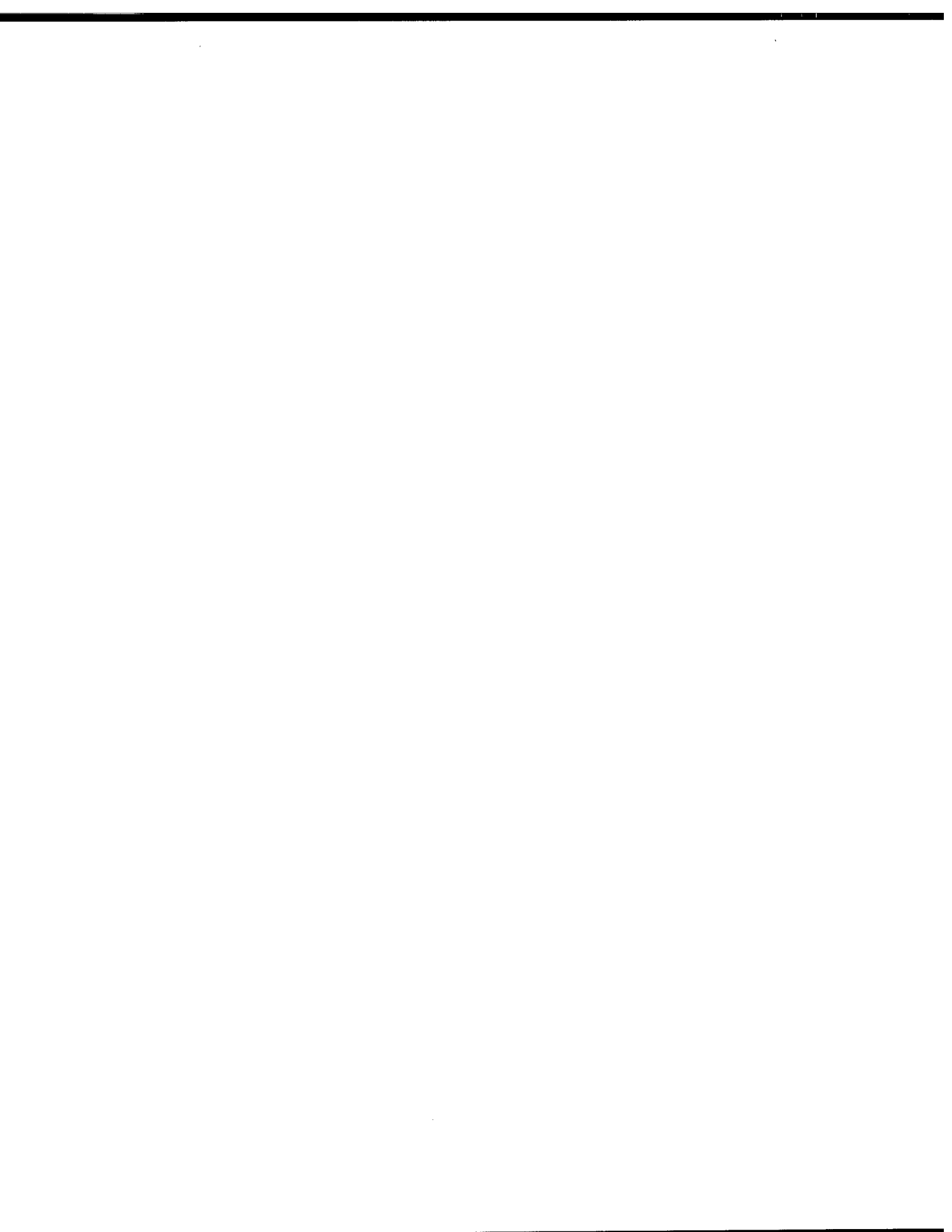
Patron Number:

Requester:

Notes: Paper #45 contained in Parent sysnum #511874

DSIS Use only:

Deliver to: CL



Materials Solutions to the Aging Aircraft Problem

by K.I. McRae

Air Vehicles Research Detachment, National Defence Headquarters, 101 Colonel By Drive, Ottawa, Ontario, K1A 0K2


ABSTRACT

The Air Vehicles Research Detachment is responsible for the delivery of all R&D that directly concerns the CF aircraft in the areas of aircraft structures and materials, aeropropulsion, aerodynamics and flight mechanics. The constraints to maintain these fleets of aging aircraft for extended periods of time has required the development of novel approaches and concepts in order to reduce the costs involved in this long term maintenance effort. This paper will outline the severity of the "aging aircraft" problem within the CF and will describe several of these recent developments that are or will be applied from the materials perspective. These will include:

- a novel heat treatment for 7075-T6 aluminum alloys in order to reduce the incidence of stress corrosion cracking and the possible in-situ application on major aircraft structural components;
- the development of methodologies for the repair and re-certification of gas turbine engine components;
- the development of improved techniques for nondestructive evaluation, particularly for the detection of hidden corrosion and cracks under fasteners; and
- the development of new metrics for the quantification of corrosion as well as methods for assessing the interaction of corrosion and fatigue damage.

DEFENCE **RiD** DÉFENSE

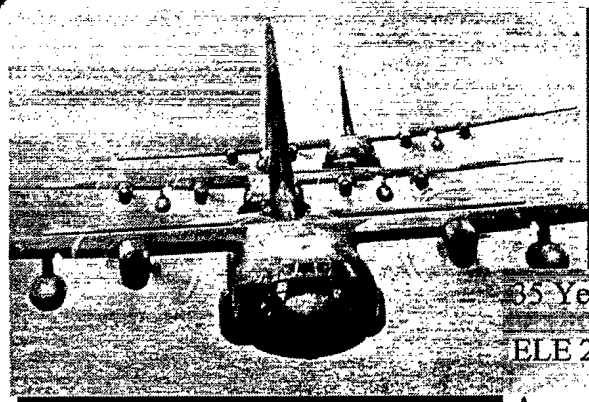
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010

 National
Défence

Défense
nationale

Canada

CC130 Hercules



35 Years Old
ELE 2010
Age on Retirement - 46

DEFENCE **RiD** DÉFENSE

Defence and Civil Institute of Environmental Medicine (DCIEM)

CP140 Aurora



18 Years Old
ELE 2010
Age on Retirement - 29



Defence and Civil Institute of Environmental Medicine (DCIEM)

CF188 Hornet



15 Years Old
ELE 2010
Age on Retirement - 26



Defence and Civil Institute of Environmental Medicine (DCIEM)

The Aging Aircraft Problem

- All aircraft fleets will see service up to or beyond their original design life.
 - Management of fatigue (airframes and engines) will continue to be an issue.
- The management and abatement of corrosion will become an increasingly important issue.
- Airworthiness of all CF fleets will be maintained, but...
 - How can the cost of maintenance be reduced?
 - When has the economic life of an aircraft been exceeded?



Defence and Civil Institute of Environmental Medicine (DCIEM)

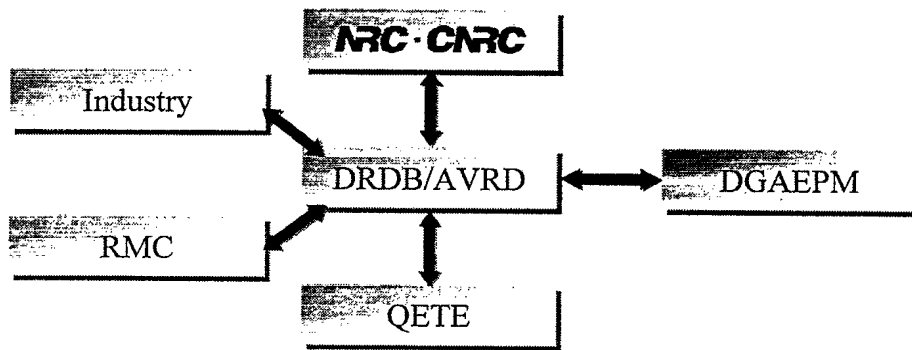
Presentation Outline

- The Aging Aircraft Problem
- Relationship of DRDB and DGAEPM programs
- Airframe structural repair technologies
- Engine life assessment and extension
- Advanced materials research
- Novel NDT techniques
- Advanced structural integrity concepts
- Conclusion



Defence and Civil Institute of Environmental Medicine (DCIEM)

Aging Aircraft Program Delivery



Defence and Civil Institute of Environmental Medicine (DCIEM)

Air Vehicles Technologies

DRDB has structured three projects within the Air Vehicles Technologies Thrust to address these problems:

- Aeropulsion/Gas Turbine Technologies
- Aircraft Structures and Materials
- Gas Turbine Repairs/reworks



Defence and Civil Institute of Environmental Medicine (DCIEM)

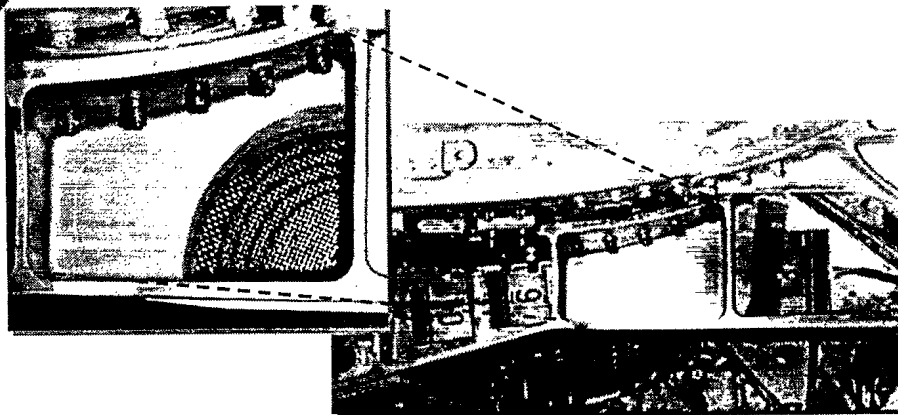
Airframe Structural Repair

- Composite patch for fatigue life enhancement
 - CF188 Bulkhead Composite Patch
 - Improved patch adhesion and durability
- Novel heat treatments
 - in-situ RRA for CC130 sloping longeron



Defence and Civil Institute of Environmental Medicine (DCIEM)

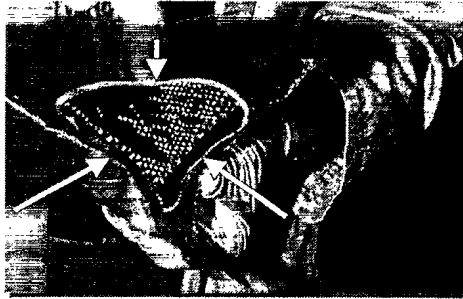
CF-18 Bulkhead Composite Patch



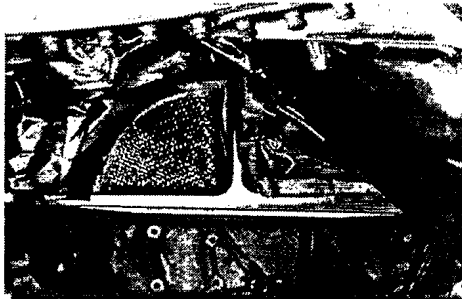
Defence and Civil Institute of Environmental Medicine (DCIEM)

Prototype Patch Installation

B-staged Patch Ready for Installation

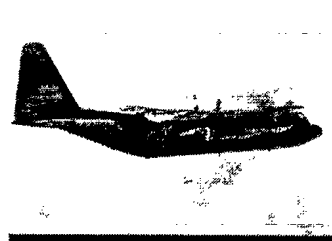


Placement of Patch in X-19 Corner



Defence and Civil Institute of Environmental Medicine (DCIEM)

In-situ RRA Treatment for CC130 Sloping Longerons



Problem

Stress corrosion cracking occurring on the sloping longeron of the CC130 Hercules

Proposed Solutions

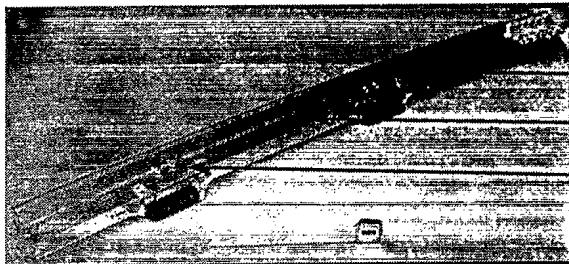
- (1) Use RRA on Al 7075-T6 to maintain the high strength of the T6 temper while gaining the corrosion resistance of the T73 temper
- (2) Adapt the parameters of the RRA process to an in-situ treatment



Defence and Civil Institute of Environmental Medicine (DCIEM)

RRA - CC130 sloping longeron

Tests were conducted on service-exposed longeron using Zimac hot bonder and heater cells/blankets, heat was applied directly to the longeron in localized regions.

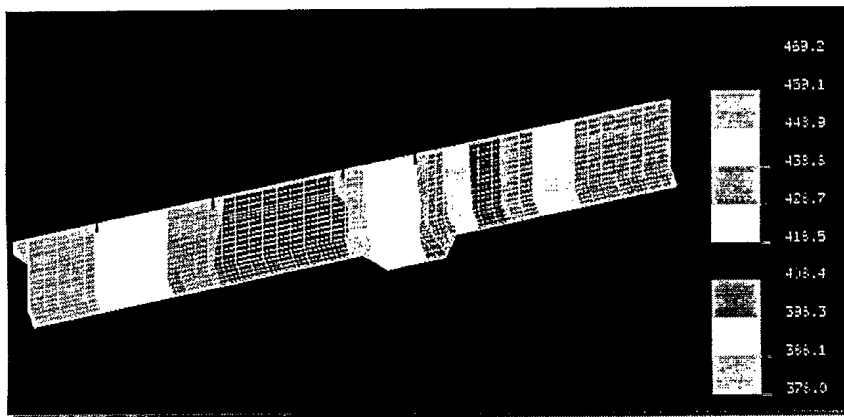


Heat-affected zone
Heat-treated zone
Heat-affected zone



Defence and Civil Institute of Environmental Medicine (DCIEM)

RRA - CC130 sloping longeron



Defence and Civil Institute of Environmental Medicine (DCIEM)

Engine Life Extension

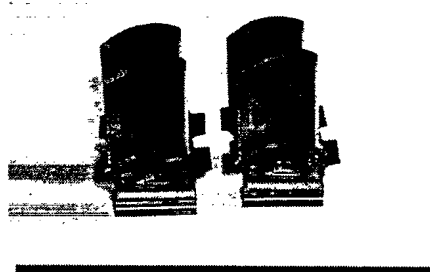
- Damage tolerance and life extension methodologies for:
 - NENE X
 - J-85 CAN 40
- Repair, Re-works and Certification Methodologies for F404



Defence and Civil Institute of Environmental Medicine (DCIEM)

Project Objectives

- Develop a qualification methodology for new repairs.
- Implement this method by qualifying a number of advanced repair techniques on the F404 engine.
- Contracted to Orenda Aerospace Corporation and NRC/IAR



Defence and Civil Institute of Environmental Medicine (DCIEM)

F404 Repair and Re-qualification



Defence and Civil Institute of Environmental Medicine (DCIEM)

Engine Repairs and Qualification

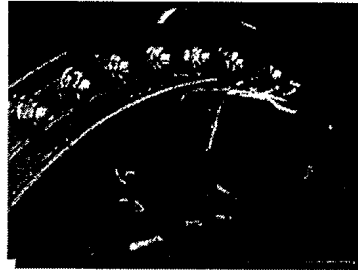
- Analysis has shown over \$18M in direct savings against \$4M investment.
- Repair methodology is being applied to many other F404 components with potential savings of over \$60M.



Defence and Civil Institute of Environmental Medicine (DCIEM)

Advanced Materials Research

- Improved methods for adhesive bonding and paint adhesion
- High temperature coatings for engine applications
- Thermal spray coatings for corrosion abatement of 7075-T6
- Hard chromium alternative technologies (HCR)



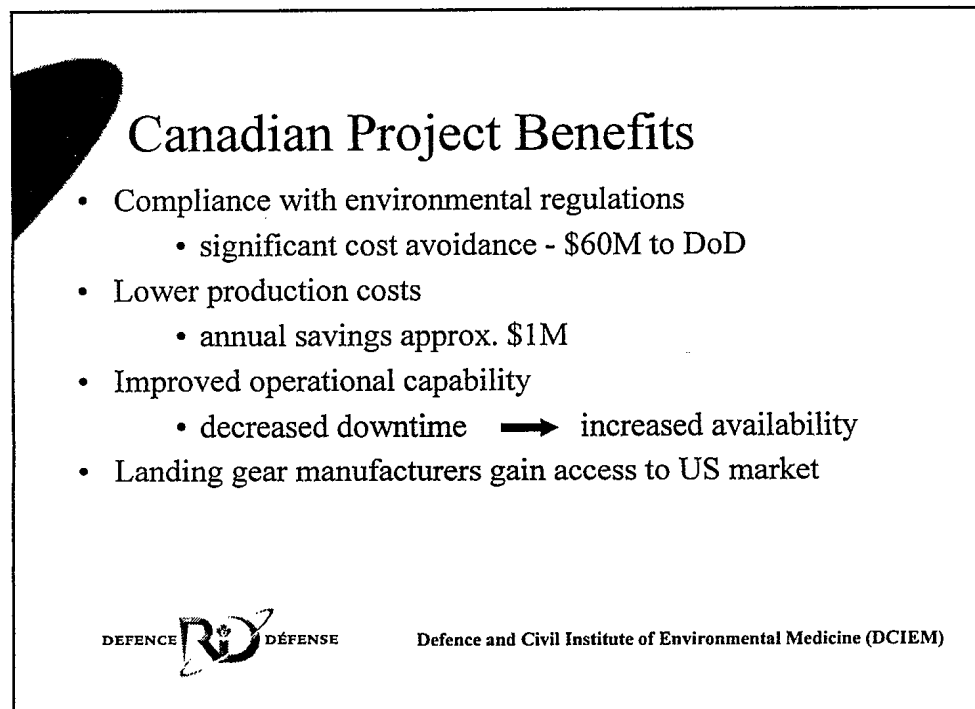
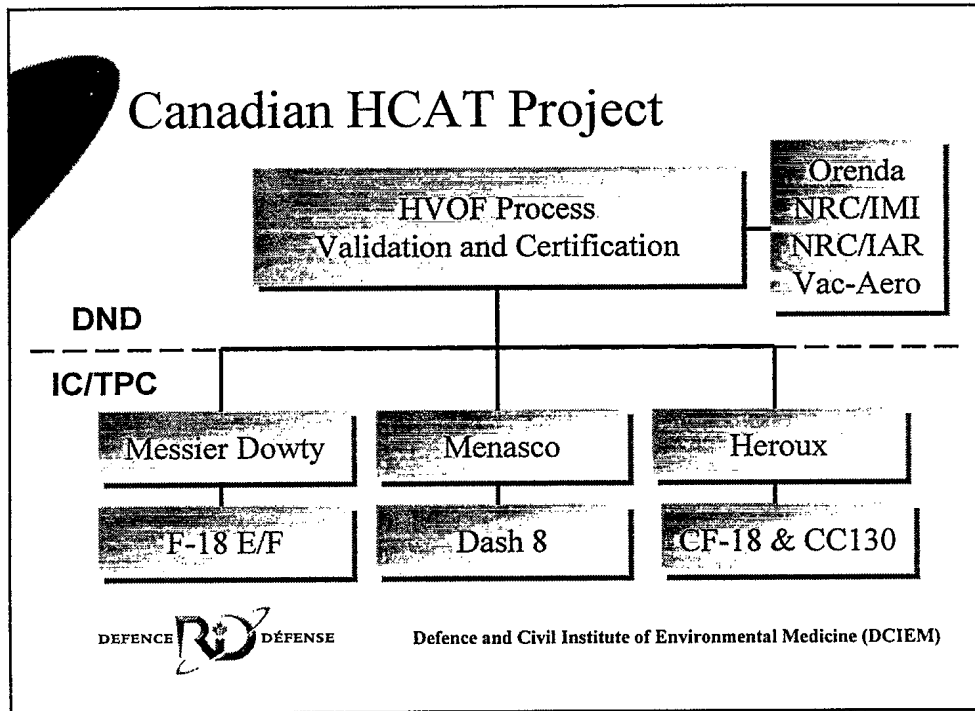
Defence and Civil Institute of Environmental Medicine (DCIEM)

Hard Chromium Alternatives

- US DoD and DND joint program to replace hard chrome on landing gears
- Elimination of Cr^{6+} from the environment
- WC-Co and WC-CoCr coatings applied by HVOF spraying
- Currently limited to landing gear applications but can extend to actuators and engine components



Defence and Civil Institute of Environmental Medicine (DCIEM)



Novel NDT Techniques

- Edge-of-light (NRC/IAR)
- Dual frequency eddy current
- Pulsed eddy current
- Laser ultrasonics
- CF-18 Rudder water ingress
- Cracks under fasteners



Defence and Civil Institute of Environmental Medicine (DCIEM)

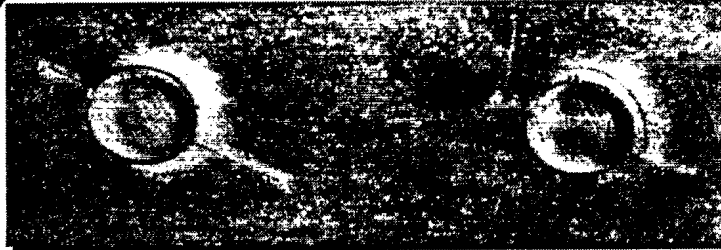
Edge-of-Light for Corrosion Detection

This is a scanner based optical inspection system which finds pillowing caused by corrosion in riveted joints.



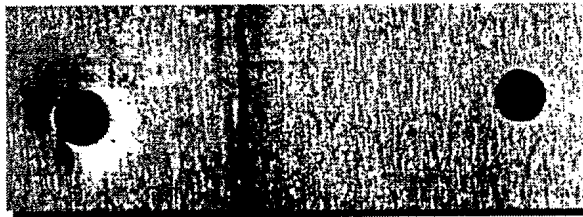
Defence and Civil Institute of Environmental Medicine (DCIEM)

Edge of Light NDI



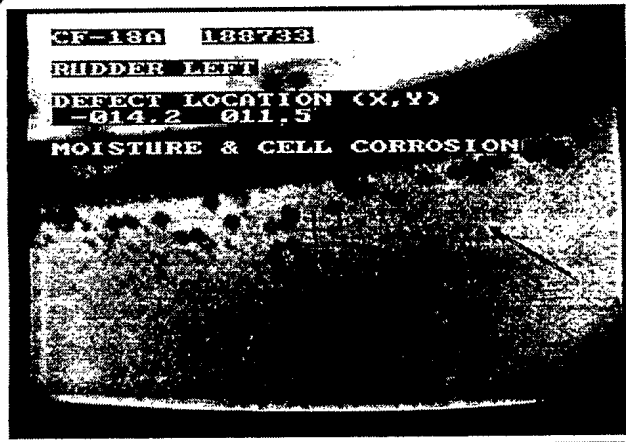
Crack
Detection

Detection of
Cold-working



Defence and Civil Institute of Environmental Medicine (DCIEM)

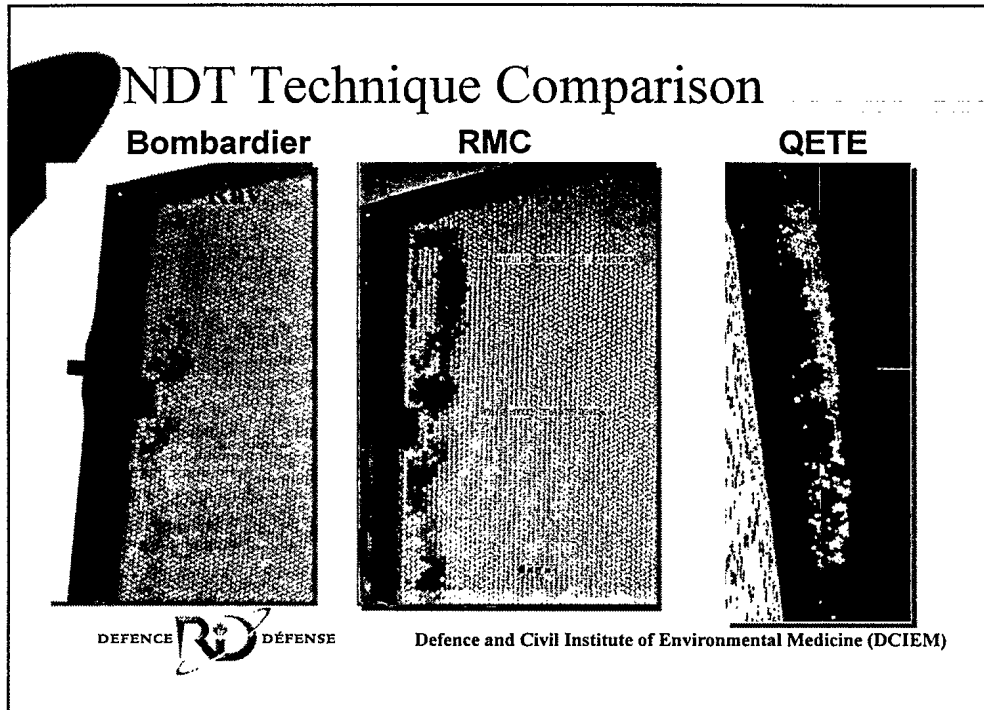
CF-18 Rudder Water Ingress



N-rays are attenuated by light elements such as hydrogen, hydrated materials or hydroxides in corrosion products.




Defence and Civil Institute of Environmental Medicine (DCIEM)



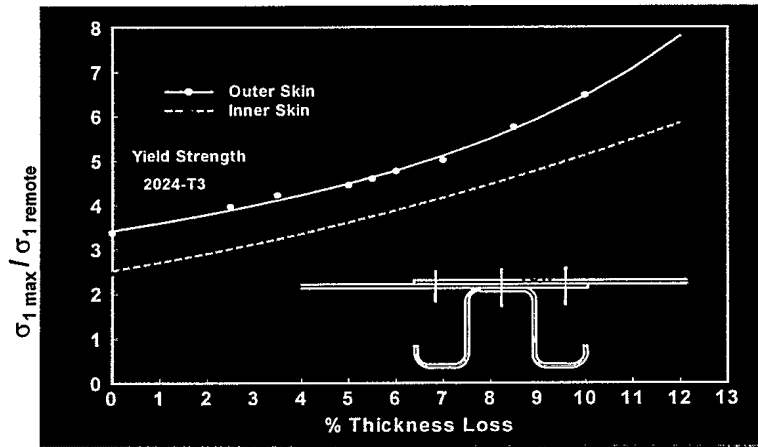
Life Cycle Management Issues

- Effect of corrosion pillowing
- Probabilistic reliability assessment
 - fly to a known level of reliability
 - integration with corrosion effects
 - probability of detection (POD) from in-service data

DEFENCE  DÉFENSE

Defence and Civil Institute of Environmental Medicine (DCIEM)

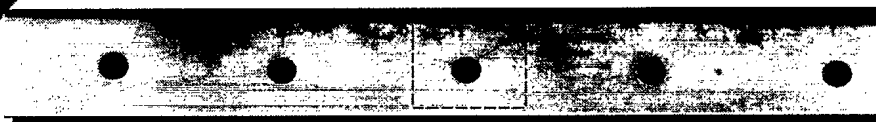
Effect of Pillowing



DEFENCE DÉFENSE

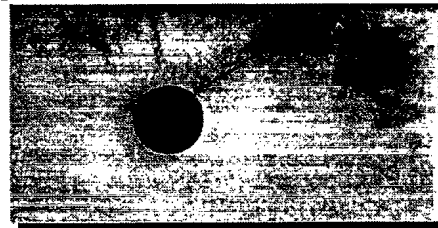
Defence and Civil Institute of Environmental Medicine (DCIEM)

Boeing 727 Specimen Teardown



X-ray images

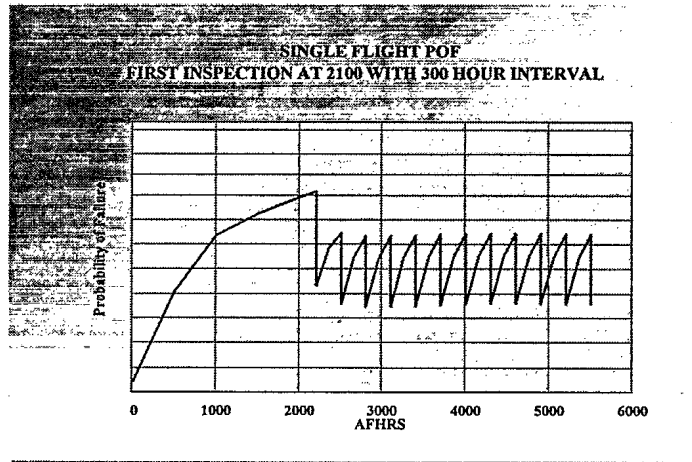
- Upper rivet row inner skin, faying surface.
- Dark areas contain ~10% thickness loss maximum.
- Cracks in the areas adjacent to maximum corrosion pillowing.



DEFENCE DÉFENSE

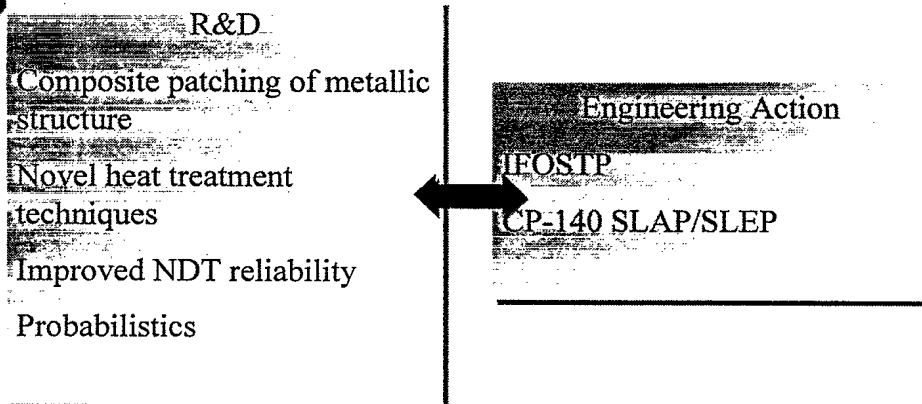
Defence and Civil Institute of Environmental Medicine (DCIEM)

Reliability Analyses



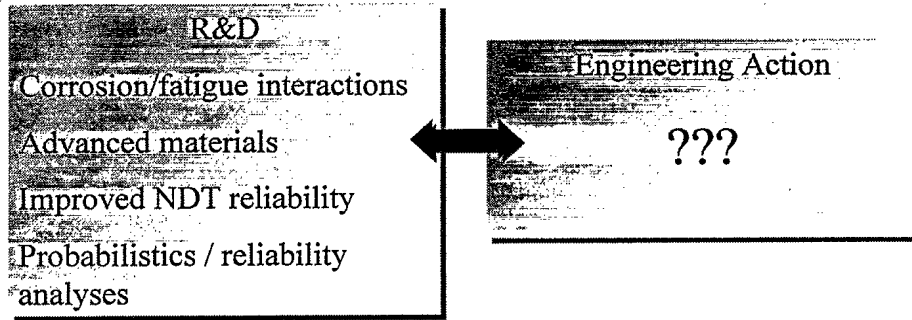
Defence and Civil Institute of Environmental Medicine (DCIEM)

Present DRDB R&D Activities



Defence and Civil Institute of Environmental Medicine (DCIEM)

Future R&D Demands



Defence and Civil Institute of Environmental Medicine (DCIEM)