DEFENCE R&D DÉFENSE

Stealth:
Materials and Techniques for Signature Reduction

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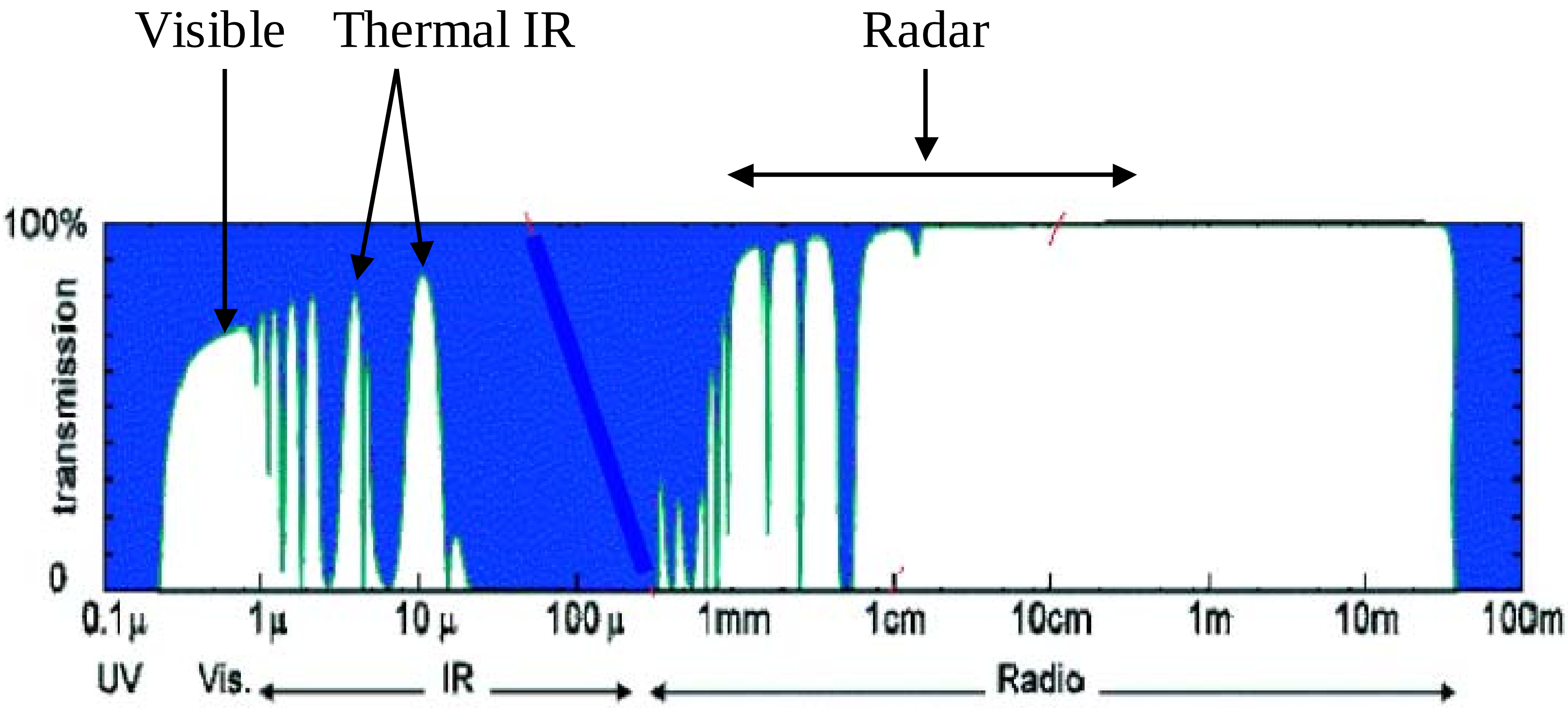
How is Stealth a Disruptive Technology?

- Improved Survivability
  - Makes enemy work harder to detect your assets thus disrupting the way they carry out operations.
- Tactical
  - Allows operation at closer ranges with increased impunity.
- Counter Stealth
  - With increasing numbers of countries developing stealth technology we will need to work harder at detecting them.

Signature Reduction Talk Overview

- Radar
  - RAM and RCS Reduction
- Thermal
  - Solar Reflective Paints
- Visual
  - Adaptive Camouflage

Atmospheric Absorption

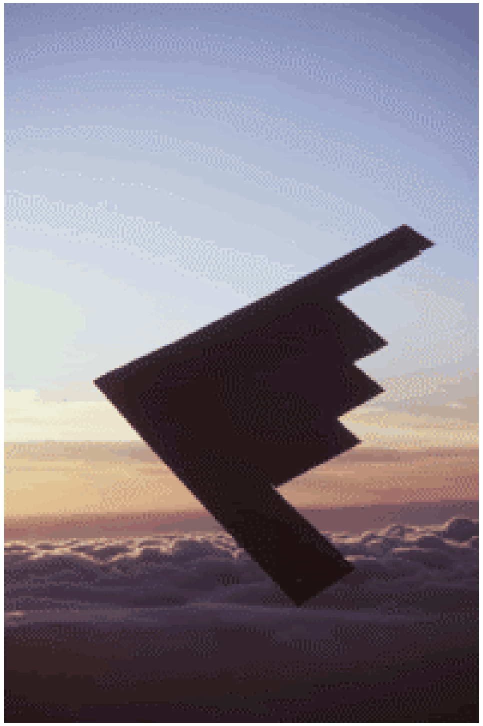


Signature and Wavelengths

- Visible
  - 400 - 720 nm (0.4 - 0.72 um)
- Near Infrared (NIR)
  - 700 - 2300 nm (0.7 - 2.3 um)
- Thermal Infrared (TIR)
  - 2.5 - 15 um
  - 3-5 um and 8-14 um are the bands of interest for thermal missile and surveillance
- mm Wavelengths
  - Battlefield Surveillance radars
- Microwaves
  - 1 to 30 cm, Fire Control radars to Early Warning radars

Rule of Balanced Observables

- A Stealth object should be designed so that every detection system arrayed against it has roughly the same range.
  - There is no point in having a plane that is invisible to radar at 5 km if it can be seen at 10 km.



Radar Absorbing Materials

Radar Absorbing Materials

- Airplanes
- Ships
- Camouflage Nets

- Radar Camouflage
- Electromagnetic Interference Suppression
  - false echoes from ship's own superstructure
- Antenna Performance Enhancement
  - Side and back lobes

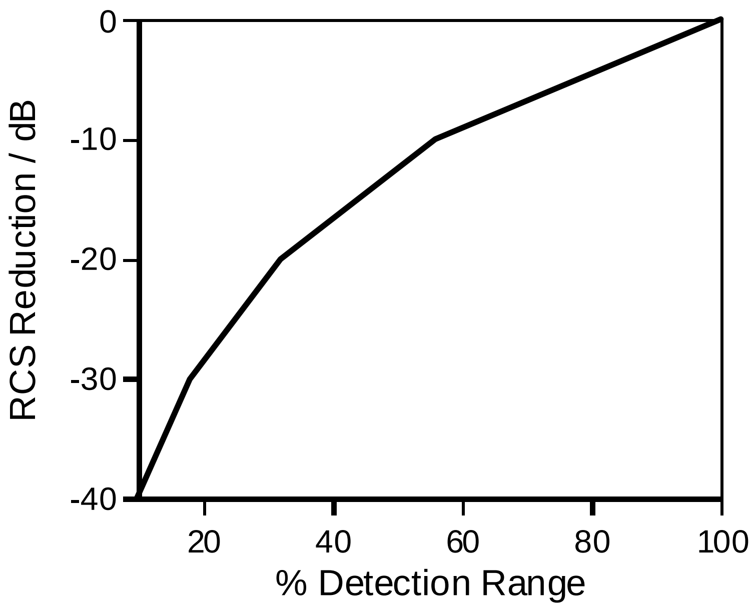
Radar Antenna

Angle Reflectors

Flat Sides

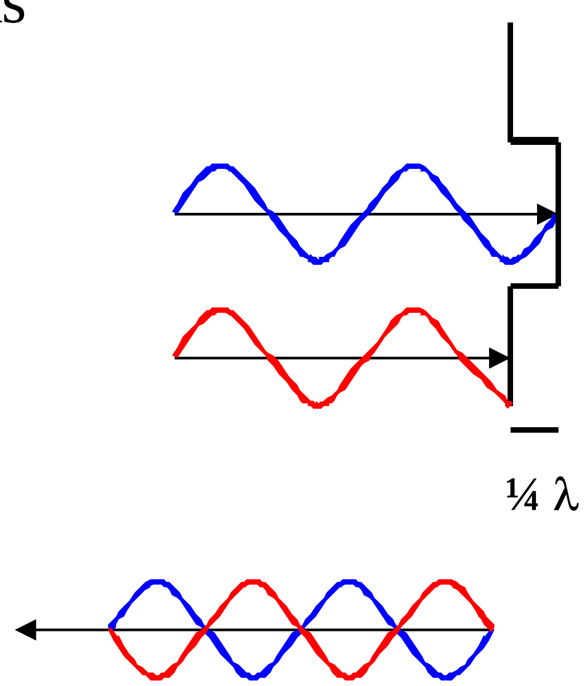
Detection Range vs Radar Cross Section

RCS Reduction	Detection Range
0%, 0 dB	100 (arbitrary)
90%, 10 dB	56
99%, 20 dB	32
99.9%, 30 dB	18
99.99%, 40 dB	10



RCS Reduction Techniques

- Shaping
- Radar Absorbing Materials
- Passive Cancellation
- Active Cancellation



Shaping

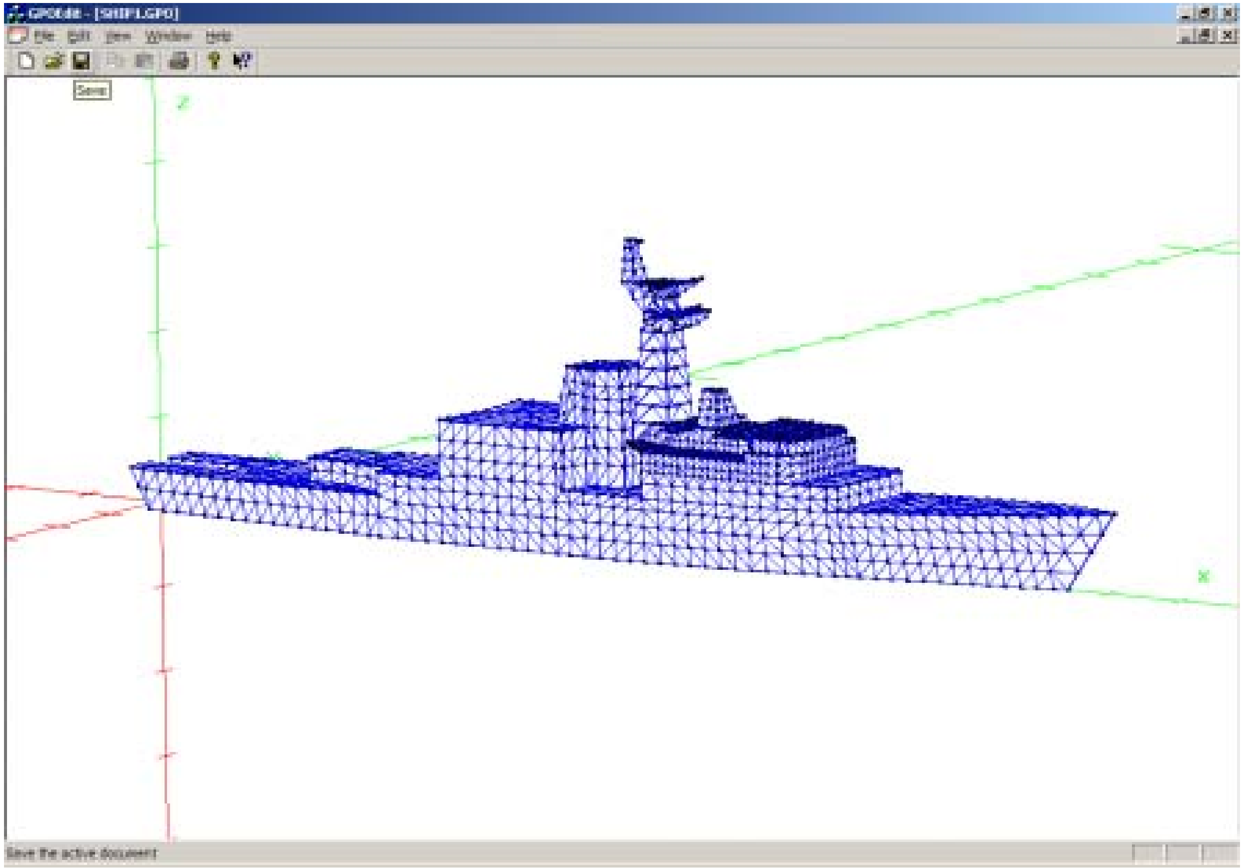
Plane	RCS
B-52	1000 m^2
F-15	25 m^2
F-117	< 0.01 m^2
Bird	0.01 m^2

Jones, Stealth Technology: The Art of Black Magic

RCS Reduction

- Optimum
  - Software optimization based on material properties, RCS reduction and platform design.
- Current
  - One-off calculations of RCS on platform by platform basis.
- Future
  - RCS modelling software based on a design.

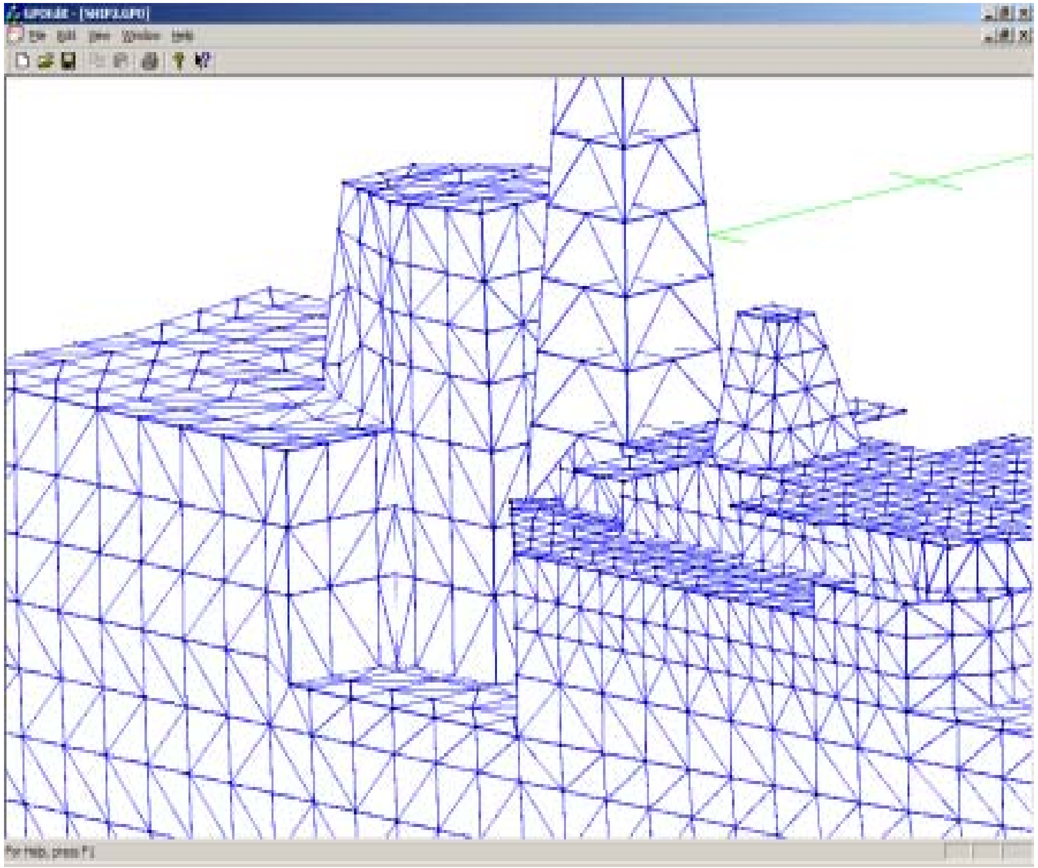
The complex ship model.



Dr Satish Kashyap, DRDC Ottawa

Drs Robert Paknys and Christopher Trueman, Concordia University

Detail of the Frigate Model

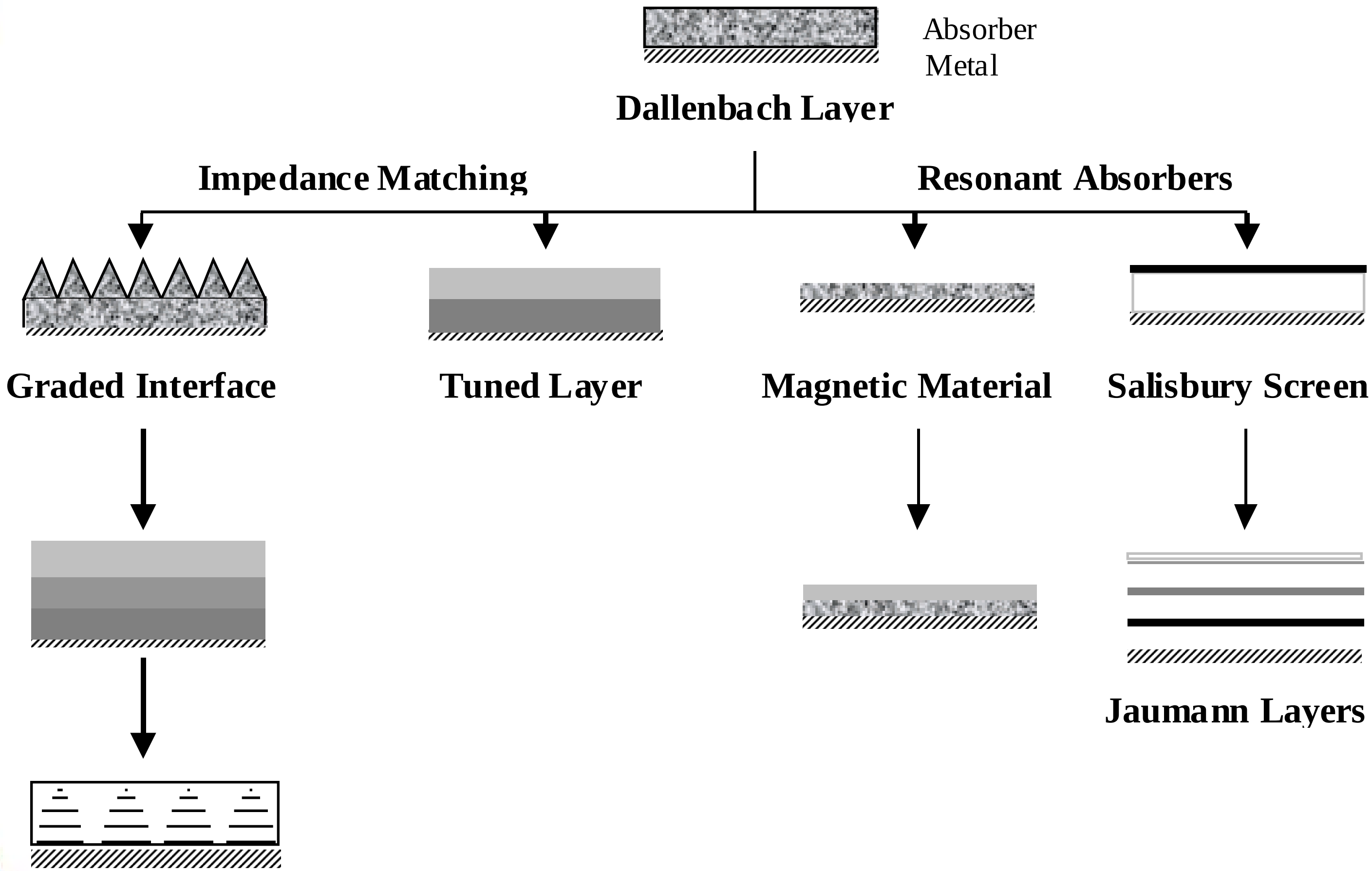


How is this disruptive?

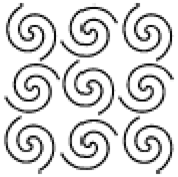
How Radar Absorption Works

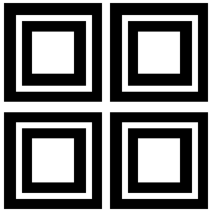
- Conducting Materials…..
  - Electric Field Induces a Current in a Conductor.
    - Resistance, Capacitance and Inductance in the conductor converts the electrical energy into heat.
    - Carbon, Conducting Polymers, Metal Powder
- Magnetic Materials……
  - Electric Field Interacts with Magnetic Domains
    - Carbonyl Iron, Ferrites

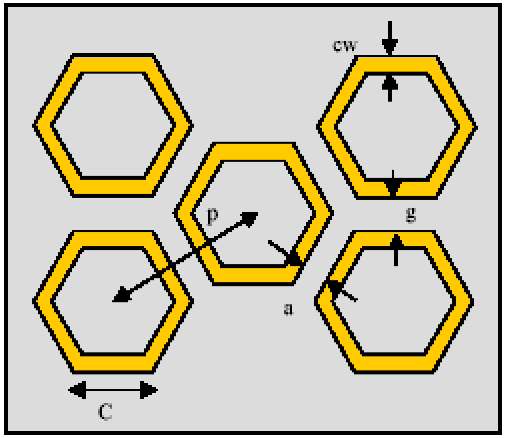
Types of RAM

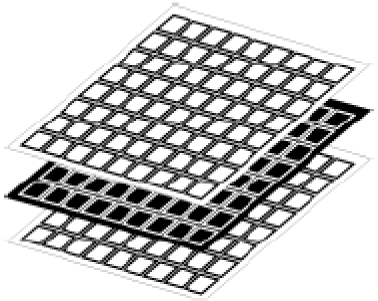

Absorber
Metal
Dallenbach Layer
Impedance Matching
Resonant Absorbers
Graded Interface
Tuned Layer
Magnetic Material
Salisbury Screen
Jaumann Layers

Frequency Selective Surfaces
Circuit Analog Material

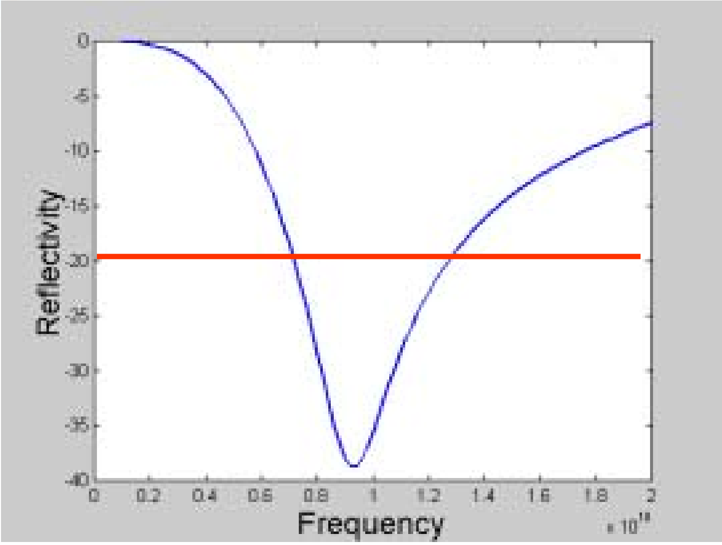




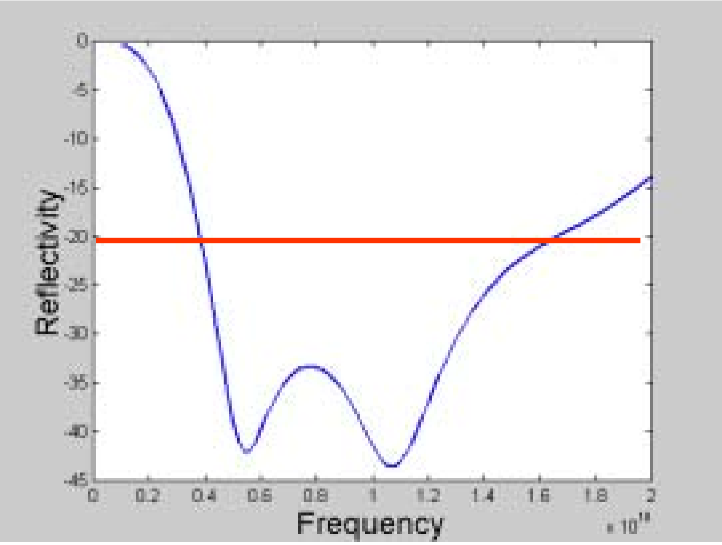




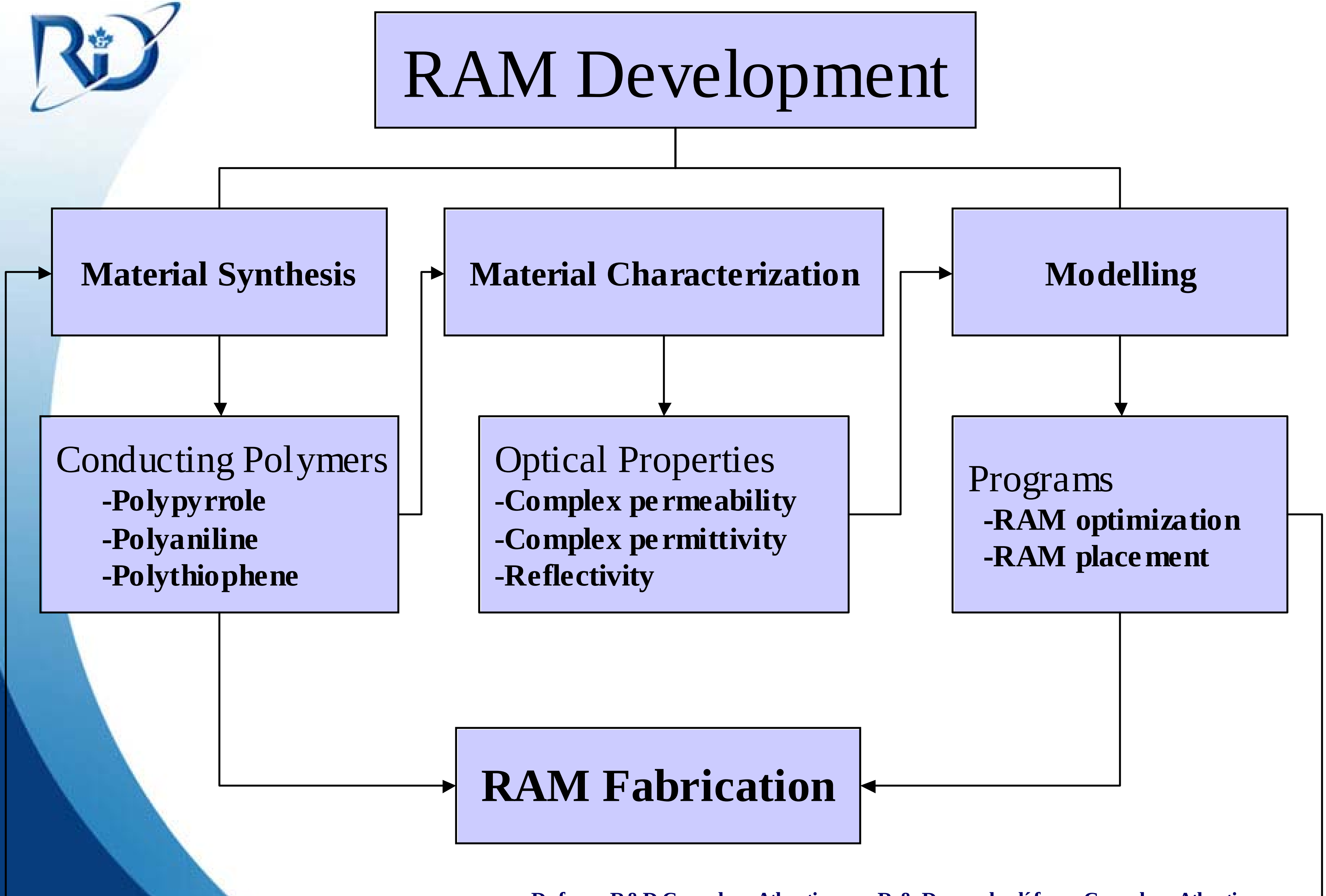
Bandwidth



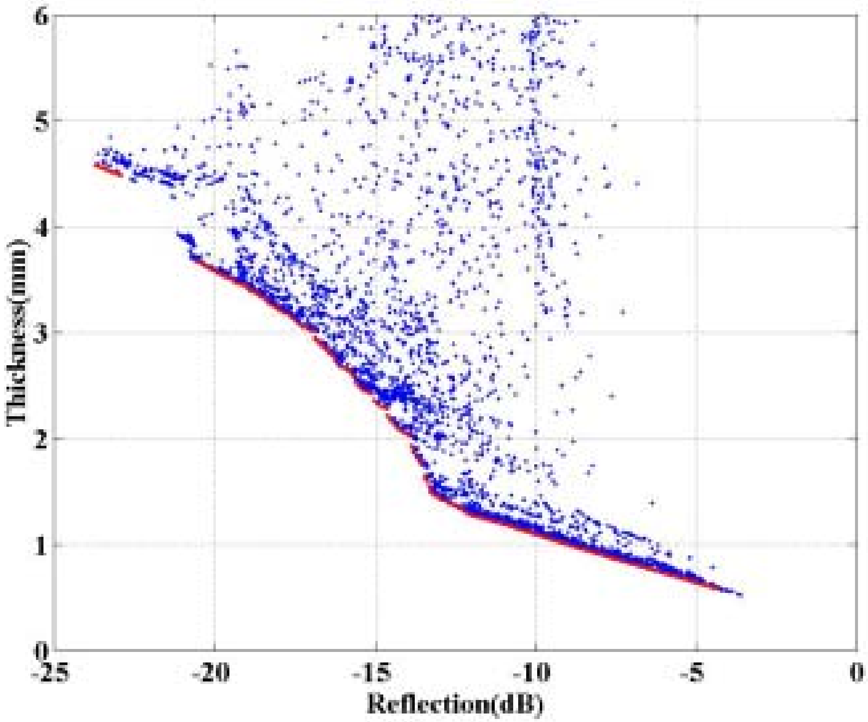
Salisbury Screen



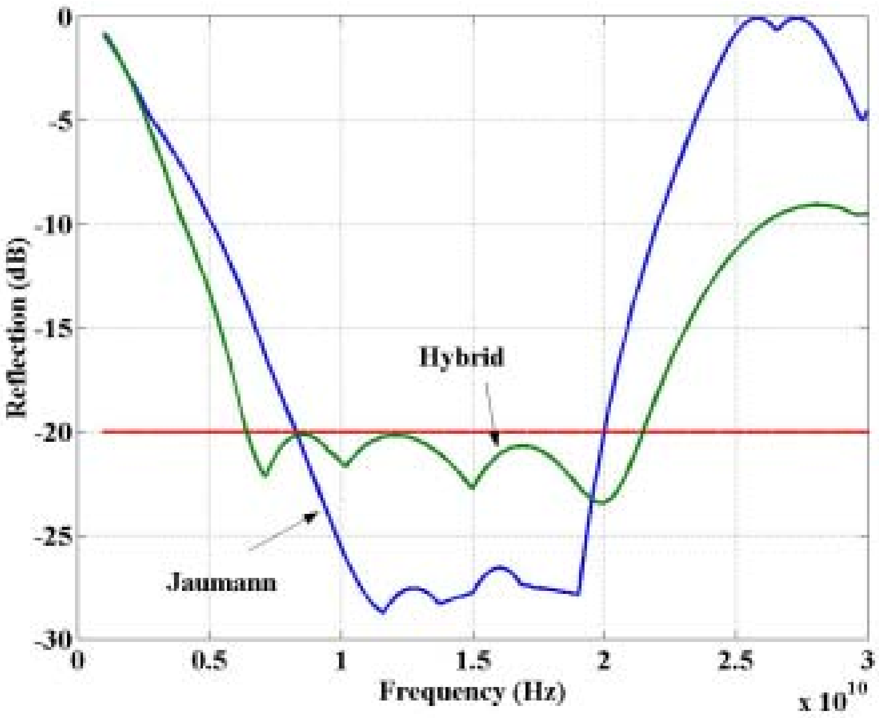
Jaumann Layers


RAM Development
Material Synthesis
Material Characterization
Modelling
Conducting Polymers
-Polypyrrole
-Polyaniline
-Polythiophene
Optical Properties
-Complex permeability
-Complex permittivity
-Reflectivity
Programs
-RAM optimization
-RAM placement
RAM Fabrication

Jaumann Absorber Optimization by the Genetic Algorithm



Optimized Structure



RCS and RAM Summary

- **Materials Synthesis**
  - Drs Trisha Huber and Paul Saville, DRDC Atlantic
  - Professor Robin Hicks, University of Victoria
- **Materials Characterization and Device Modelling**
  - Professor Maria Stuchly, University of Victoria
- **Radar Cross Section**
  - Dr Satish Kashyap, DRDC Ottawa
  - Professors Paknys and Trueman, Concordia University

Thermal Camouflage

Solar Reflective Paint

Stealth?

- Reduce excessive heating of equipment due to absorption of solar radiation
- By reducing the heating of the equipment the thermal signature is reduced

Dr Terry Foster, DRDC Atlantic
TTCP

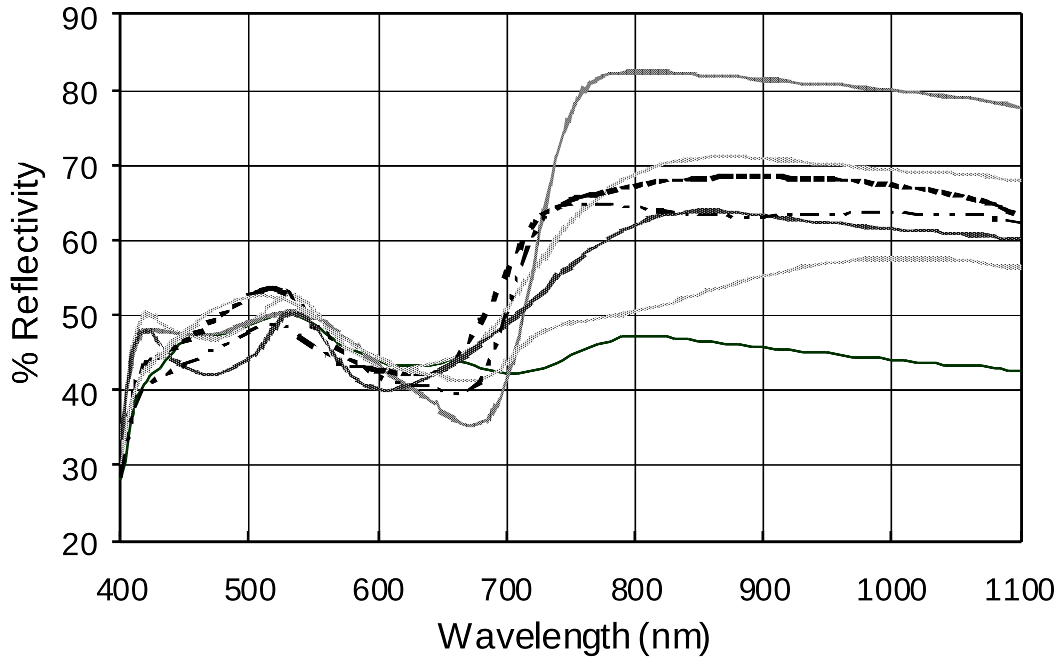
Distribution of Solar Energy

- 5% ultra-violet (less than 400 nm)
- 45% in the visible region
- 50% in the solar infrared region.

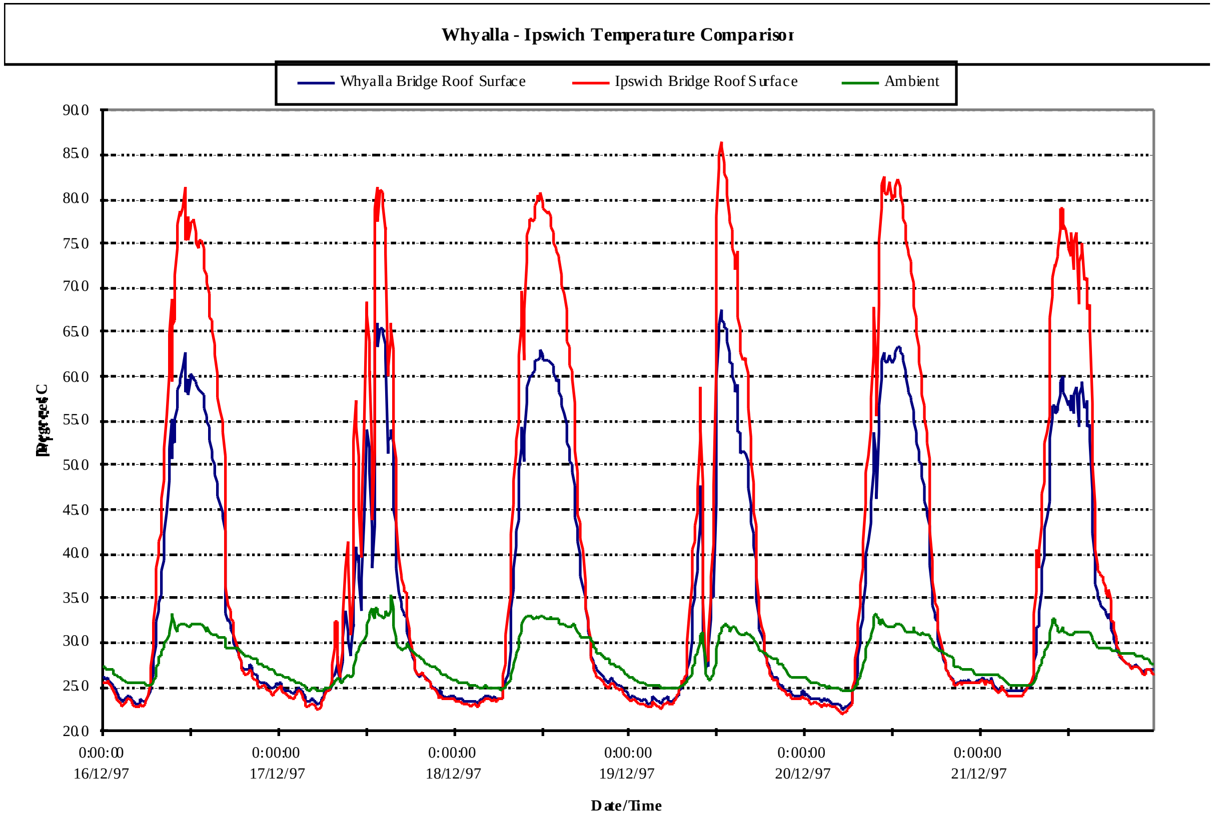
Visible and IR Radiation of Coatings

- The solar radiation striking a coated surface is either reflected, absorbed or transmitted at each interface
- The reflected radiation can be either specular (mirror-like) or diffuse (scattered) and is dependent on the pigments used in the coating and/or the texture of the surface.
- Radiation not reflected from the film is converted into heat or chemical energy.

Solar IR Reflective Coatings

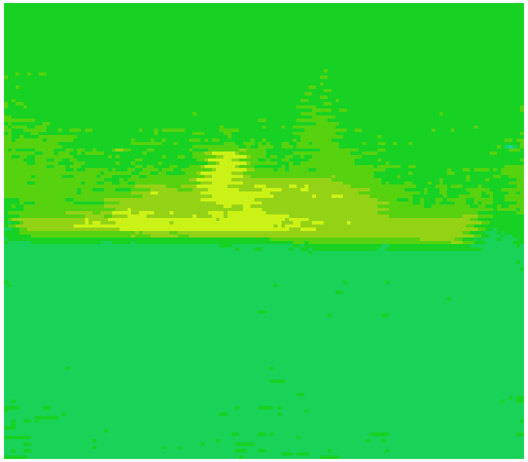


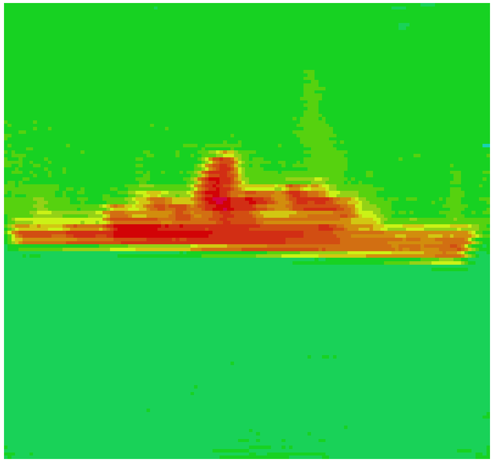
Ambient and Surface Temperatures



Ambient temperature, and surface temperatures of HMAS Whyalla and HMAS Ipswitch in the sea off Cairns during six successive days in December, 1997.

Comparison of Coatings





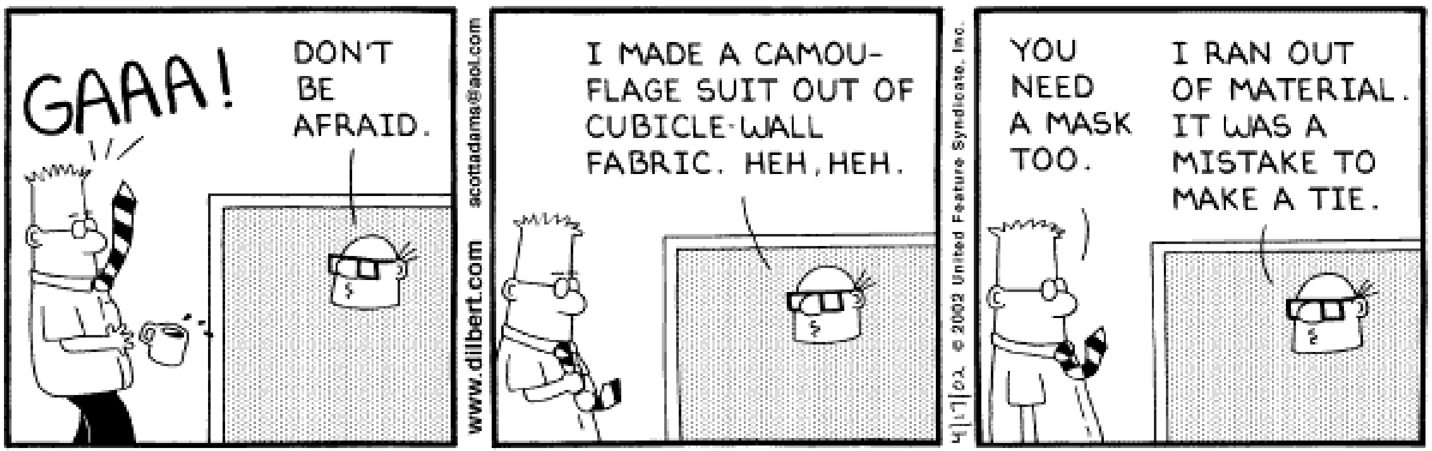
A false-color image of reflected infrared energy in the 8-12 micrometer band from two US mine countermeasure (MCM)-class ships with (left) and without (right) the low solar absorbance paint. The reduction in radiated energy achieved by this paint has important survivability benefits.

Adaptive Camouflage

Variable Camouflage

- Reduced Detection and Increased Survivability through Adaptation

Variable Camouflage

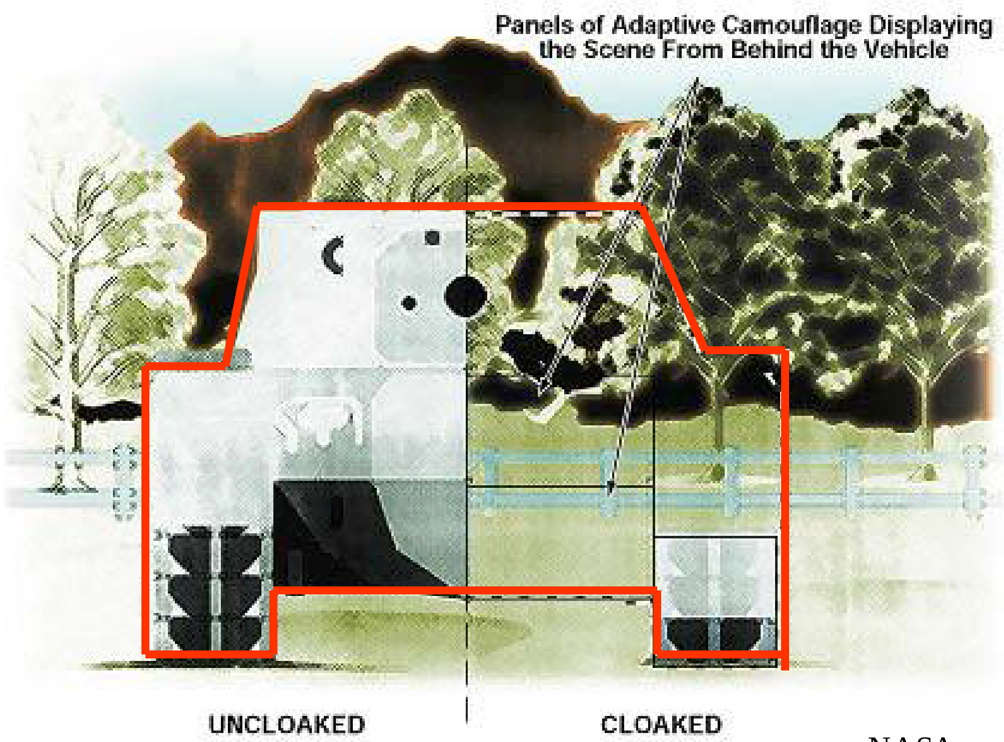


Variable Camouflage

- **Soldiers**
  - Photochromic
- **Tanks**
  - Thermal/Visible, Peltier cooling and Liquid Crystals
- **Planes**
  - Lights, Photochromic B52, Electrochromic SR71

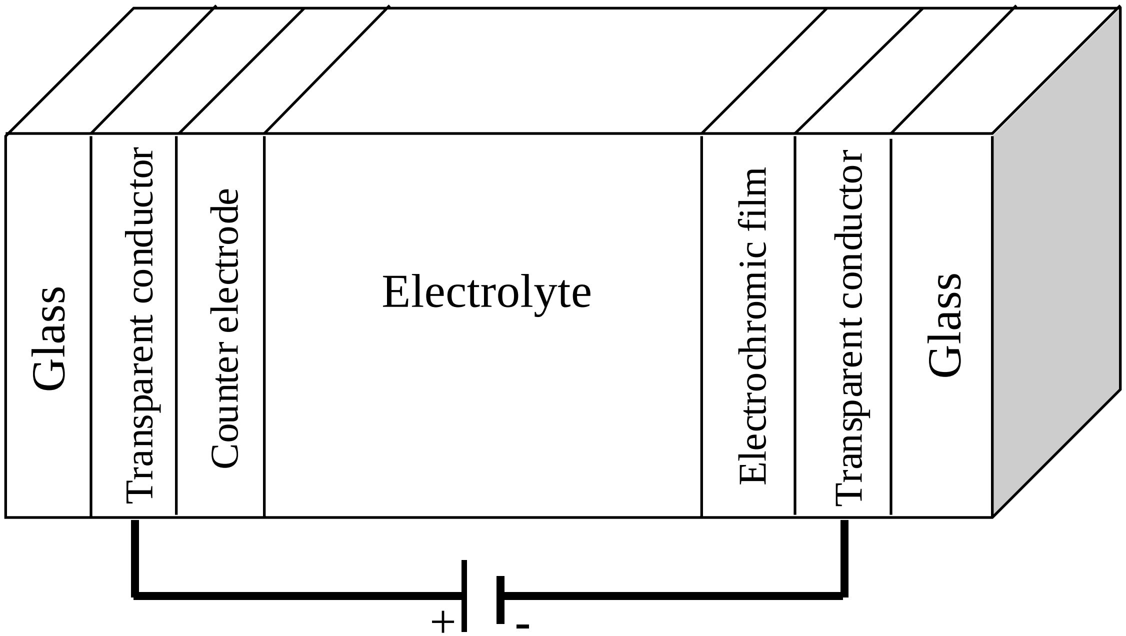
Project Aim

To increase survivability of CF assets through reduced risk of detection.



NASA

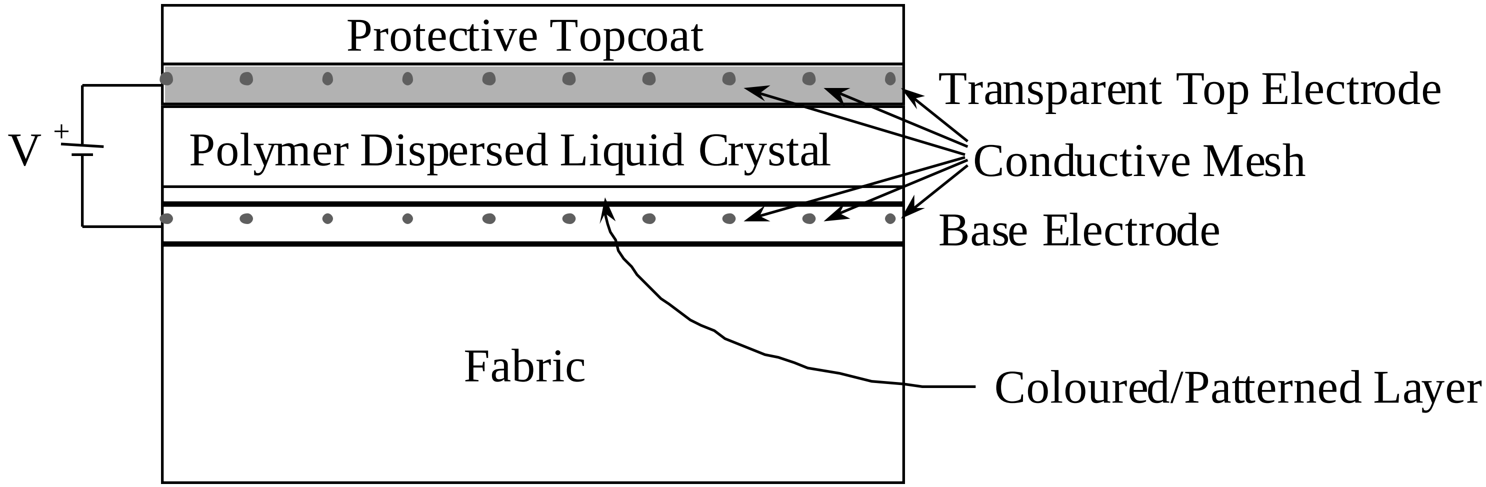
Electrochromic Materials



$$WO_3 + xM^+ + xe^- \longleftrightarrow M_xWO_3$$

Colourless Blue

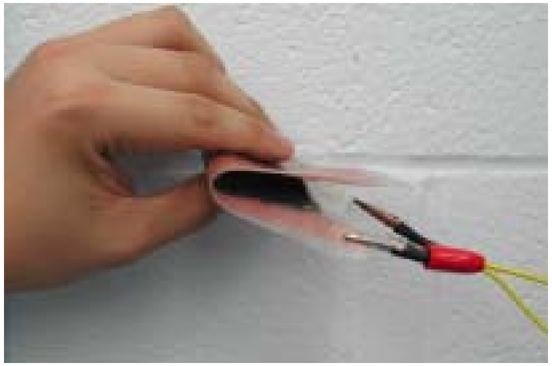
Liquid Crystal Devices



Electrochromic

State 1

State 2



Bodycote


Canada

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