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Space Debris Mitigation Technologies

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Space Debris Mitigation

Application of IADC Mitigation Guidelines

Application of UN-COPUOUS Space Debris Mitigation Guidelines endorsed Nov.2007

- Limit Debris Release during normal operation
- Minimize potential for break-ups during operational phase
- Limit the probability of accidental collision in-orbit
- Avoid intentional destruction and other harmful activities
- Minimize potential for post-mission break-ups resulting from stored energy
- Limit the long-term presence of spacecraft and launch vehicles orbital stages in LEO after the end of their mission
- Limit the long terms interference of spacecraft and launch vehicle orbital stages in GEO.

ISO: Debris Mitigation Standard & GEO Disposal standard.

Prevention:
Guidelines to limit operational debris:eg. Reduction of bolts, covers, straps, clean pyrotechnic devices and residuals.

Protection of satellites to limit debris impact effects and ageing process.
These include specific shielding and other solutions including self healing materials.

End Of Life (EOL) removal: retrieval, active de-orbit technologies such as tether assisted, deliberate break-up of spacecraft sections through demise technologies or disposal in graveyard orbit.

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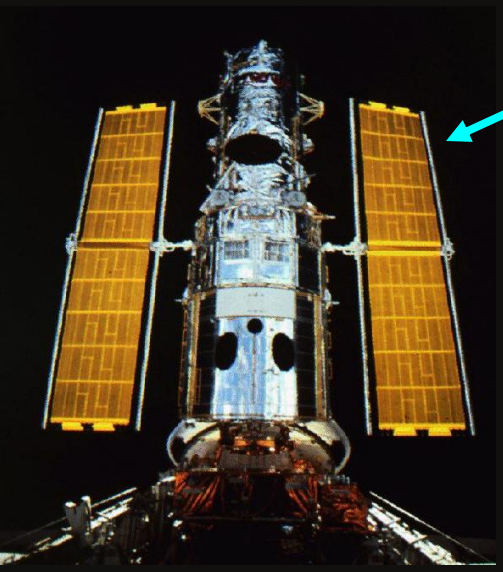
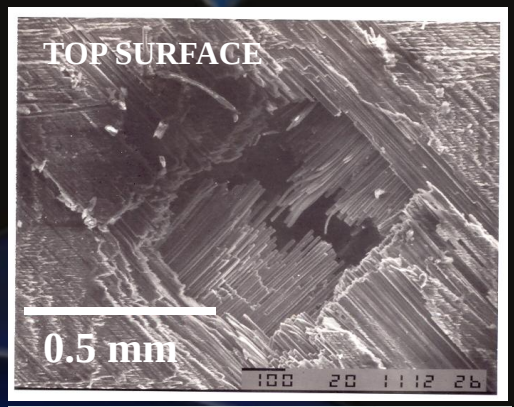
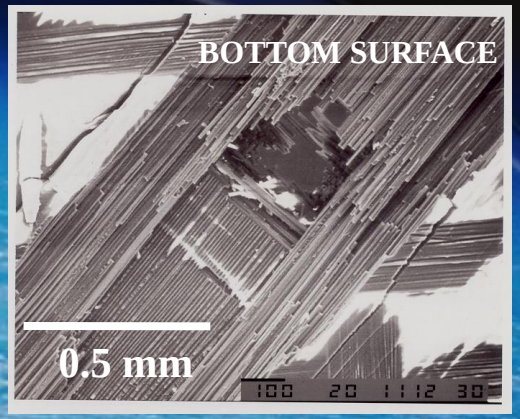
Space Debris Experiments



- LDEF – Long Duration Exposure Facility
- Hubble Space Telescope impact data
- European Retrievable Carrier (EuReCa)
- Space Shuttle window and radiator impact data
- Space Flyer Unit (SFU)
- Mir impact data
- International Space Station





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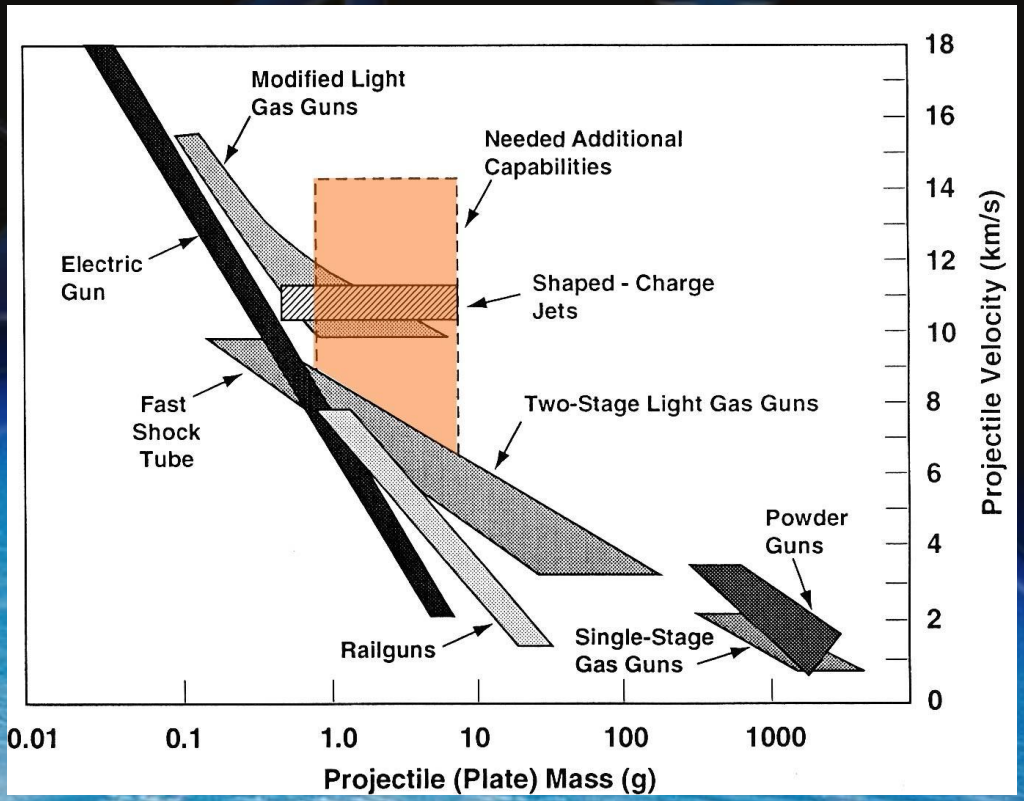
Hypervelocity Launcher for Laboratory Testing of Orbital Debris and Micrometeoroid Impact

- Current launchers are unable to achieve projectile mass and velocity of interest for orbital debris studies.

From:

Orbital Debris: A Technical Assessment, Committee on Space Debris, National Research Council, National Academy Academies Press, Washington D.C., 1995.



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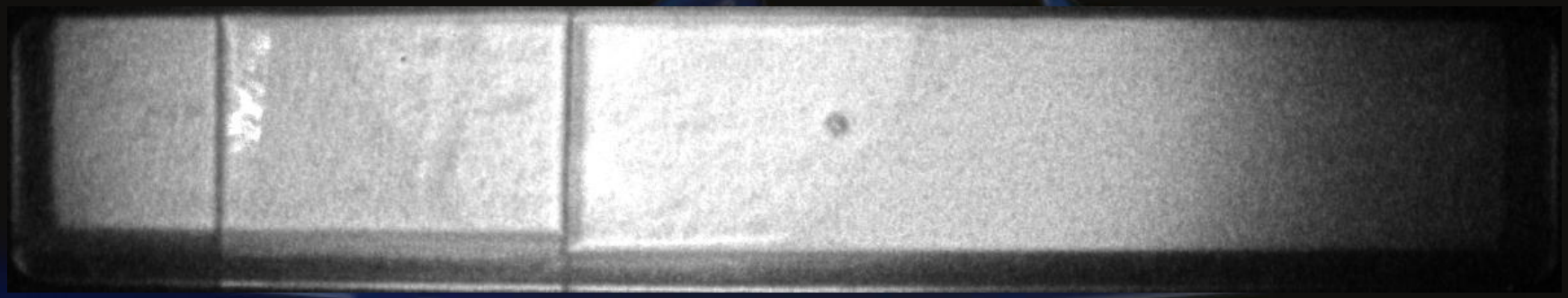
Debris shields & impact tests

- Impact of a 0.3 g projectile traveling at 4.5 km/s impacting a double-wall aluminum “Whipple Bumper”



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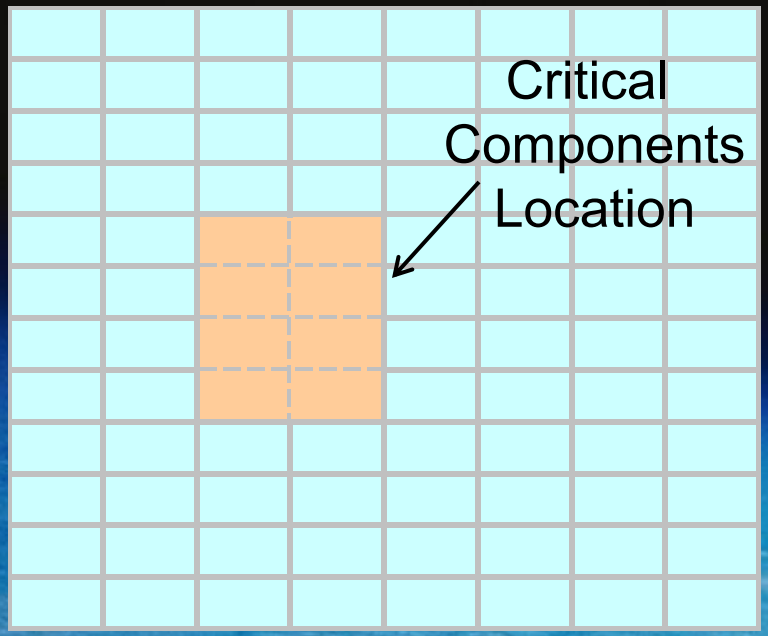
Earth Observation

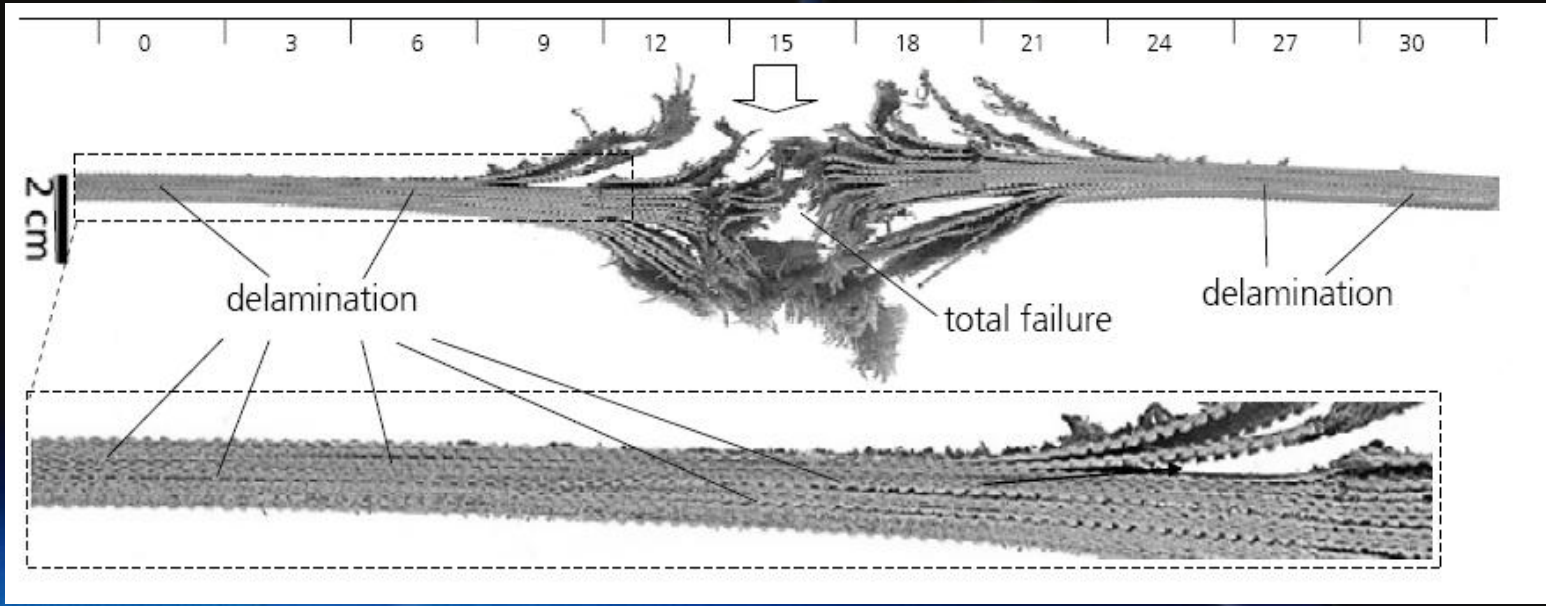
RADARSAT-2

RADARSAT-2

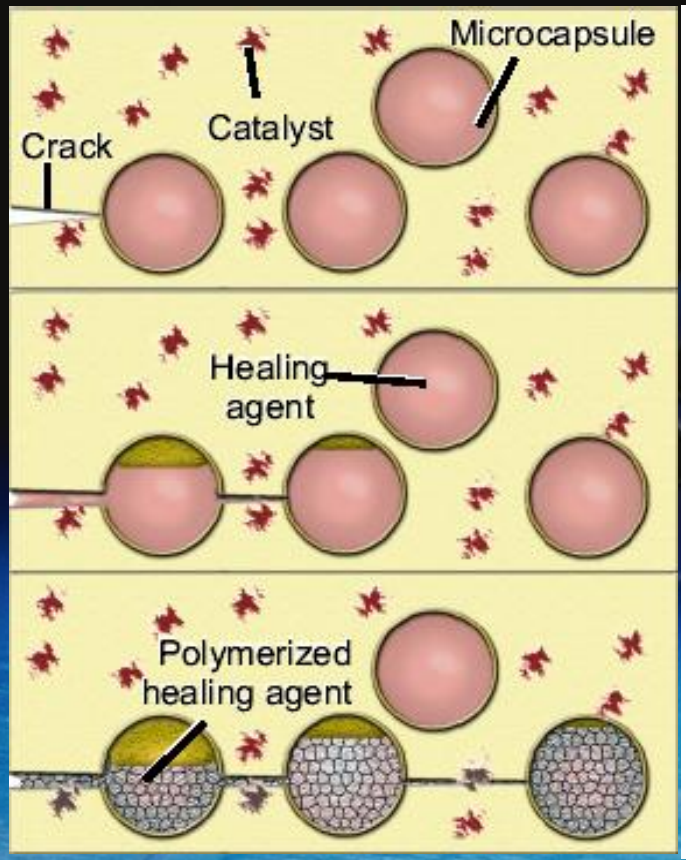
Antenna Structure Made of Multi Cell Aluminium Panels

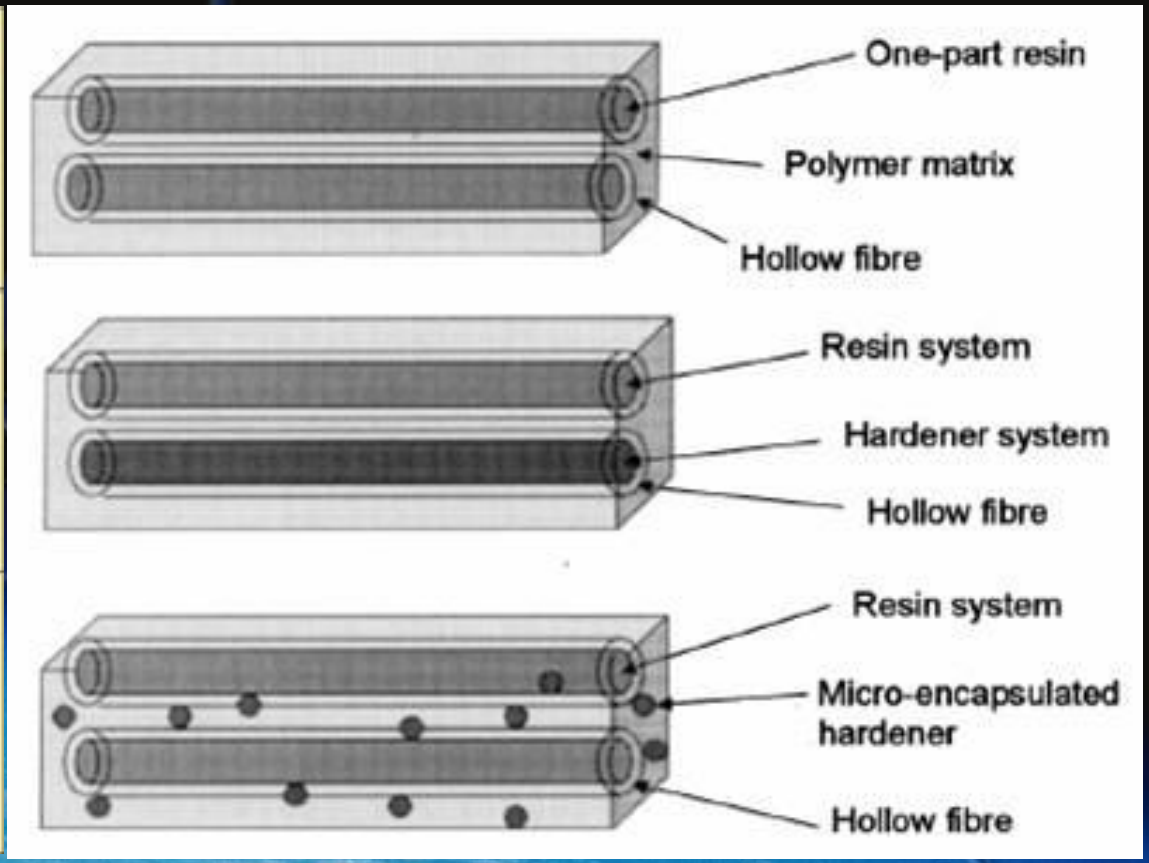


Debris effect on multilayer CFRP (Carbon Fiber Reinforced Polymers)



Self Healing Concept: Crack filling repair mechanism





Idea demonstrated at University of Illinois (Urbana US) [White 2001]

White, S. R. et al. "Autonomic healing of polymer composites" Nature 409, 794- 797(2001)

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Mechanical & Thermal Shock Tests

Before Thermal Shock **After Thermal shock**

Standard sample

Sample with the developed healing agent

Amplification (X24)
Healed cracks
(dark color lines)

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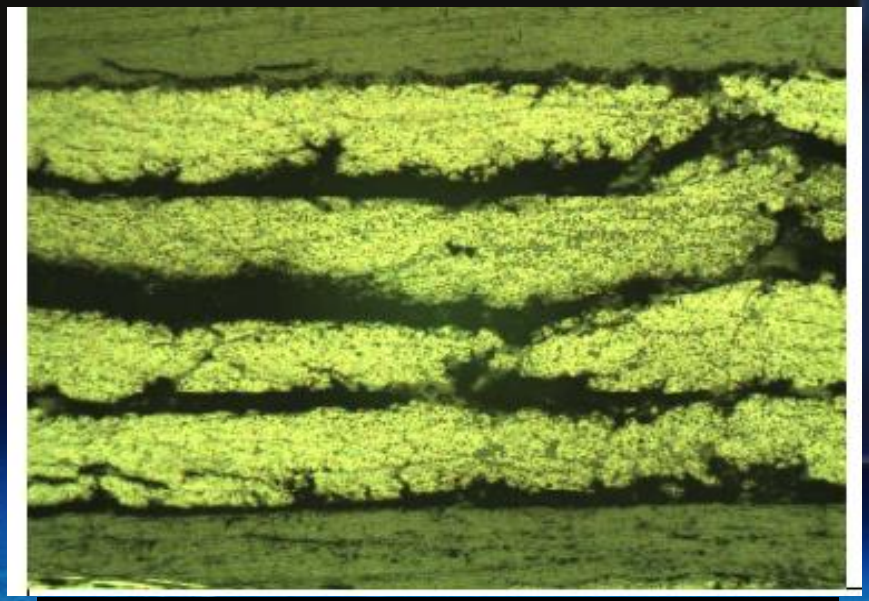
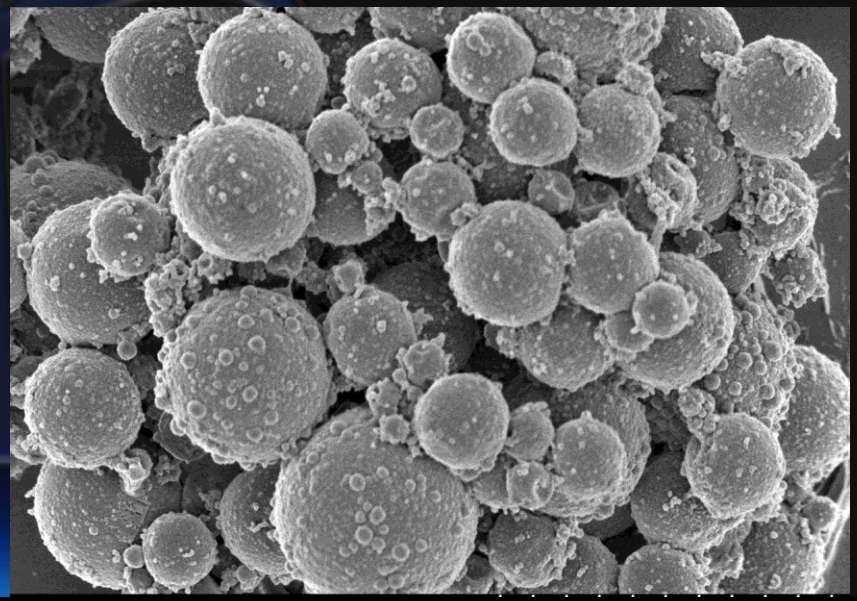
Debris Mitigation through Self Healing

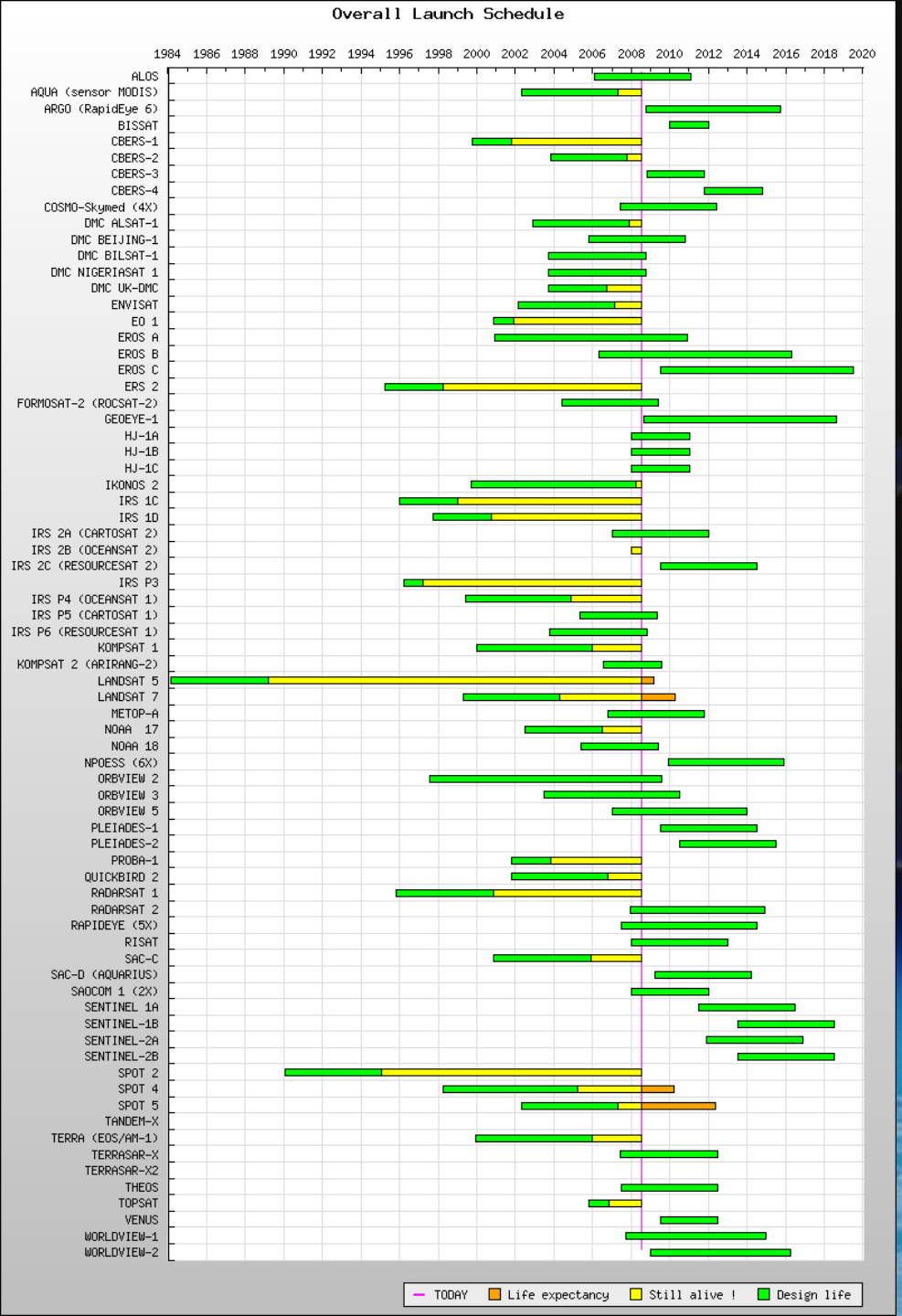


Self Healing with small microcapsules embedded within CFRP



Innovative Self Healing With Small Microcapsules (1-5 microns)

EO Launch Schedule



General trend to exceed design life of spacecraft by satellites operators.

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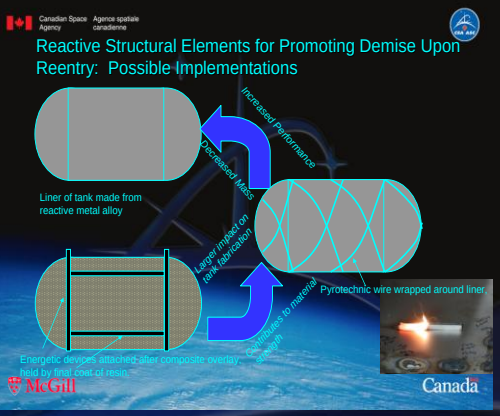
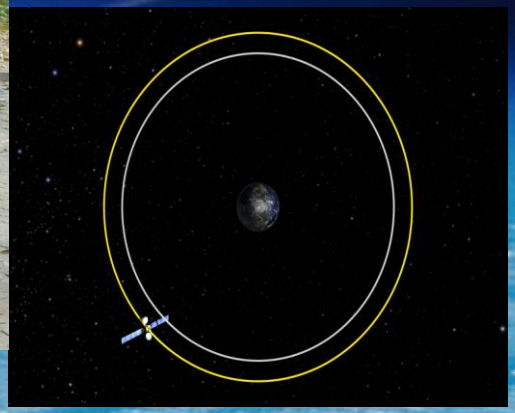
End of Life Practices

Retrieval of INTELSAT VI by STS 49 Endeavour's crew





- Retrieval
- For LEO: De-orbiting or re-entry in less than 25 years)
- Demise Technology
- For GEO: Use of Graveyard Orbit (eg. re-orbit to 300 km above GEO)

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Ways of Raising Awareness

- Participate in international forums to discuss and highlight the challenges ahead.
- Establish the way forward in promoting technical exchange and international cooperation focussed on preserving the space environment & to assure a sustainable access to space .

  - "International Conference on Protection of Materials and Structures from the Space Environment – ICPMSE" initiated in Canada as a bi-annual event since 1992.
  - "International Symposium on Materials in a Space Environment"
  - IADC
  - UN-COPUOS
  - COSPAR
  - "5th European Conference on Space Debris, ESA/ESOC, Darmstadt"
  - "Space Debris Congress" May 7-9th, 2009

Merci!

Any Questions??