# INTERNATIONAL ACADEMY OF ASTRONAUTICS

# STATUS REPORT ON SPACE DEBRIS

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# THE INTERNATIONAL ACADEMY OF ASTRONAUTICS

- **Independent non-governmental international organization recognized by the United Nations in 1996.**
- **Founded 16 August 1960, Stockholm, Sweden, by Theodore Von Karman.**
- **Aims:**
  - Foster the development of astronautics for peaceful purposes
  - Recognize individuals who have distinguished themselves in a related branch of science or technology
  - Provide a program through which members may contribute to international endeavors
  - Encourage international cooperation in the advancement of aerospace science

# THE INTERNATIONAL ACADEMY OF ASTRONAUTICS

- **Members:**
  - 899 Full Members
  - 277 Corresponding Members
  - 84 countries represented
- **Publications:**
  - Acta Astronautica, the journal of the International Academy of Astronautics (monthly)
- **Activities:**
  - Regional meetings
  - conferences and symposia,
  - Cooperation with other academies and organizations
  - Publications (books, Acta Astronautica)
  - Studies,

# IAA SPACE DEBRIS STUDIES

- **Several studies since more than 20 years**
  - Position Paper on Orbital Debris,  May 1993
  - Position Paper on Orbital Debris,  September 2001
  - Space Debris Mitigation: Implementing Zero Debris Creation Zones,  October 2005
  - Space Traffic Management,  September 2005
  - Space Debris Environment Remediation (August 2013)

- **Need for a status report presenting:**
  - List of research fields in relation with space debris
  - Status of activities in each of these fields
  - Identification of main challenges
  - Proposals for further research

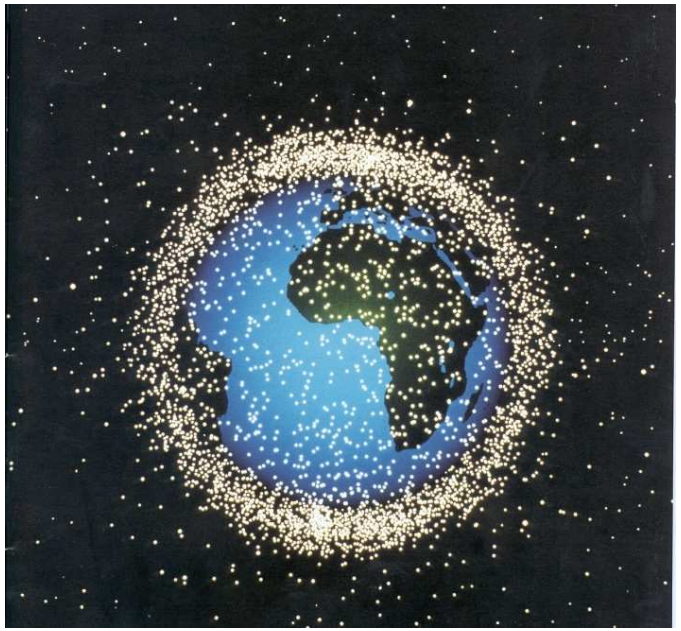
# STATUS REPORT ON SPACE DEBRIS

The report will address the following issues:

- **Present status: in-orbit situation**
- **Measurements available**
- **Space surveillance**
- **In-orbit collisions**
- **Reentering space objects**
- **Future environment**
- **Debris mitigation**
- **Remediation**
- **Protection**
- **Legal**
- **References & Standards**
- **International aspects**

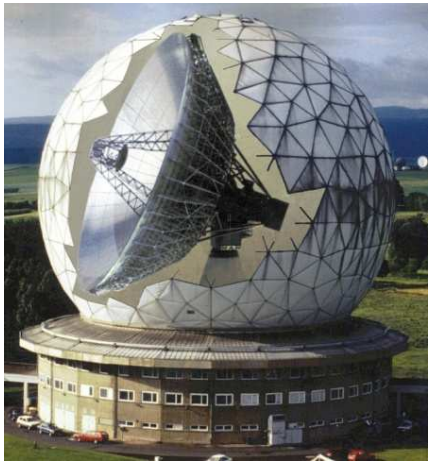
# PRESENT STATUS

- **Assessment of the on-orbit situation:**
  - How many debris?
  - Which size?
  - Where?
  - Origin?
  - List of collisions and of fragmentations
  - Uncertainties, confidence level



- **Main challenges:**
  - Classified data
  - International consensus
  - Knowledge of the small debris population

# MEASUREMENTS



- **Technical solutions to detect and track debris**
  - On-ground and/or in-orbit solutions
  - Large/small debris
  - Radar, optical, detectors,….

- **Main challenges:**
  - Availability of tracking facilities
  - Performances: sensitivity, accuracy
  - Small debris above 500 km altitude
  - Objects in low-inclination orbits
  - Coordinated campaigns

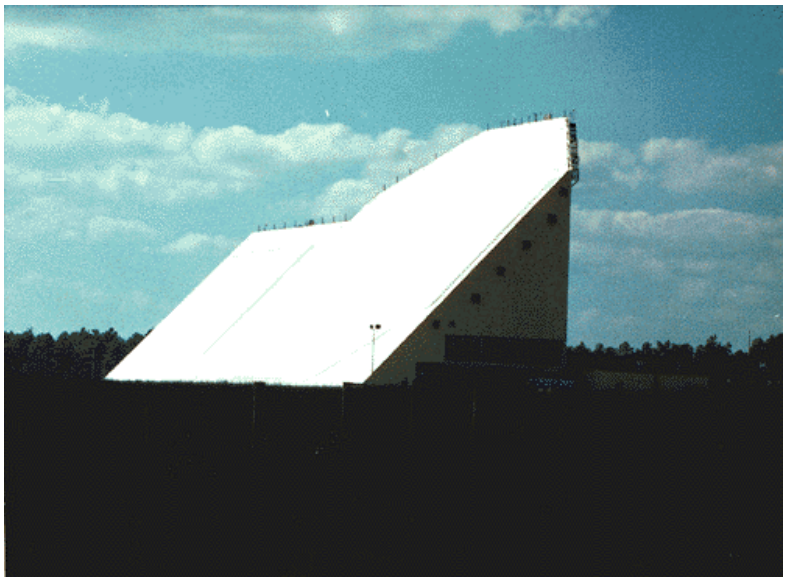
# SPACE SURVEILLANCE

- **Existing military networks**
  - Available output: catalogs, measurements, warnings (collision and reentry)
  - Limits: size, altitude, inclination
  - Accuracy: critical issue for collision avoidance and reentry predictions

- **Main challenges:**
  - Unique source of data
  - Availability and accuracy
  - Data policy
  - Objects < 7-8 cm are not cataloged

  →need to improve sensitivity and accuracy

  →develop international cooperation



# COLLISION RISK MANAGEMENT

- **Situation:**
  - Large objects are cataloged
  - Collisions between cataloged objects are catastrophic (i.e. production of debris)
  - Conjunction messages are published by JSpOC
  - Some operators perform avoidance maneuvres

- **Main challenges:**
  - All dangerous debris are not cataloged
  - Many alerts received for a given close approach
  - Need for additional tracking measurements to confirm the risk
  - Expertise and tools necessary to analyze conjunction messages
  - Uncertainties may lead to large avoidance maneuvres or false alarms

# REENTERING SPACE OBJECTS

- **Situation:**
  - Most of reentries are uncontrolled
  - In average random reentry of a large object per week
  - 20 to 40 % of the initial mass survive to reentry
  - Some debris reach the ground
  - No casualty reported up to now
  - Large uncertainties in predictions

- **Main challenges:**
  - To reduce the number of random reentries:
    - controlled reentries
    - Partially controlled reentries: selection of the « best » orbits
  - To reduce casualty area: design for demise

# FUTURE ENVIRONMENT

## Situation:

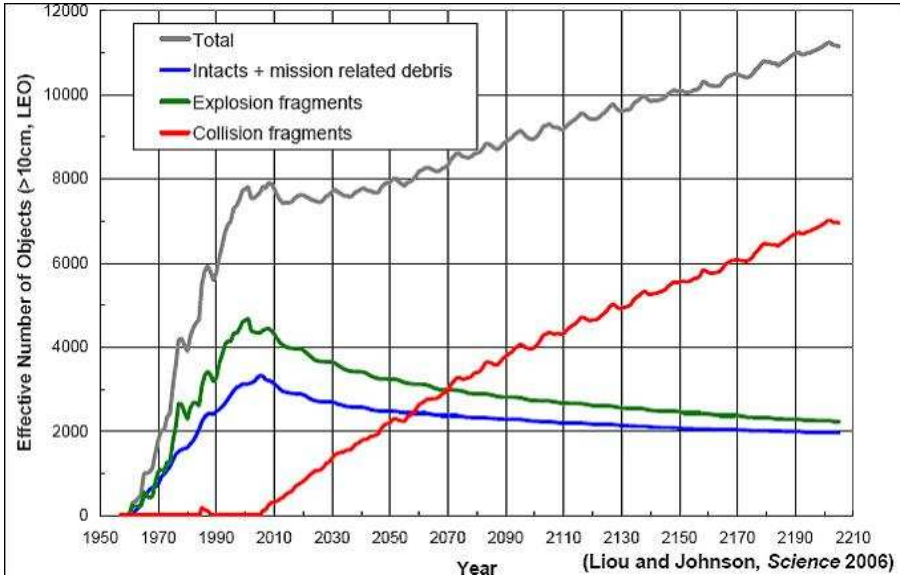
- Need to know the future (100-200 years) environment around the Earth
- Development of models predicting the long term evolution of the space debris population
- Cascading effect in LEO (Kessler syndrome)?

  →confirm the need and urgency for active debris removal

  →confirm the need for stronger mitigation measures

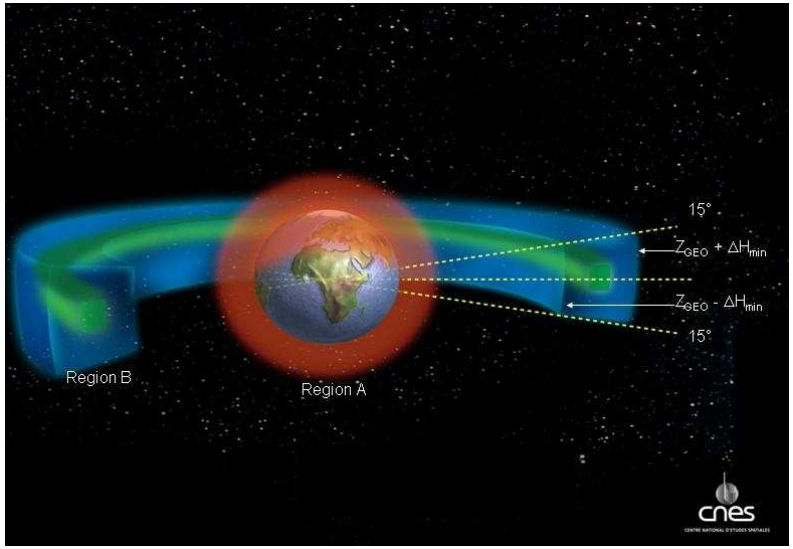
## Main challenges:

- Reliability (instability) of results
- High sensitivity to critical inputs:
  - Solar activity
  - Fragmentation model,
  - Future traffic model: launch rate, number, characteristics and orbits of future objects
  - Application level of mitigation measures



(Liou and Johnson, *Science* 2006)

# DEBRIS MITIGATION




- **situation:**
  - Mitigation measures initially proposed by NASA
  - IADC Mitigation Guidelines published in 2002
  - High level principles of the UN-COPUOS in 2007
  - Detailed technical standards developed within ISO
  - Regulatory regimes implemented by some countries

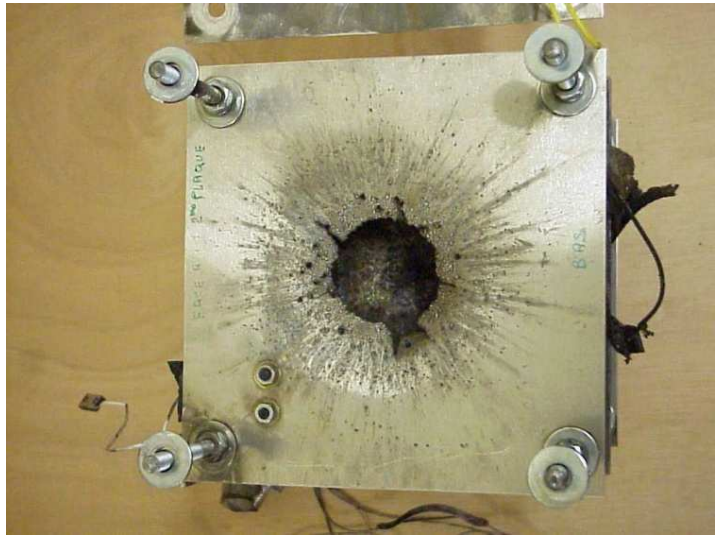
- **Main challenges:**
  - Technical and/or economical difficulties highlighted by operators
  - Insufficient application level, particularly in LEO
    - need to reinforce application by all operators
  - further research necessary to find and improve solutions
  - need to develop legal mechanisms by spacefaring countries

# REMEDIATION


- **Situation: if the need is confirmed…**
  - Technical difficulties:
    - rendez-vous with an uncooperative target, approach,
    - Capture of a tumbling object,
    - Deorbiting solution
  - Economical difficulty: cost, who will pay?
  - Legal issues: owner of space debris,
  - Political issues: transparency, international agreement

- **Main challenges:**
  - Demonstrate feasibility at reasonable cost:
    - need to study efficient and innovative solutions
    - In-orbit technology demonstrations
  - International cooperation:
    - Financing mechanisms
    - Legal and political issues

# PROTECTION

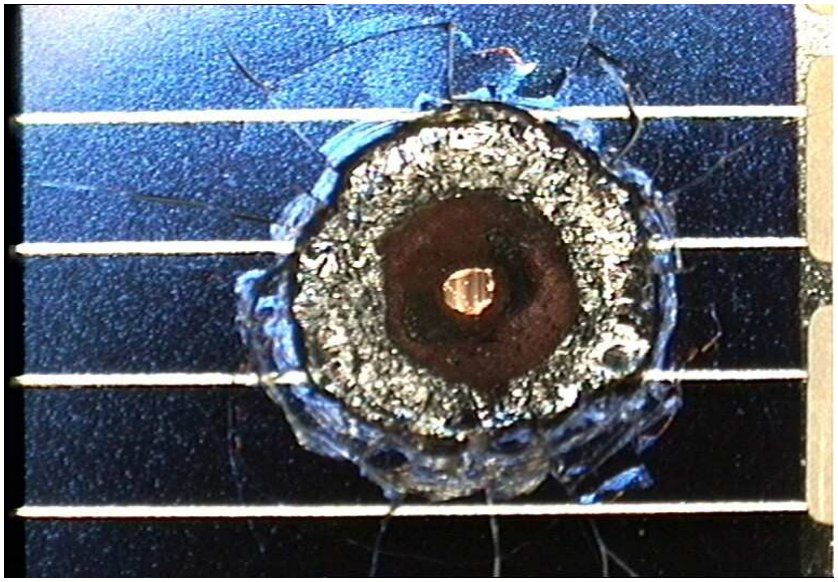


## Situation:

- Impacts by small debris may damage satellites
- Classical satellites are not shielded
- Limited protection through structural elements
- Difficulty to establish the cause of a failure

## Main challenges:

- need to assess satellite vulnerability on a given orbit: damage equations
- Study solutions to reduce vulnerability:
  - architecture,
  - redundancies,
  - location of critical components,
  - reinforced structure,
  - materials selection, …



# LEGAL ISSUES

- **Situation:**
  - UN Treaties:
    - Space Treaty 1967,
    - Liability Convention 1972,
    - Registration Convention
  - There is no strong legal basis for space debris
  - Definition of space, of space debris?
  - Liability in case of collision, future active debris removal?

- **Main challenges**
  - international agreement/cooperation necessary
  - development of legal systems at national level
  - Start working on space debris at the Legal Sub Committee of the UN COPUOS
  - update of UN Treaties?

# REFERENCES AND STANDARDS

- **References and standards:**
  - IADC mitigation Guidelines published in 2002
  - COPUOS Mitigation Guidelines published in 2007, working group on the Long Term Sustainability of Space Activity
  - Space debris standards developed at ISO (24113 in particular published in 2010)
  - Experience gained through application of guidelines by operators

- **Main challenges:**
  - References and standards shall be regularly updated
    - Need to update IADC Mitigation Guidelines and ISO standards
  - In the future need to reinforce mitigation measures
  - Balance between mitigation effectiveness and cost

# INTERNATIONAL ASPECTS

- **Situation:**
  - Space debris is a global issue, all spacefaring nations concerned
  - Mitigation measures shall be applied
  - Economical concurrence between industry/operators
  - Cooperation necessary
    - →same rules
    - →international consensus
  - New space faring nations, new actors (Universities for instance)

- **Main challenges:**
  - Develop international cooperation
  - Involve newcomers at IADC and UN COPUOS
  - Same rules: avoid « flags of convenience » in space

# SUMMARY

- **Space debris**
  - is a very complex issue
  - addresses many different technical domains
  - has implications in legal, economical and political areas

- **The IAA decided a new study:**
  - To establish a clear picture of the present situation
  - To identify main difficulties and challenges
  - To recommend research activities to solve main issues

- **A group of international experts was set up within IAA**

- **Work started in 2013, final report expected in 2015**