Inter-Agency Space Debris Coordination Committee Presentation to the 47th Session of Scientific and Technical Subcommittee of United Nations Committee on the Peaceful Uses of Outer Space, February 2010

IADC Protection Manual and IADC Response to UNCOPUOS Request on Internationally Accessible Databases of Objects in Outer Space

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IADC Chair

Presentation Outline

- IADC Protection Manual
  - Meteoroid / Orbital Debris Risk Assessment
  - Component / Subsystem Ballistic Limit Equations
  - Test Methods and Facilities Calibration
  - Numerical Modelling
  - Protection Design Guidelines and Standards
- Internationally Accessible Databases
  - Background
  - IADC Deliberations
  - Observations
  - IADC Recommendation

IADC Terms of Reference

- Purpose:
  - Exchange information on space debris research activities between members
  - To facilitate opportunities for cooperation in space debris research
  - Review progress of cooperative activities
  - Identify space debris mitigation options
- Structure:
  - Members are national or international space agencies that perform space activities and actively contribute to space debris research
  - The work program is governed by a steering group and performed in 4 working groups (measurements, environment & database, protection, mitigation)
  - As part of their terms-of-reference, IADC fosters the exchange of data on data on all these basic areas of space debris research, and in particular, related to the protection of spacecraft from meteoroid and orbital debris
- Membership:

ASI, BNSC, CNES, CNSA, DLR, ESA, ISRO, JAXA, NASA, NSAU, ROSCOSMOS

Scope of IADC Protection Manual

The Protection Manual provides:

- A standard framework to assess meteoroid and orbital debris risk
- Validated ballistic limit equations
- Benchmark results for cross-calibration of test facilities
- Benchmark cases for validation of numerical simulations
- Design guidelines for protection of spacecraft

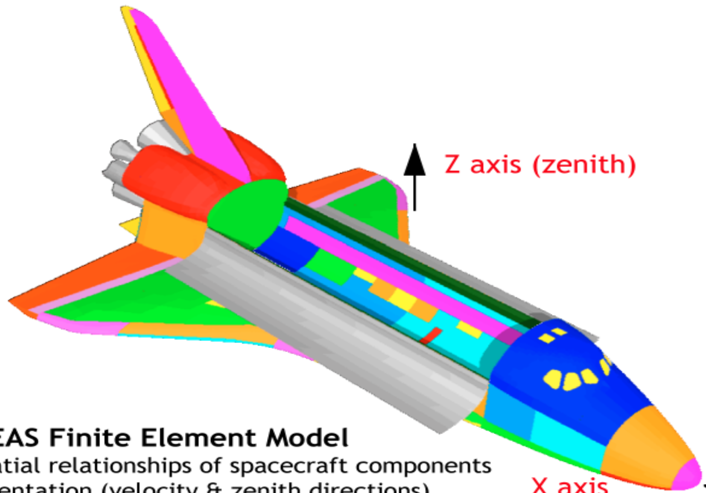
Meteoroid / Orbital Debris Risk Assessment

- Definition of standard procedures for meteoroid and orbital debris risk assessment
- Comparison and validation of software tools adopted by member agencies
- Example applications

Example: Risk Assessment using BUMPER (NASA)

1

Spacecraft Configuration (I-DEAS)



I-DEAS Finite Element Model
- Spatial relationships of spacecraft components
- Orientation (velocity & zenith directions)
- M&D shield locations

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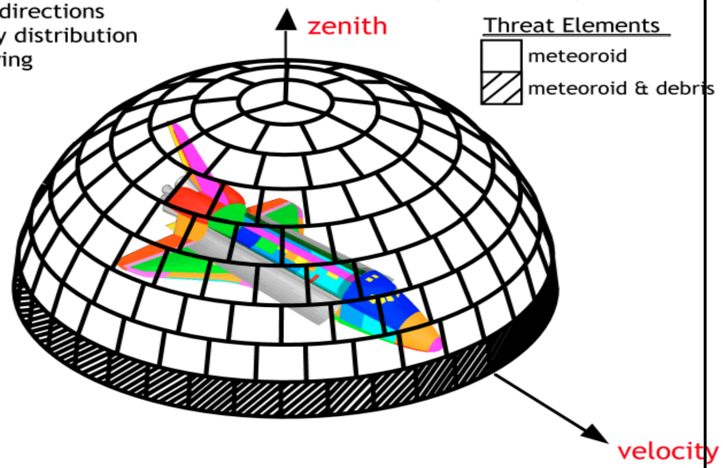
Meteoroid & Debris Environments (GEOMETRY)
- Threat directions
- Velocity distribution
- Shadowing



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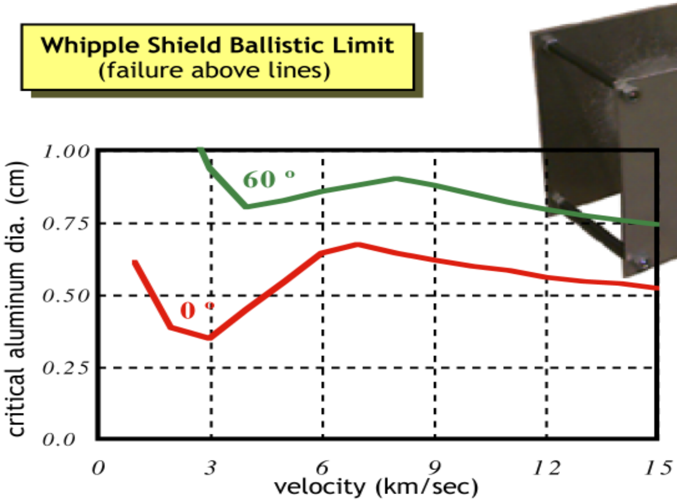
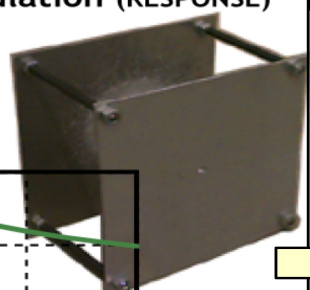
Critical Particle Diameter Calculation (RESPONSE)





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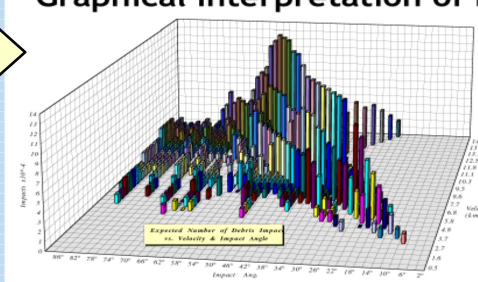
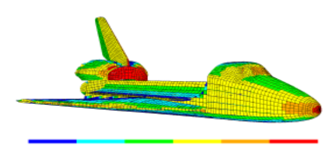
Compute Penetrating Flux & PNP statistics (SHIELD)

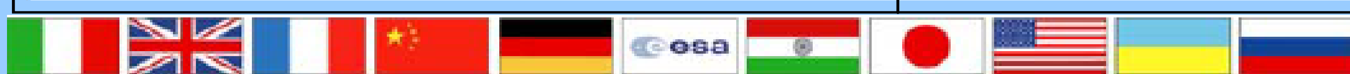
Space Shuttle Orbital Debris Threat Assessment

	Impact Risk From 1mm Ø Debris		Debris Penetration Risk	
Orbiter Region	*Probability No Impact*	*Odds of Impact*	*Probability No Penetration*	*Odds of Penetration*
RCC	0.995338	1/214	0.995541	1/224
windows	0.999335	1/1505	0.999796	1/4912
pb door radiators	0.990465	1/105	0.999998	1/625000
wing & fuselage TPS	0.965074	1/29	0.998923	1/928
fwd fuselage TPS	0.985522	1/69	0.999022	1/1023
payload bay & bulkheads	0.997443	1/391	0.999839	1/6223
TOTALS	**0.934622**	**1/15**	**0.993132**	**1/146**

Graphical Interpretation of Results (I-DEAS & EXCEL)



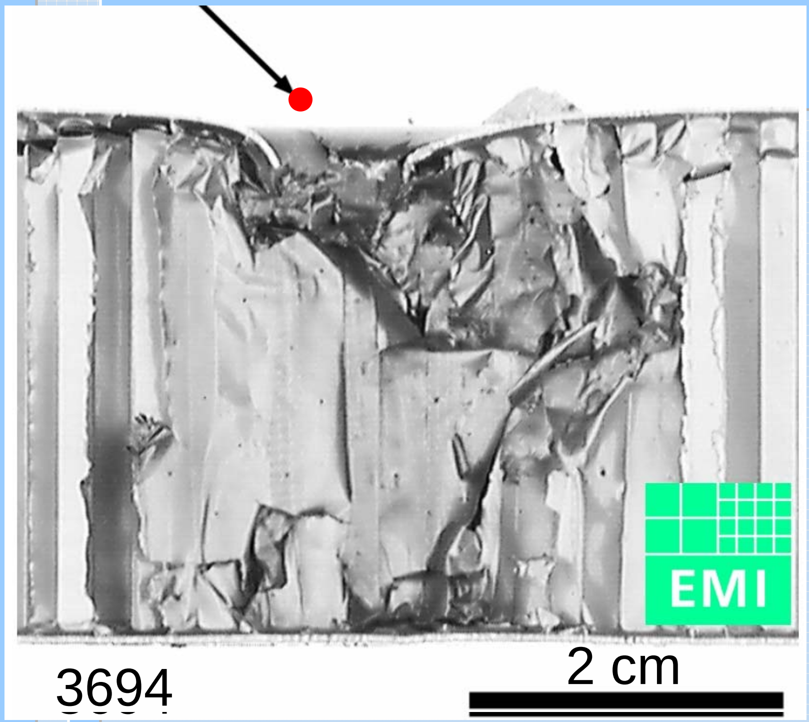


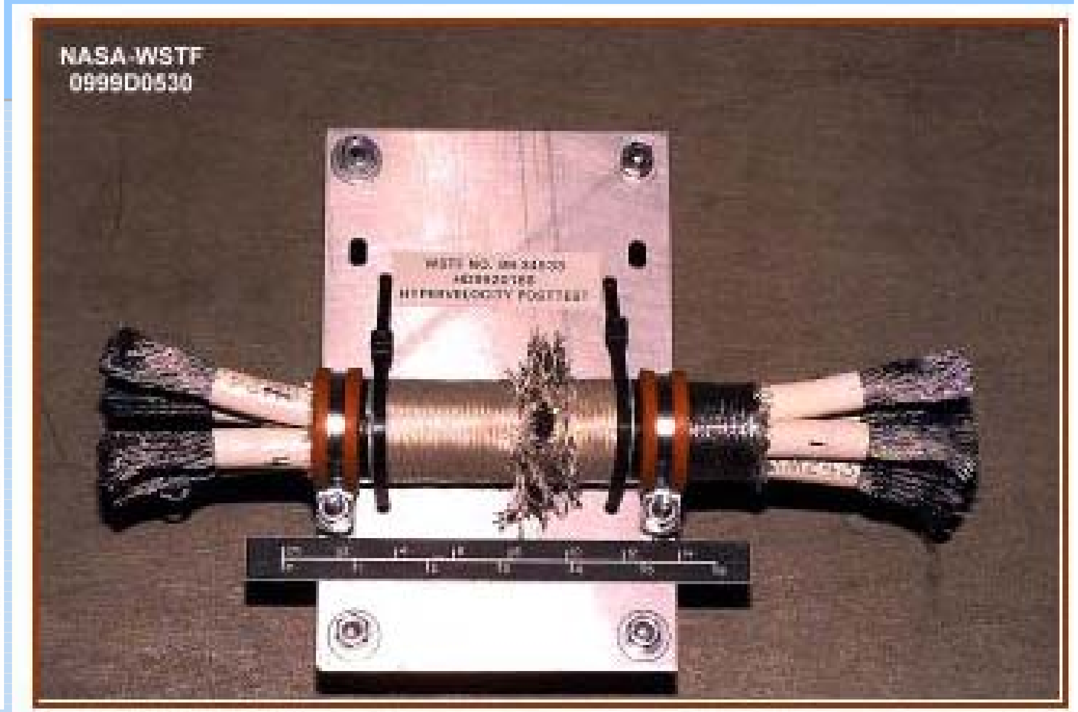


Component / Subsystem Ballistic Limit Equations

- Ballistic limit equations are developed to define impact conditions (i.e. particle size,particle density, impact velocity, and impact angle) that result in threshold failure of specific spacecraft components or subsystems
- The Protection Manual uses a combination of hypervelocity impact test results and analyses to determine the ballistic limit equations
- Documentation of reliable equations describing the damage induced by hypervelocity impacts to spacecraft structures and equipment
- Limits of validity and example applications

Typical Hypervelocity Impact Tests





Impact on a Honeycomb Core Sandwich Sample by a 1.74 mm particle at 7.2 km/s and 45º angle

Power cable impacted by a 3.57 mm Al sphere at 6.6 km/s and 45º impact angle

Test Methods and Facilities Calibration

- Laboratory methods to launch particles to hypervelocity
- Capabilities of impact test facilities available among member agencies, including relevant diagnostic instrumentation
- Procedures and results of members’ facilities cross-calibration

Example:

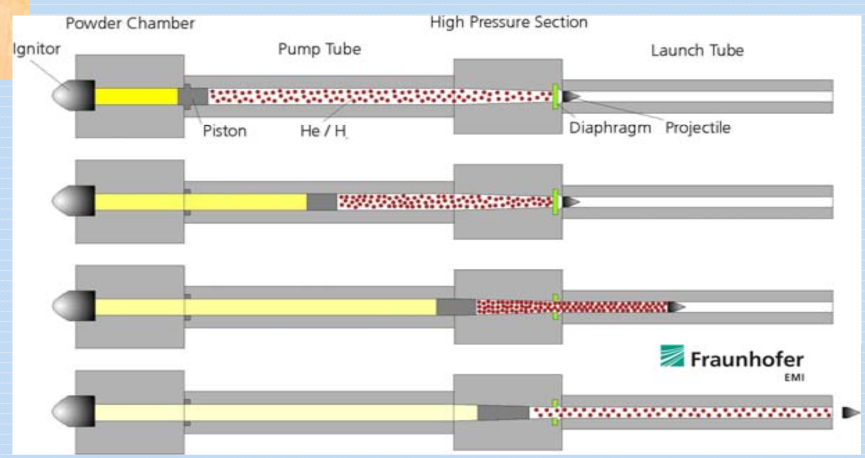
Two-Stage Light-Gas Gun ("Space Gun") at Fraunhofer Ernst-Mach-Institute

Launch Tube dia. ranging from 6.5 mm to 15 mm.

The pump tube dia. is 40 mm.

Max. velocity ca. 9.5 km/s for masses of about 10 mg

Working principle of a Two-Stage Light-Gas Gun

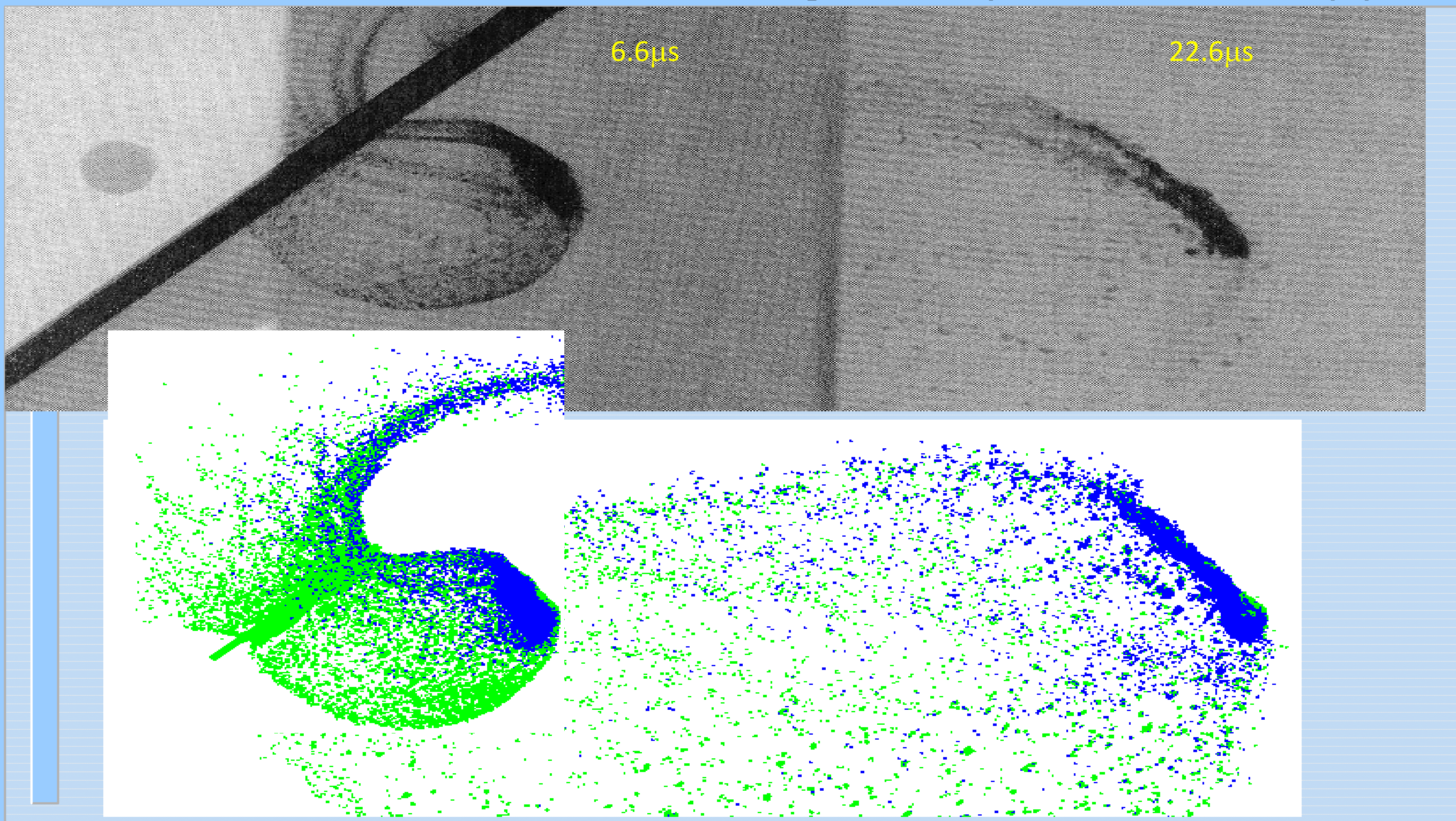


Numerical Modelling

- Approach for numerically modelling hypervelocity impact events
- Development of equations of state for materials employed as part of meteoroid and orbital debris protection systems
- Codes validation

Example: Oblique Impact Simulation

Aluminium sphere impacting at 45 degrees and 6.6 km/s. Excellent correspondence between simulations and experiments [from: Report No. ESA CR(P) 4218].



Protection Design Guidelines and Standards

- General recommendations
- Recommendations for structure, thermal control and shield design
- Recommendations for equipment design and placement

Protection Manual Status and Development Plan

- The Protection Manual is a public document and can be downloaded at www.iadc-online.org
- The Protection Manual is regularly updated to reflect the evolution of the acquired experience
- A new version of the document is in preparation and is scheduled for release later this year

Internationally Accessible Databases of Objects in Outer Space

Internationally Accessible Databases on Objects in Outer Space: Background

- **At the 52nd session of COPUOS, the Committee invited Member States of the IADC to prompt the IADC to advise the Scientific and Technical Subcommittee on a proposal by the delegations of Germany and Italy**

  (References: A/AC.105/2009/CRP.19 and A/AC.105/2009/CRP.20/Rev.1)

- **The joint proposal called upon the IADC "to develop first ideas on concrete measures with the purpose of making available already existing sources of information as well as data and information on objects in outer space for the promotion of a safe and sustainable development of the peaceful uses of outer space"**

- **The stated objective of the joint proposal was "to avoid collisions in outer space between operational spacecraft and space debris and other operational spacecraft respectively, as well as to protect the Earth's population in case of re-entering debris"**

IADC Deliberations

- The Steering Group of the IADC met in Daejeon, Republic of Korea, on 14 October 2009 and discussed the aforementioned request of COPUOS

- The IADC notes the value, to the aerospace community and to the world as a whole, of effective efforts to reduce the potential for accidental collisions between objects in space and the hazards to people and property on Earth from re-entering debris

- After thoughtful consideration, the IADC concludes that <u>currently available information</u> on the existing population of objects in outer space is insufficient to support either satellite conjunction assessments or predictions of risk object re-entries to the degree required for responsible operational decisions

IADC Observations

- The IADC notes that actionable satellite conjunction assessments require precision orbital trajectory information with quantified uncertainty values
  - Currently available mean general perturbation elements are insufficient

- The IADC notes further that efforts are underway to expand the quantity and quality of satellite conjunction assessments, using satellite operator information as well as other space situational awareness information

- IADC experience involving 11 re-entry exercises since 1998 indicates that the accurate prediction of time and location of re-entering space objects remains a significant challenge

IADC Recommendation

- **The IADC notes that at its 47th session the Scientific and Technical Subcommittee of COPUOS will commence a multi-year work plan on the topic of long-term sustainability of outer space activities**

- **The IADC recommends that the concept of the development of readily available databases to promote the safe operation of operational satellites and to forecast the re-entry of potentially hazardous space objects be further addressed under the agenda item on long-term sustainability of outer space activities**

- **The IADC will continue to consider the important topic of internationally accessible satellite databases and offers its future support to STSC in this matter**

THANK YOU