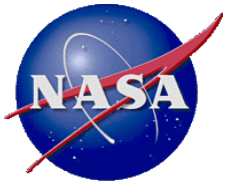
National Aeronautics and Space Administration



Orbital Debris Environment Modeling

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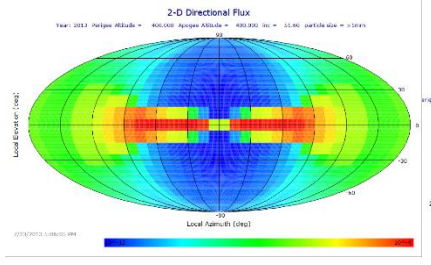
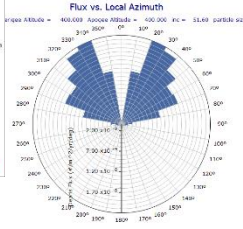
National Aeronautics and Space Administration

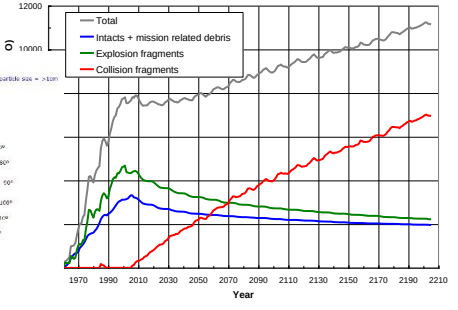
U.S.-China Expert Workshop on Orbital Debris Mitigation and Satellite Collision Avoidance

Washington DC, U.S.A., 27 June 2016

End-to-End Orbital Debris Activities at NASA







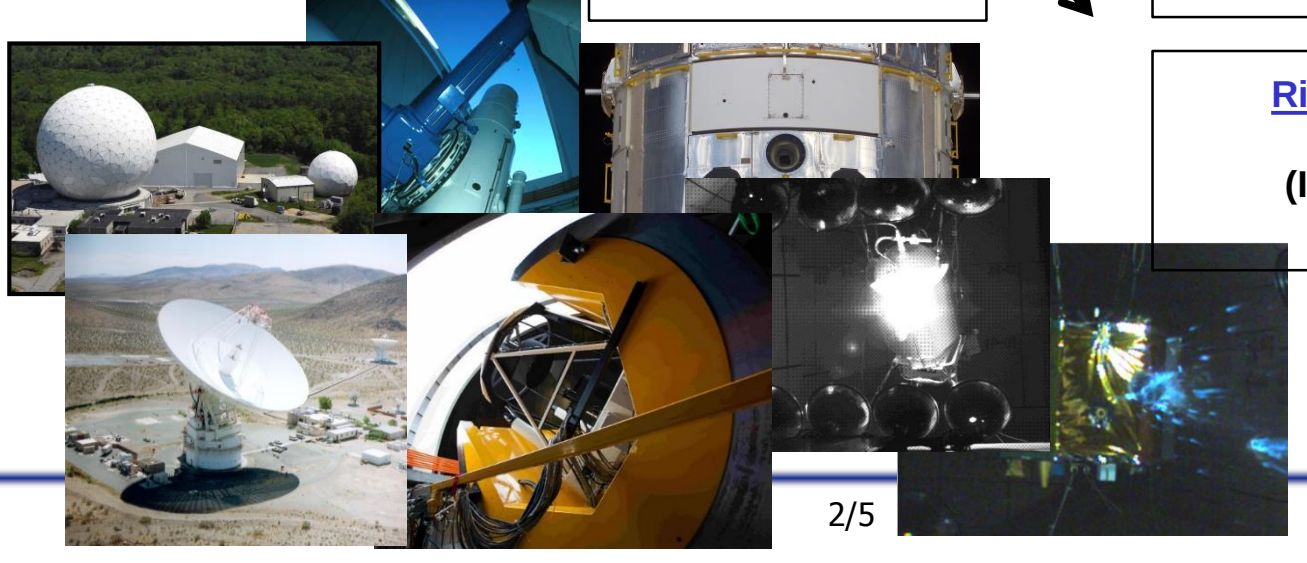
Measurements
Radar
Optical
In-situ
Laboratory

Modeling
Breakup
Engineering
Evolutionary
Reentry

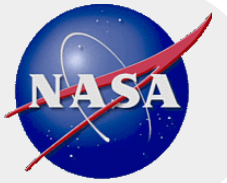
Environment Management
Mitigation
Remediation
Policy
Mission Requirements

Coordination
U.S. Government
IADC
United Nations

Risk Assessment
Space assets
(ISS, Orion, etc)
Reentry



Orbital Debris (OD) Modeling Overview



- **NASA OD engineering model**
  - Is a mathematical model capable of predicting OD impact risks for critical space assets (ISS, etc.)
- **NASA OD evolutionary model**
  - Is a physical model capable of predicting future OD environment
  - Supports the development of US/NASA OD mitigation guidelines
- **NASA satellite breakup model**
  - Describes the outcome of a satellite breakup (explosion or collision)

History of the NASA OD Engineering Models

- **NASA Pre-1990**
  - Used a simple flux curve based mostly on model results
- **ORDEM96**
  - Obtained Haystack radar data for debris in the 1 cm to 10 cm regime and used simple equations to describe debris environment
- **ORDEM2000**
  - Populations were derived from additional optical and in-situ data and then processed to generate a 3-dimensional LEO environment model
- **ORDEM 3.0**
  - Populations were derived from additional data, new techniques were developed to expand the model to GEO, material density and uncertainties were incorporated into model predictions

ORDEM 3.0

- **ORDEM 3.0 represents NASA's best estimate of the current and near future orbital debris environment**
  - The environment is dynamic and must be updated periodically
  - The model is based on all of NASA and DOD's measurement and the state-of-the-art modeling techniques
    - **JSpOC catalog data, Haystack/HAX/Goldstone ground-based radar data, optical data, and *in situ* data from spacecraft (*e.g.*, Shuttle) returned surfaces**