Orbital Debris Environment Modeling

J.-C. Liou, PhD
Chief Scientist for Orbital Debris
National Aeronautics and Space Administration

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

Effective Number of Objects (>10cm, LEO)
Total Intacts + mission related debris
Explosion fragments
Collision fragments

Year
National Aeronautics and Space Administration

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