MONITORING THE HEAVENS, TODAY AND TOMORROW

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Outline

• Growth of the Cataloged Earth Satellite Population

• Current and Future NASA and DoD Space Surveillance Capabilities
  – Low Earth Orbits
  – High Earth Orbits

• Potential Future Environments

• Summary
Cataloged objects >10 cm diameter

1960
Growth of the Earth Satellite Population

1965

Cataloged objects >10 cm diameter
Growth of the Earth Satellite Population

1970

Cataloged objects >10 cm diameter
Growth of the Earth Satellite Population

Cataloged objects >10 cm diameter

1975
Growth of the Earth Satellite Population

Cataloged objects >10 cm diameter

1980
1985

Cataloged objects >10 cm diameter
Growth of the Earth Satellite Population

Cataloged objects >10 cm diameter

1990
Growth of the Earth Satellite Population

Cataloged objects >10 cm diameter
Growth of the Earth Satellite Population

Cataloged objects >10 cm diameter

2000
Growth of the Earth Satellite Population

Cataloged objects >10 cm diameter
Potential Shuttle Damage

- Window Replacement
- EVA Suit Penetration
- Radiator Penetration
- RCC Penetration
- TPS Tile Penetration
- Cabin Penetration
- Cargo Bay Damage

Spacecraft Surface Inspections

Debris Diameter in Centimeters

0.001 0.01 0.1 1 10 100 1000

Haystack Radar

Haystack Auxiliary Radar

Goldstone Radars

Space Surveillance Network
Space Surveillance Network: LEO (> 5 cm), GEO (> ~1 m)

Organized as:
- Dedicated = primary
- Collateral = secondary
- Contributing = contracted services

LSSC = Lincoln Space Surveillance Center
Millstone, Haystack, HAX
MSSS = Maui Space Surveillance System
(former AMOS/MOTIF site)
Haystack/Haystack Auxiliary:
LEO (0.5–10 cm)

- Haystack and HAX measurements have been NASA’s main source of data on debris between 0.5 – 10 cm.
- Haystack (X-band; 0.058° FOV) has collected data since 1990
- Haystack Auxiliary (HAX) (Ku-band; 0.1° FOV) has collected data since 1993
- Currently ~600 hrs of data per year on each radar are collected under joint NASA-DoD program
Goldstone Bistatic Radar Complex:
LEO (0.2 – 1 cm)

- X-band Transmitter: 70 m dish antenna
  Receiver: 35 m dish antenna
  (separated by 0.5 km)

- Goldstone has the capability of detecting debris as small as 2 mm diameter at low altitudes; can reach as high as 4000 km

- Goldstone is available for only 100-200 hours each year and has a very small (0.02°) FOV
Spacecraft Surface Examinations:
LEO (≤ 0.1 cm)
Large Area Debris Collector (LAD-C): LEO (> 0.01 cm)

LAD-C
Large Area Debris Collector
to deploy on ISS in 2008
 Orbital Debris Environment

Cross-sectional Flux of a Given Size and Larger [Number/m²·Yr]

Diameter [cm]
Satellite Density in LEO: Altitude Distribution
Spatial density of cataloged objects between 800 and 900 km
High Earth Orbits: MEO and GEO

- The primary environment characterization and satellite cataloging for high Earth orbits are provided by a collection of ground-based optical and radar sensors and the Space-Based Visible instrument on the MSX spacecraft.

- The smallest objects typically seen by these sensors in high Earth orbits are typically tens of centimeters in diameter; nearly 1 m in GEO.
NASA Michigan Orbital Debris Survey Telescope:
GEO (> 20 cm)

- Location: Cero Tololo Inter-American Observatory, Chile
- 0.6/0.9 m Curtis Schmidt telescope
- Comprehensive surveys of the GEO region since 2001
Joint NASA-DoD project to deploy a 1-meter, remotely controlled telescope on the Kwajalein Atoll, Pacific Ocean.

Principal objective will be to detect small objects in low inclination orbits, including GTO and the GEO region.

Deployment possible by 2008.
Future LEO Environment with No New Launches

No new space launches after 2005
Future LEO Projection: >10 cm

Average Spatial Density for Debris Size > 10 Centimeters

- 200-250 km Altitude
- 500-550 km Altitude
- 800-850 km Altitude
- 1500-1550 km Altitude
Future LEO Projection: >1 mm

Average Spatial Density for Debris Size > 1 Millimeter

- 200-250 km Altitude
- 500-550 km Altitude
- 800-850 km Altitude
- 1500-1550 km Altitude
Summary

• The current Earth satellite population in LEO for all sizes is relatively well-established by a combination of deterministic and statistical means. At higher altitudes, the population of satellites with diameters of less than 1 m is not well defined.

• Although a few new sensors might become operational in the near- to mid-term, no major improvement in environment characterization is anticipated during this period.

• With the increasing deployment of micro- and pico-satellites and with the continued growth of the small debris population, a need exists for better space surveillance to support spacecraft design and operations.