Inter-Agency Space Debris Coordination Committee

IADC Observation Campaigns

43rd Session of
UNCOPUOS S&T SC
IADC Organization

- Membership: space agencies of China, ESA, France, Germany, India, Italy, Japan, Russia, Ukraine, the United Kingdom, and the United States

- Organization structure:
  - Steering group
  - WG-1: measurements
  - WG-2: environment & database
  - WG-3: protection
  - WG-4: mitigation

- Scope of activities defined in IADC Terms of Reference (see IADC Web-site: http://www.iadc-online.org)
IADC WG–1 (Measurements)

- Scope and objectives of WG–1 activities:
  - Ground- and space-based measurements and related techniques, e.g. radar, optical and infrared
  - Detectors and collectors for small-size particulates onboard space vehicles; analysis of spacecraft surfaces exposed to the space environment
  - Review of space debris research efforts in the area of measurement techniques
  - Identification, evaluation and recommendation of new opportunities for cooperation
- Coordinated measurement campaigns:
The Space Debris Environment

- Low-Earth Orbit (LEO): 0 < H < 2000km

- Objects in LEO (*):
  - d>1m: ~2,300
  - d>10cm: ~10,000
  - d>1cm: ~190,000

- Objects outside LEO (*):
  - d>1m: ~2,000
  - d>10cm: ~8,000
  - d>1cm: ~290,000

(*) According to the MASTER–2001 model of ESA
Observing Space Debris in LEO

• Radars are the preferred sensor type for LEO observations

• Advantages:
  – day/night and all-weather capability due to active illumination of the target
  – good detection effectiveness (depending on radar frequency, emitted power, antenna gain, …)
  – insensitive to high field-of-view crossing speeds
  – simplified (bulk) data processing capabilities

• Disadvantages:
  – sensitivity decreases with $1/(\text{range-to-target})^4$
  – debris size estimation may be ambiguous
Participating Radars (1)

- Goldstone (USA, left): bi-static mode with 34m transmitter and 70m receiver antenna, 500m apart; detection limit: ~2mm
- Haystack LRIR and HAX (USA, center): mono-static mode with 36m and 12m antenna; detection limit: ~5mm and ~3cm
- Cobra Dane (USA, right): phased array of 29m diameter with 96 sub-arrays; detection limit: ~5cm
Participating Radars (2)

- TIRA (D, left): mono-static mode with 34m transmitter and receiver antenna, detection limit: ~2cm
- TIRA/Effelsberg (D, center): bi-static mode with 34m TIRA transmitter and 100m Effelsberg receiver antenna; detection limit: ~9mm
- EISCAT (FIN/N/S, right): mono-static, ionosphere research radar with 32m antenna; detection limit: ~2cm
Sample Results of a LEO Campaign

- Strategy: Earth-fixed radar beam park; mono- or bi-static
- Performance drivers: antenna diameter, radar frequency, emitted power, system noise level
- Data products: range, angles, Doppler-inclination, size (RCS)
Observing Space Debris in GEO

• Telescopes are the preferred sensors for GEO observations

• Advantages:
  – target is illuminated by the Sun
  – sensitivity decreases only with $1/(\text{range-to-target})^2$

• Disadvantages:
  – observability depends on weather conditions, target illumination, and moon phase
  – observation processing more complex than for radar
  – field-of-view crossing speeds must be limited
  – a single sensor only sees a fraction of the GEO ring
Participating Telescopes (1)

- **ESA SD telescope (ESA, left):** 1.0m aperture; 4 x 2k x 2k CCD mosaic; limiting mag.: ~20 (2 sec) → ~15cm objects in GEO
- **TAROT telescope (F, center):** 25cm aperture; 2k x 2k CCD; limiting mag.: ~17 (10 sec) → ~ 50cm objects in GEO
- **CAT telescope (I, right):** 40cm aperture; 1k x 1k CCD; limiting mag.: ~17 (20 sec) → ~ 50cm objects in GEO
Participating Telescopes (2)

- MODEST telescope (USA, left): 61cm aperture; 2k x 2k CCD; limiting mag.: ~18 (5 sec) → ~30cm objects in GEO
- PIMS telescopes (UK, center): 40cm aperture; 1k x 1k CCD; limiting mag.: ~17.5 (3 sec) → ~35cm objects in GEO
- Bisei telescope (J, right): 0.5/1.0m aperture; 2/10 x 2k x 4k CCD mosaic; limiting mag.: ~18 → ~30cm objects in GEO
Sample Results of a GEO Campaign

- Strategy: Earth–fixed stare and/or sidereal tracking mode
- Performance drivers: aperture diameter, characteristics of the CCD (pixel resolution, quantum efficiency, read–out time, S/N)
- Data products: angular positions ($\alpha, \delta$), visual magnitude
Conclusions

• Since its formation in 1993 IADC has coordinated several international observation campaigns for the Low-Earth Orbit (LEO) and for the Geostationary Orbit (GEO) regions.

• Predominantly, radar techniques are applied for LEO surveys, and optical techniques are used for GEO surveys.

• Campaign results are ...
  – reported to IADC in standardized formats
  – important to calibrate debris environment models
  – useful to compare sensor performances
  – suited to identify populations below the detection size thresholds of operational surveillance systems.

• IADC might extend future campaigns beyond LEO and GEO.