INTER-AGENCY SPACE DEBRIS COORDINATION COMMITTEE (IADC)

SPACE DEBRIS ISSUES IN THE GEOSTATIONARY ORBIT AND THE GEOSTATIONARY TRANSFER ORBITS

Presented to:
37-th Session of the SCIENTIFIC AND TECHNICAL SUBCOMMITTEE COMMITTEE ON THE PEACEFUL USES OF OUTER SPACE UNITED NATIONS
OVERVIEW OF PRESENTATION

- THE GEOSTATIONARY TRANSFER ORBITS

- THE CURRENT POPULATION IN GEO

- THE IADC GEO OBSERVATION CAMPAIGN

- THE RECOMMENDATION OF IADC FOR THE DISPOSITION OF GEOSTATIONARY SATELLITES AT END-OF-LIFE
THE GEOSTATIONARY TRANSFER ORBIT (GTO)

- Purpose: transfer orbit to geostationary orbit

- Typical parameters:
  - perigee altitude from about 200 km to several thousand km's
  - apogee at or above the geostationary altitude (35786 km) at low latitude
  - apsidal line close to equatorial plane
  - inclination close to latitude of launch site (0-10 deg; 26-30 deg; 48-50 deg)
  - majority of objects in GTO are upper stages and mission-related objects
Lat 30
Lon -40
Height 48000
Lat 0
Lon –100
Height 48000
Lat 89.999
Lon –10
Height 100,000
GTO (2)

- Two transfer modes:
  - mode 1: launcher delivers S/C in GTO;
    - S/C reaches with own propulsion near-GEO orbit
    - super-synchronous transfer may be of interest in some cases
    - final upper stage remains in GTO
  - mode 2: launcher delivers S/C in a near-GEO orbit;
    - final upper stage remains in GEO space
GTO (3)

- Orbital lifetime of objects in GTO depends strongly on perigee altitude and orientation of orbit with respect to Sun and Moon

- GTO objects may pass for extended periods through LEO and GEO space
  - Relative velocity with respect to GEO: 1.5 - 2 km/s
  - Relative velocity with respect to LEO: 3 - 18 km/s
SATELLITES IN THE GEOSTATIONARY ORBIT

- Satellites are assigned nominal longitude and longitude window
- Typical size of longitude window is 0.2 deg
- Because of orbital perturbations station-keeping is required
  - control of longitude & latitude (E/W & N/S)
  - control of longitude only (E/W)
- Capacity increase by allocating several spacecraft to the same longitude window (co-location), e.g. 8 ASTRA S/C at 12 deg. E
  - Collisions among S/C in same longitude window are avoided by using slightly different orbits (eccentricity, inclination)
  - Special operation measures needed to avoid collisions (more precise orbit determination and control)
THE GEOSTATIONARY RING

- Comprises all geostationary orbits
- Comprises the space of the operational geostationary satellites
  - Radial dimension: 35786 km ± 75 km
  - N-S dimension (geocentric): ± 15 deg
THE CURRENT POPULATION IN GEO

- About 800 catalogued objects

- About 230 - 250 spacecraft are controlled

- Two breakups are known in GEO: Ekran S/C and Titan upper stage. Fragments are not cataloged.

- Tracking capabilities of routine space surveillance: 1 meter

- Experimental campaigns by ESA, NASA and CNES searching for debris show a significant population of unknown objects in the size region 20 cm - 100 cm

- Information on micro-debris and meteoroids is obtained with dust detectors (e.g. GORID on Express-2)
THE IADC GEO OBSERVATION CAMPAIGN

- General objective: Determine the extent and character of debris in the geosynchronous region.

  - Specific objective: characterise uncatalogued objects in GEO region as to
    - brightness
    - inclination
    - RA of ascending node
    - mean motion

- Progress hampered due to lack of suitable optical facilities (min. aperture of about 1 meter desirable)
COLLISION RISKS IN GEO

- among controlled spacecraft: very small collision risk except for co-located spacecraft

- operational S/C are at risk by uncontrolled S/C (maximum impact velocity 800 m/s)

- operational S/C are at risk by objects in GTO (maximum impact velocity approximately 2 km/s)
A STRATEGY FOR GEO DISPOSAL

- The objective is to protect the geostationary ring for future operations.

  The strategy for control is to manage the disposition of the kinetic and chemically stored energy to preclude hazards to current and future operational spacecraft.

  - The kinetic energy of the S/C or rocket body cannot be eliminated but the S/C or rocket body can be displaced to a region of reduced spatial density and therefore one in which the risk of collision is minimized.
A STRATEGY FOR GEO DISPOSAL (2)

- The manoeuvre to reorbit the S/C at end-of-life is an efficient and effective method of disposing of residual propellant and pressurants.

- To preclude inadvertent increase in the energy of a GEO crossing, the reorbiting manoeuvre should be planned and executed as a multi-burn series of manoeuvres.

- The residual energy should be used to maximize the displacement from the GEO ring

- Depletion of other forms of stored energy is required to preclude cross contamination from the disposal region to GEO (e.g. battery explosion).
A STRATEGY FOR GEO DISPOSAL (3)

- These measures will not guarantee the indefinite availability of GEO current levels of environmental risk but they will maximize the future expectation at reasonable cost.
RECOMMENDATION ON DEBRIS MANAGEMENT IN THE GEOSTATIONARY RING

Considering the importance of the Geostationary Ring (GEO) for space applications and the long-term consequences of any action taken at end of mission to dispose of spacecraft in the GEO region, the Inter-Agency Space Debris Coordination Committee (IADC) recommends that:

- The IADC endorses the ITU Recommendation ITU-RS. 1003 June 1993 that at end of mission S/C be reorbited into a disposal orbit above the geostationary ring.

- The IADC recommends that in so far as possible, operational debris not be inserted into GEO.
RECOMMENDATION ON DEBRIS MANAGEMENT IN THE GEOSTATIONARY RING (2)

- The IADC recommends that at end-of-life satellites in GEO be reorbited and passivated. The reorbiting manoeuvre displaces the satellite to a region above GEO to reduce the spatial density; the passivation in disposal region reduces the threat of cross contamination of the region by inadvertent explosions.

- The minimum perigee altitude above the geostationary altitude of 35786 km should be not less than $\min \Delta H$ (in km):

$$\min \Delta H = 235 \text{ km} + Cr \times 1000 \times A/m$$

$Cr$ is a coefficient between 0 and 2. $A$ is the cross-sectional area ($m^{**2}$) and $m$ the S/C mass (kg)
RECOMMENDATION ON DEBRIS MANAGEMENT IN THE GEOSTATIONARY RING (3)

- There is no reason to circularize the orbit at a particular altitude since altitude variations reduce the spatial density, which is desirable.

- The manoeuvre to achieve the increased perigee should be executed as a multi-burn series of manoeuvres in order to minimize the probability that errors of estimate in the residual propellant will leave the S/C in a GEO crossing orbit.

- The IADC recommends that when relocated to the supersynchronous disposal region, the S/C should be depleted of all other sources of stored energy, pressurant gases, battery energy, etc. in order that inadvertent explosions can be avoided and debris be ejected back into GEO.

RECOMMENDATION ON DEBRIS MANAGEMENT IN
THE GEOSTATIONARY RING (4)

- The IADC recommends that rocket upper stages used for inserting geostationary satellites into GEO are placed in a disposal region with a perigee located at least min $\Delta H$ above the geostationary altitude.
IADC ISSUES

- Oct. 11-13, 1999: 17-th IADC at ESOC, Darmstadt (Germany) with more than 100 participants
- National Space Agency of the Ukraine (NSAU) applies for membership in IADC
- Feb. 16, 2000: IADC Steering Group Meeting