# INTER-AGENCY SPACE DEBRIS COORDINATION COMMITTEE (IADC)

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

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SCIENTIFIC AND TECHNICAL SUBCOMMITTEE
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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**

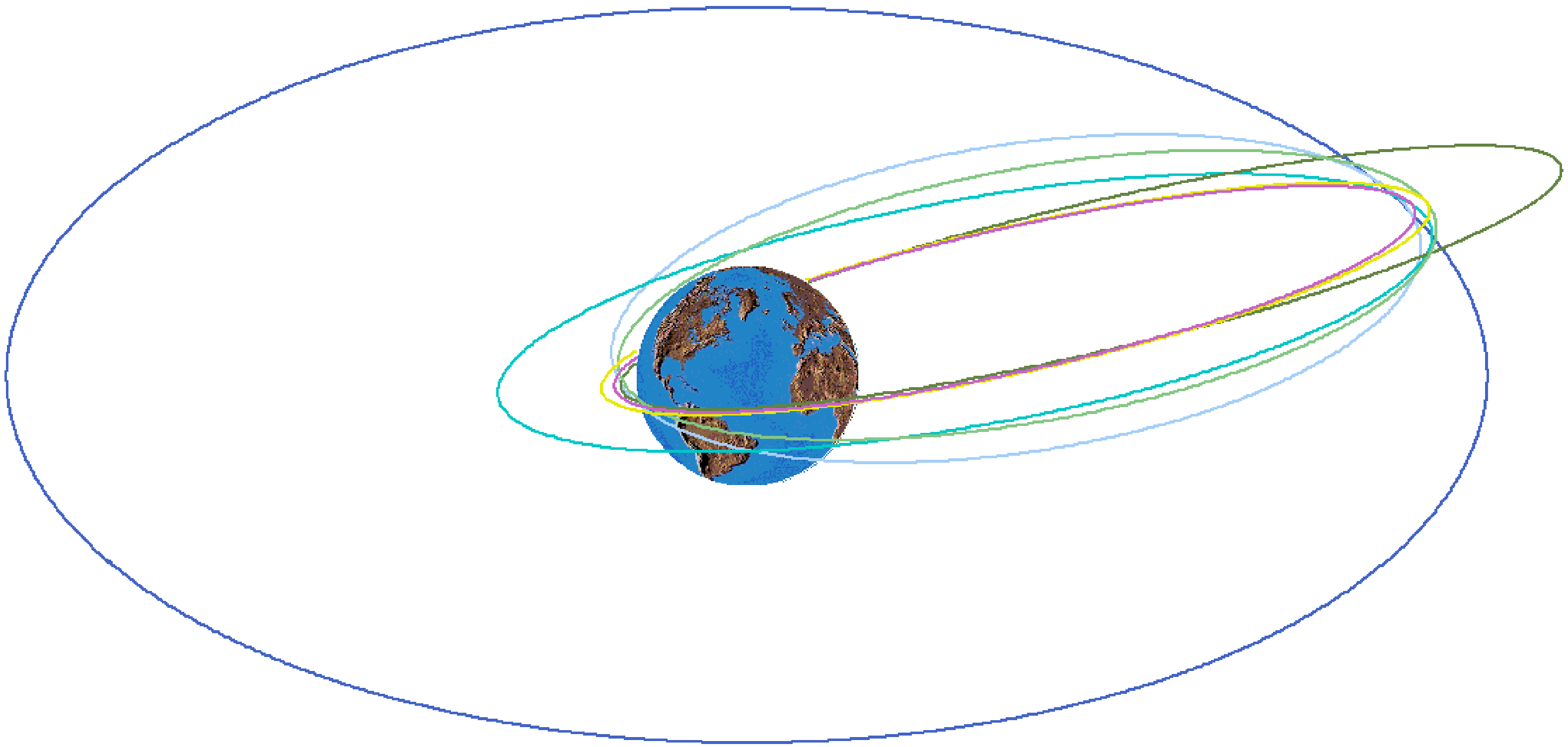
# THE GEOSTATIONARY TRANSFER ORBIT (GTO)

- Purpose: transfer orbit to geostationary orbit

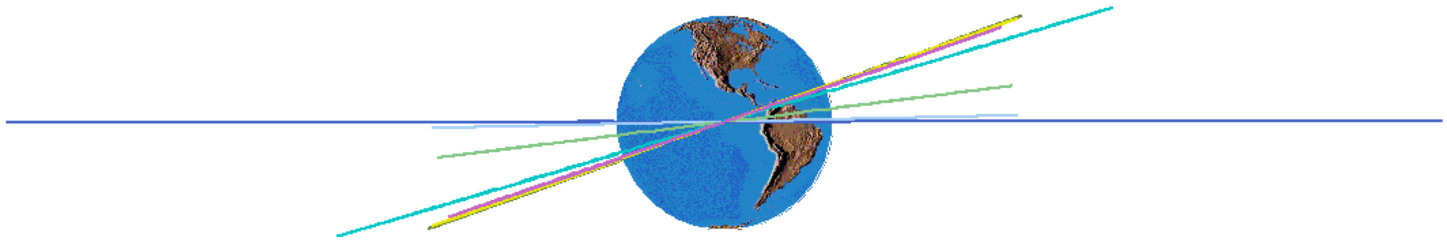
- Typical parameters:

  - 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

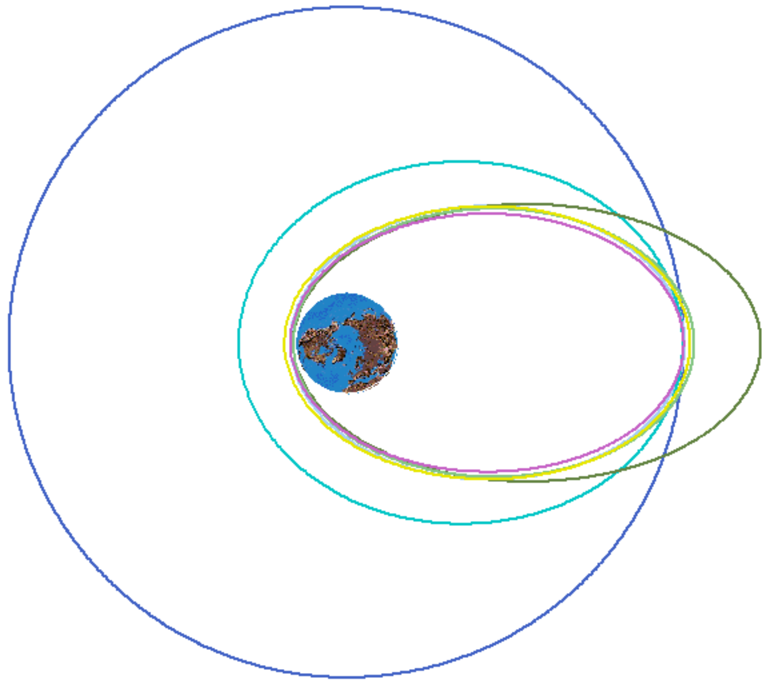
**Lat 30**
**Lon –40**
**Height 48000**



**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 I 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 ΔH (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**
- **June 13-16, 2000: 18-th IADC at Colorado Springs (U.S.A.)**