SATELLITE PLANNING & REGULATORY CONSIDERATIONS

ECE 514E-SATELLITE & RADAR ENGINEERING

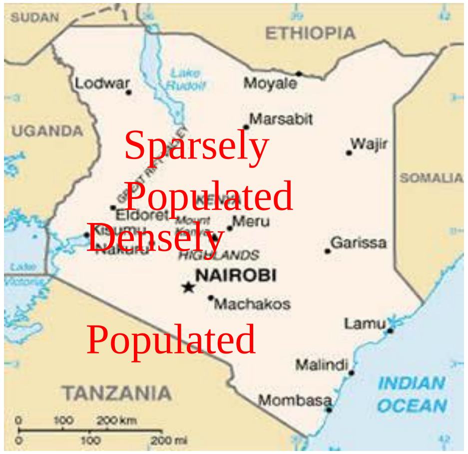
Tuesday, January 29, 2019

FACTORS TO CONSIDER WHEN PLANNING FOR A NEW SATELLITE

1. Coverage over a large area to suit sparsely populated areas or satellite broadcasting services.

2. Costs independent of distance and intervening terrain, ease of connecting locations in mountainous regions, islands, deserts, forests and swamps

3. Speed of installation and capacity to provide short-term and emergency services using transportable terminals, e.g. Flyaway



FACTORS TO CONSIDER WHEN PLANNING FOR A NEW SATELLITE

1. Broadcast nature of satellite transmissions and facility in providing television, radio, teleconferencing, news, data and Internet services.

2. Flexibility to adopt varying traffic demands and types of services,

3. Capacity to provide media diversity for terrestrial cable and radio links.

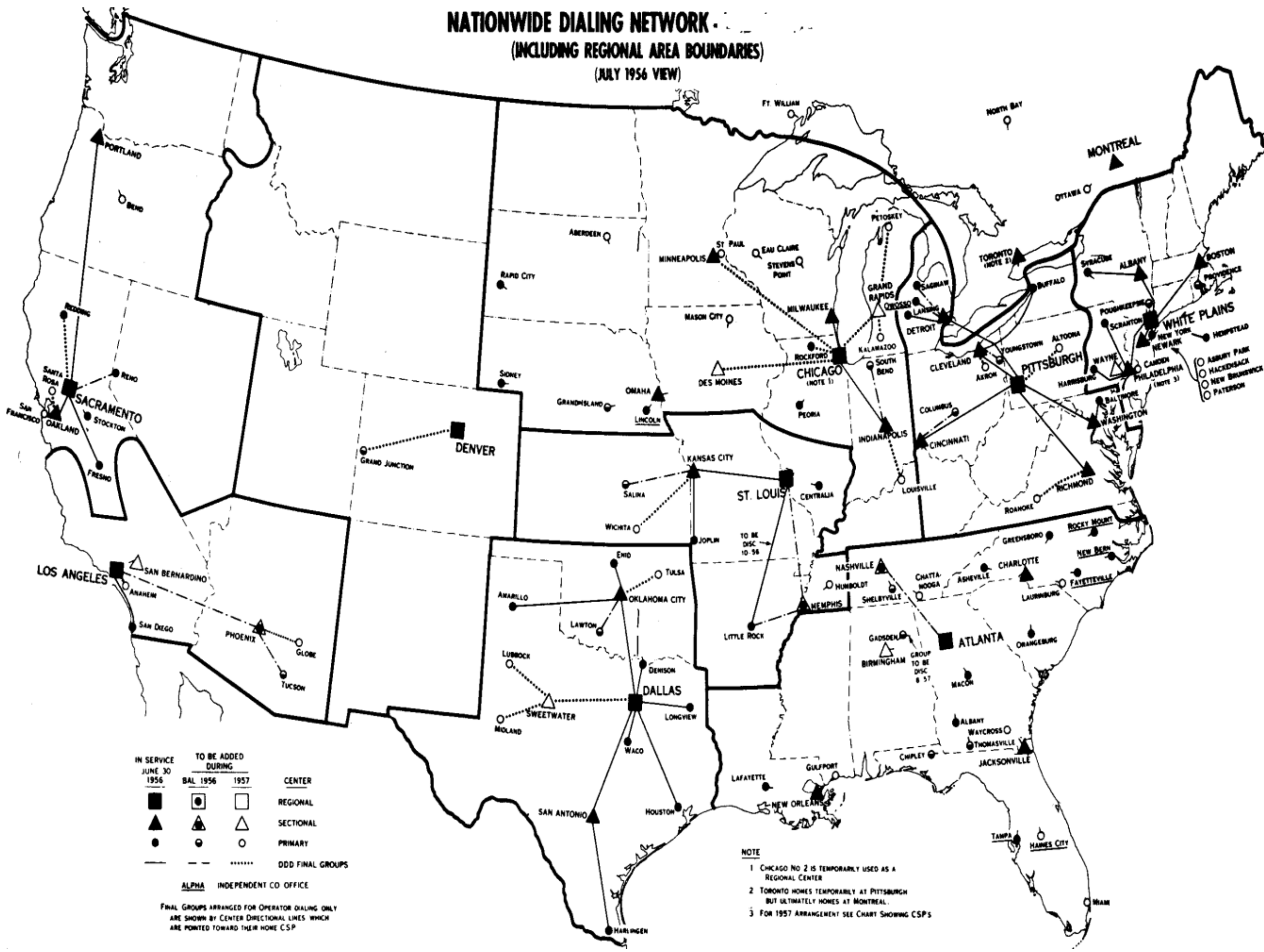
THE PLANNING PROCESS

1. Planning should take into account the above advantages and be compatible with:
   - National Switching Plan
   - National Transmission Plan

2. Assess the total service requirements and the allocation of transmission media:
   - Cable
   - Radio
   - Optic Fibre
   - Satellite

NATIONAL SWITCHING PLAN - FIXED

- National Switching Plan for fixed networks shows you areas with:
  a) high population
  b) High usage of voice and data/internet services
  c) Un-served or marginalized areas.

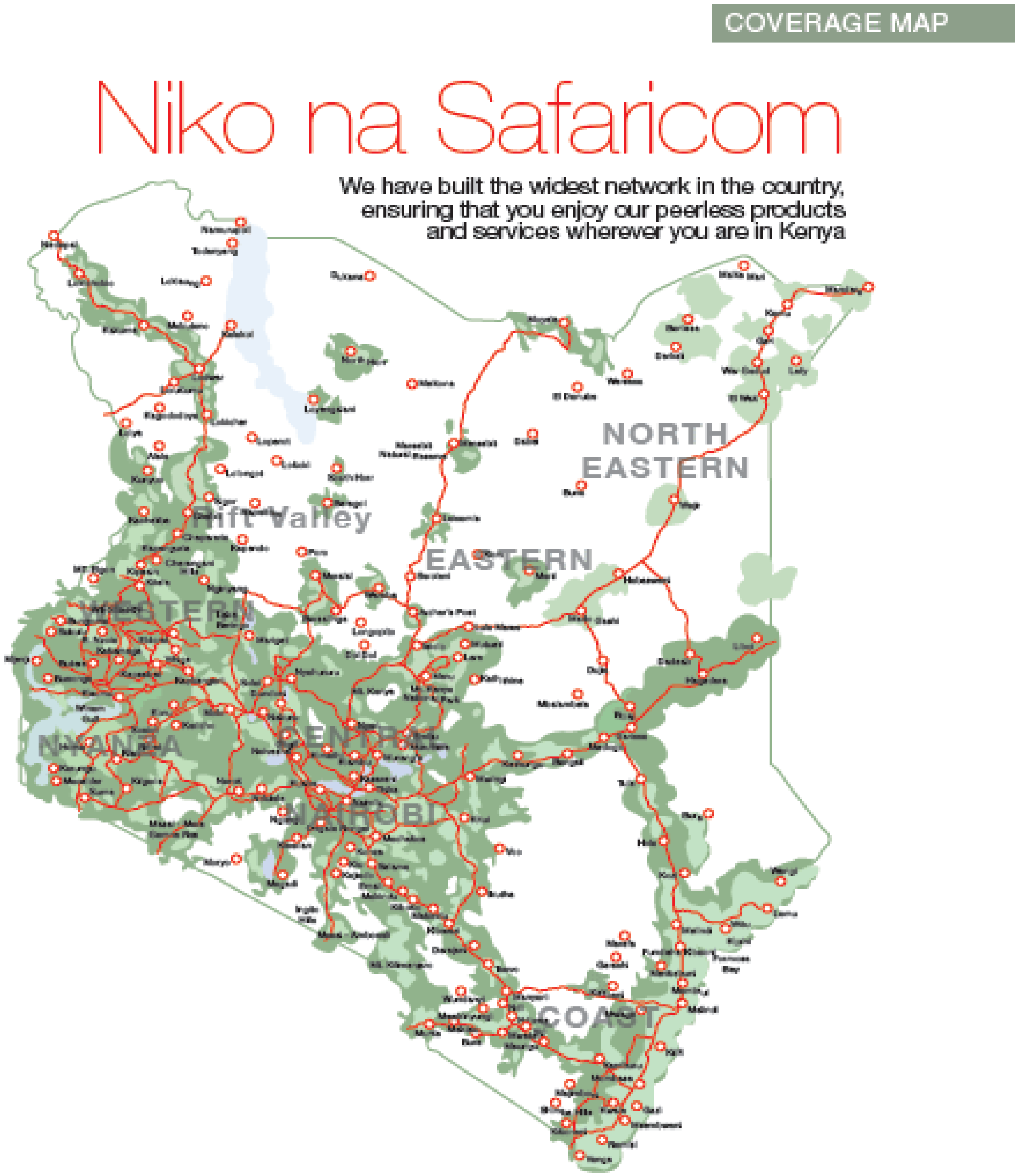


FIXED NATIONAL SWITCHING PLAN - KENYA

Most of the high income potential subscribers reside in urban areas.
But there are times like during emergencies, national census, national election that telecommunication services are required in remote areas.

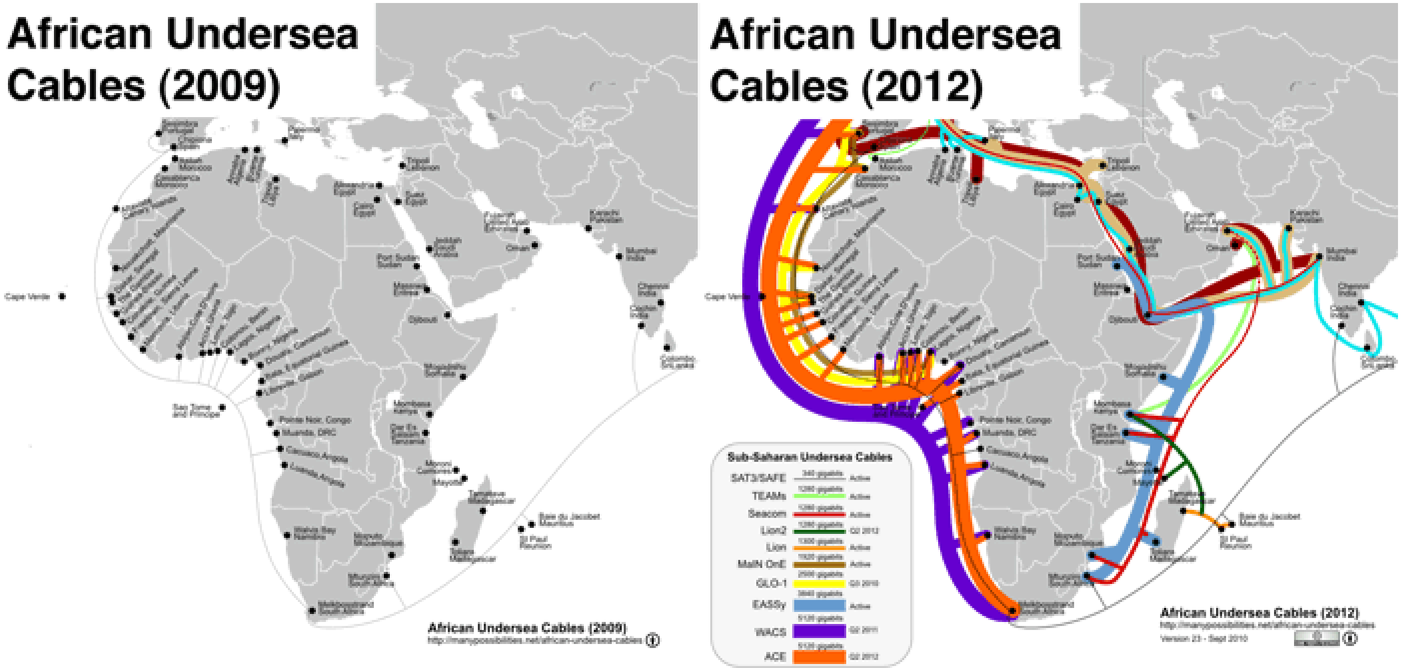
NATIONAL SWITCHING PLAN - MOBILE

- Mobile coverage is better obtained by checking the recent coverage maps of mobile operators in the country.
- From the coverage maps you can establish areas with:
  a) high population
  b) High usage of voice and data/internet services
  c) Un-served or marginalized areas.



NATIONAL TRANSMISSION PLAN – INTERNATIONAL FIBRE OPTIC CABLES

1. Submarine fibre optic cables are a major competitor to satellite for the following international services:
   a) International telephone services
   b) Carrier broadcasting services
   c) Internet/other data services
2. This is more evident in Africa where increased access to submarine fibre optic cables has led to dwindling revenues from satellite services.



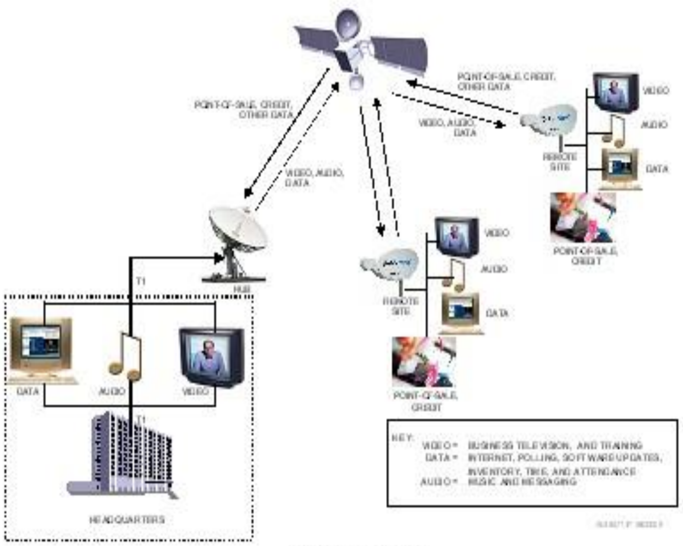
PLANNING PROCESS (2)

1. Satellite Design Life is 10-15 years
1. Traffic projections (including traffic for future applications) have to be made for 10-15 years
2. Three to four years required for:
   a) Preparing Spacecraft Specifications
   b) Preparing Request for Proposals
   c) RFP Evaluation
   d) Ordering and Construction of Satellite

PRELIMINARY SYSTEM ENGINEERING

1. From projections of traffic to be carried over a satellite network, a traffic matrix is prepared indicating:
   a) the number of carriers,
   b) channel capacities
   c) inter-connections required.

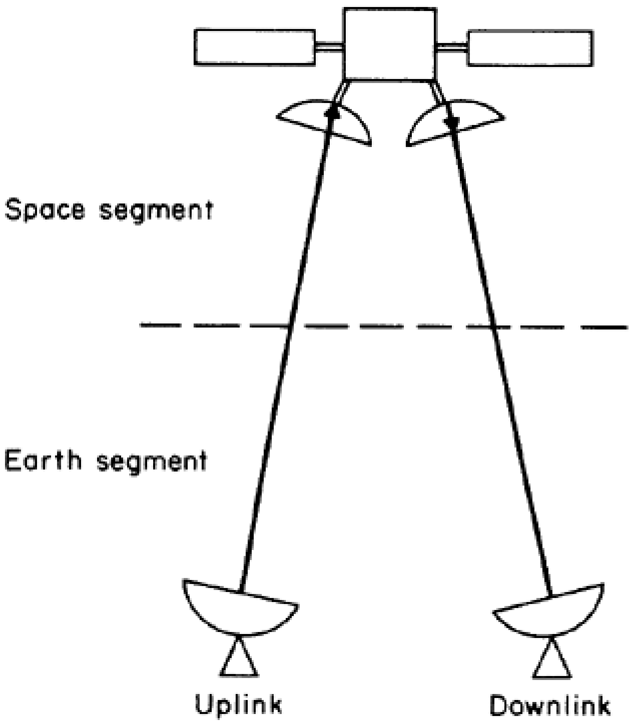
2. Establishing the **number of satellite transponders** required is an iterative process involving tentative assumptions regarding earth-station and satellite parameters and then optimizing the parameters in relation to:
   a) Overall system costs
   b) Channel capacity ,
   c) Performance required.



NETWORK DIAGRAM

DETAILED PLANNING

1. Detailed planning of a satellite system may be broadly divided into two areas, i.e
   i) space segment
   ii) earth segment.



2. These two segments may be handled by different organizations in some countries.

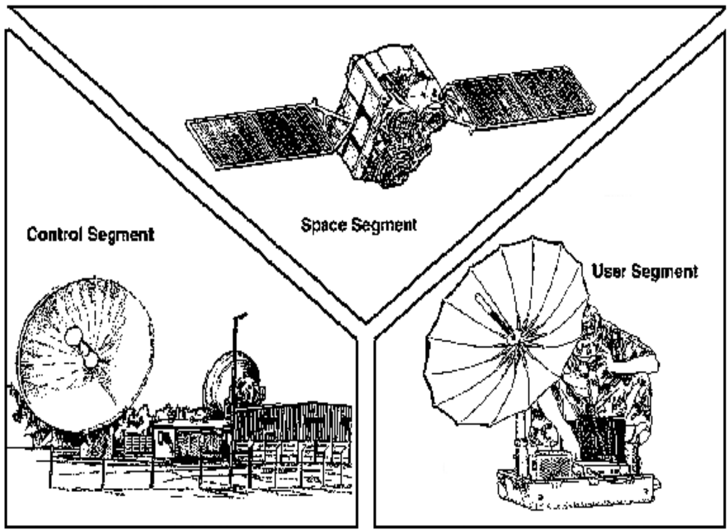
3. Procedures for coordination between the planning groups should be established.

SPACE-SEGMENT PLANNING (1)

The functions of space segment planning are as follows:

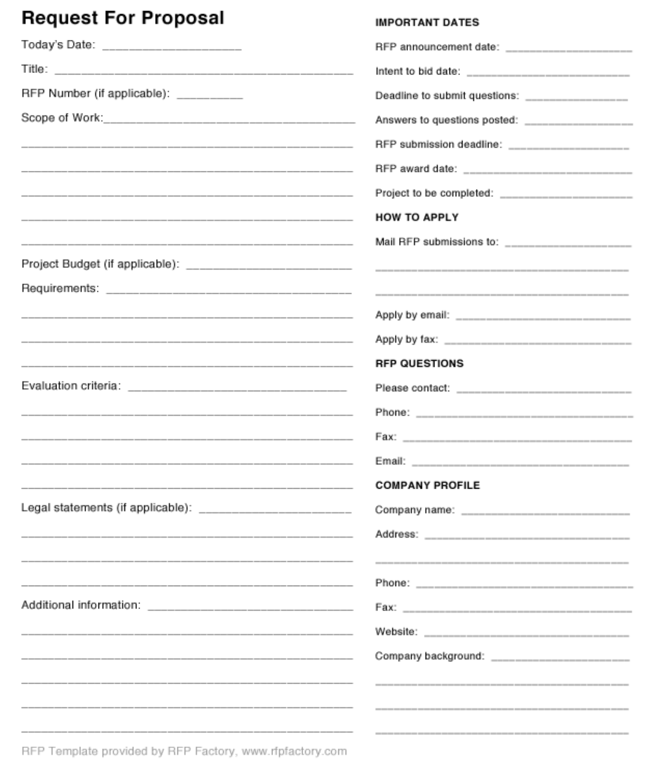
1. Collection of customer requirements, service and mission requirements;
2. Preliminary studies regarding various options for spacecraft, spare philosophy, time schedules and system cost.
3. Orbit and spectrum requirements, selection of orbit slot and follow up of coordination procedures.
4. Selection of launch vehicle.

Figure 4-1. Space System Segments



SPACE-SEGMENT PLANNING (2)

5. Preparation of request-for-proposal (RFP) for satellites and associated control facilities;
6. Evaluation of RFP and award of contract;
7. Finalization of launch vehicle agreement;
8. Establishment of satellite and launch vehicle contract monitoring.


Request For Proposal

Today's Date:

Title:

RFP Number (if applicable):

Scope of Work:

Project Budget (if applicable):

Requirements:

Evaluation criteria:

Legal statements (if applicable):

Additional information:

IMPORTANT DATES

RFP announcement date:

Intent to bid date:

Deadline to submit questions:

Answers to questions posted:

RFP submission deadline:

RFP award date:

Project to be completed:

HOW TO APPLY

Mail RFP submissions to:

Apply by email:

Apply by fax:

RFP QUESTIONS

Please contact:

Phone:

Fax:

Email:

COMPANY PROFILE

Company name:

Address:

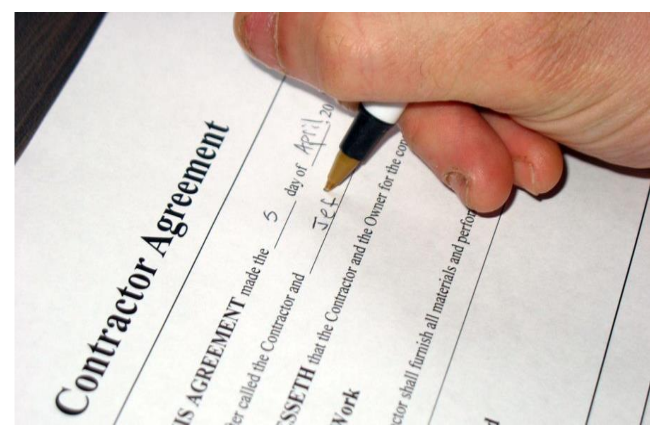
Phone:

Fax:

Website:

Company background:

RFP Template provided by RFP Factory, www.rfpfactory.com



EARTH STATION PLANNING (1)

Earth Station Planning involves the following tasks:

1. Collection of service requirements and traffic matrix;
2. Finalization of transmission plan taking into consideration the specified space segment characteristics;
3. Preparation of the overall definition for the ground segment;
4. Finalization of earth-station equipment specification, preparation of request-for-proposals for ground segment, evaluation of RFP and ordering of equipment;

EARTH STATION PLANNING (2)

5. Selection of earth-station sites and electromagnetic compatibility (EMC) survey;

6. Notification and frequency clearance for selected sites;

7. Preparation of plans for building and award of contract for building construction;

8. Ordering of water and electric supplies and power plant.

INSTALLATION PLANNING

1. Construction of spacecraft, supply of earth-station equipment, site selection and construction of approach roads and buildings are long lead time items and these activities are carried out concurrently.
2. Simultaneously, arrangements should be made for recruitment and training of staff for installation, operation and maintenance.
3. Provision for training by manufacturers may be provided when ordering equipment.

INSTALLATION ACTIVITIES

1. Construction of buildings, civil works and provision of infrastructure;
2. Detailed engineering including drawing-up of layout plan for equipment and definition of the interfaces between the different items of equipment;
3. Monitor equipment supply orders and order for any shortcoming and installation materials;
4. Transportation of equipment and materials to site, physical inspection of items supplied and dispatch of reports to the manufacturers, as necessary, for damage and shortage;

INSTALLATION ACTIVITIES (1)

1. Award of contract for installation of antenna and towers and supervision of work;
2. Installation and acceptance testing of equipment and power plant;
3. Commissioning of equipment, local line-up;

4. Assistance in the evaluation of the earth stations by a network operations control centre (NOCC) as per acceptance procedures. Acceptance testing includes antenna radiation patterns

INSTALLATION ACTIVITIES (2)

5. Line-up for operational links;

6. Integration of circuits into the terrestrial telecommunication ,network, trunk automatic and manual exchanges, etc., and coordination with other organizations for extension of circuits to users.

OPERATION AND MAINTENANCE (1)

1. Establishment of procedures for coordination between agencies concerned with spacecraft operations, earth-station operations and the telecommunication network;
2. Laying down schedules for manning earth station and definition of duties;
3. Preparation of line-up procedures, operational procedures and preparation of test schedules for equipment as per manufacturer's recommendation;
4. Setting up of a network operations and control centre (NOCC) for monitoring and control;

OPERATION AND MAINTENANCE (2)

5. Preparation of daily, weekly and monthly operational schedules as per transmission plan and service requirements and notification of these to a Spacecraft Control Centre and NOCC;
6. Establishment of central and regional repair centres, calibration facilities and fault control procedures.

ITU-RS SERIES RECOMMENDATIONS (FIXED SATELLITES)

1. **Rec. ITU-R S.725** Technical characteristics for very small aperture terminals (VSATs)
2. **Rec. ITU-R S.726-1** Maximum permissible level of spurious emissions from very small aperture terminals (VSATs)
3. **Rec. ITU-R S.727** Cross-polarization isolation from very small aperture terminals (VSATs)

4. **Rec. ITU-R S.729** Control and monitoring function of very small aperture terminals (VSATs)
5. **Rec. ITU-R S.lOO1** Use of systems in the fixed-satellite service in the event of natural disasters and similar emergencies for warning and relief operations

ITU-RS SERIES RECOMMENDATIONS (FIXED SATELLITES)

8. **Rec. ITU-R S. 1 149-1** Network architecture and equipment functional aspects of digital satellite systems in the fixed-satellite service forming part of synchronous digital hierarchy transport networks.
9. **Rec. ITU-R S. 1250** Network management architecture for digital satellite systems forming part of SDH transport networks in the fixed-satellite service.

ITU-RS SERIES RECOMMENDATIONS (FIXED SATELLITES)

10. **Rec. ITU-R S. 125 1** Network management - Performance management object class definitions for satellite systems network elements forming part of SDH transport networks in the fixed-satellite service

FREQUENCY SHARING BETWEEN NETWORKS OF THE FIXED-SATELLITE SERVICE

- **Rec. ITU-R S.466-6**: Maximum permissible level of interference in a telephone channel of a geostationary-satellite network in the fixed-satellite service employing frequency modulation with frequency-division multiplex, caused by other networks of this service

FREQUENCY SHARING BETWEEN NETWORKS OF THE FIXED-SATELLITE SERVICE

- **Rec. ITU-R S.483-3** Maximum permissible level of interference :in a television channel of a geostationary-satellite network in the fixed-satellite service employing frequency modulation, caused by other networks of this service

FREQUENCY SHARING BETWEEN NETWORKS OF THE FIXED-SATELLITE SERVICE

- **Rec. ITU-R S.523-4** Maximum permissible levels of interference in a geostationary-satellite network in the fixed-satellite service using 8-bit PCM encoded telephony, caused by other networks of this service

FREQUENCY SHARING BETWEEN NETWORKS OF THE FIXED-SATELLITE SERVICE

- **Rec. ITU-R S. 1323:** Maximum permissible levels of interference in a satellite network (GSOFSS; non-GSOFSS; non-GSOIMSS feeder links) for a hypothetical reference digital path in the fixed-satellite service caused by other co-directional networks below 30 GHz

ITU-R B0 SERIES RECOMMENDATIONS (BROADCASTING-SATELLITE SERVICE)

- **Rec. ITU-R B0.650-2:** Standards for conventional television systems for satellite broadcasting.

- **Rec. ITU-R B0.65 1:** Digital PCM coding for the emission of high-quality sound signals in satellite broadcasting (l 5 kHz nominal bandwidth)

ITU-R B0 SERIES RECOMMENDATIONS (BROADCASTING-SATELLITE SERVICE)

- Digital multi-programme emission systems for television, sound and data services for satellites operating in the 11/1 2 GHz frequency range.

- Common functional requirements for the reception of digital multi-programme television emissions by satellites operating in the 1 111 2 GHz frequency range

PLANNING AND SHARING

- **Rec. ITU-R B0.600-1:** Standardized set of test conditions and measurement procedures for the subjective and objective determination of protection ratios for television in the terrestrial broadcasting and the broadcasting-satellite services.
- **Rec. ITU-R B0.1212:** Calculation of total interference between geostationary-satellite networks in the broadcasting-satellite service

PLANNING AND SHARING

- **Rec. ITU-R B0.1213:** Reference receiving earth station antenna patterns for re-planning purposes to be used in the revision of the WARC-77 BSS plans for Regions 1 and 3.

SATELLITE SERVICES

ECE 514E – SATELLITE & RADAR ENGINEERING

SATELLITE SERVICES

Most Satellite Coordination issues involve:

FSS -- Fixed-Satellite Service

BSS -- Broadcasting-Satellite Service

MSS -- Mobile-Satellite Service

OTHER SATELLITE SERVICES

ISS - Inter-Satellite Service

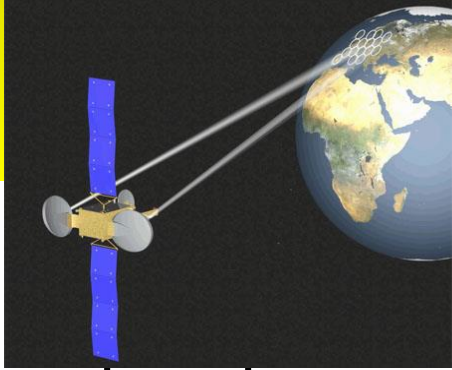
RNSS - Radio Navigation Satellite Service

EESS - Earth Exploration-Satellite Service

SOS - Space Operation Service

RAS - Radio Astronomy Service

FREQUENCY REGULATION



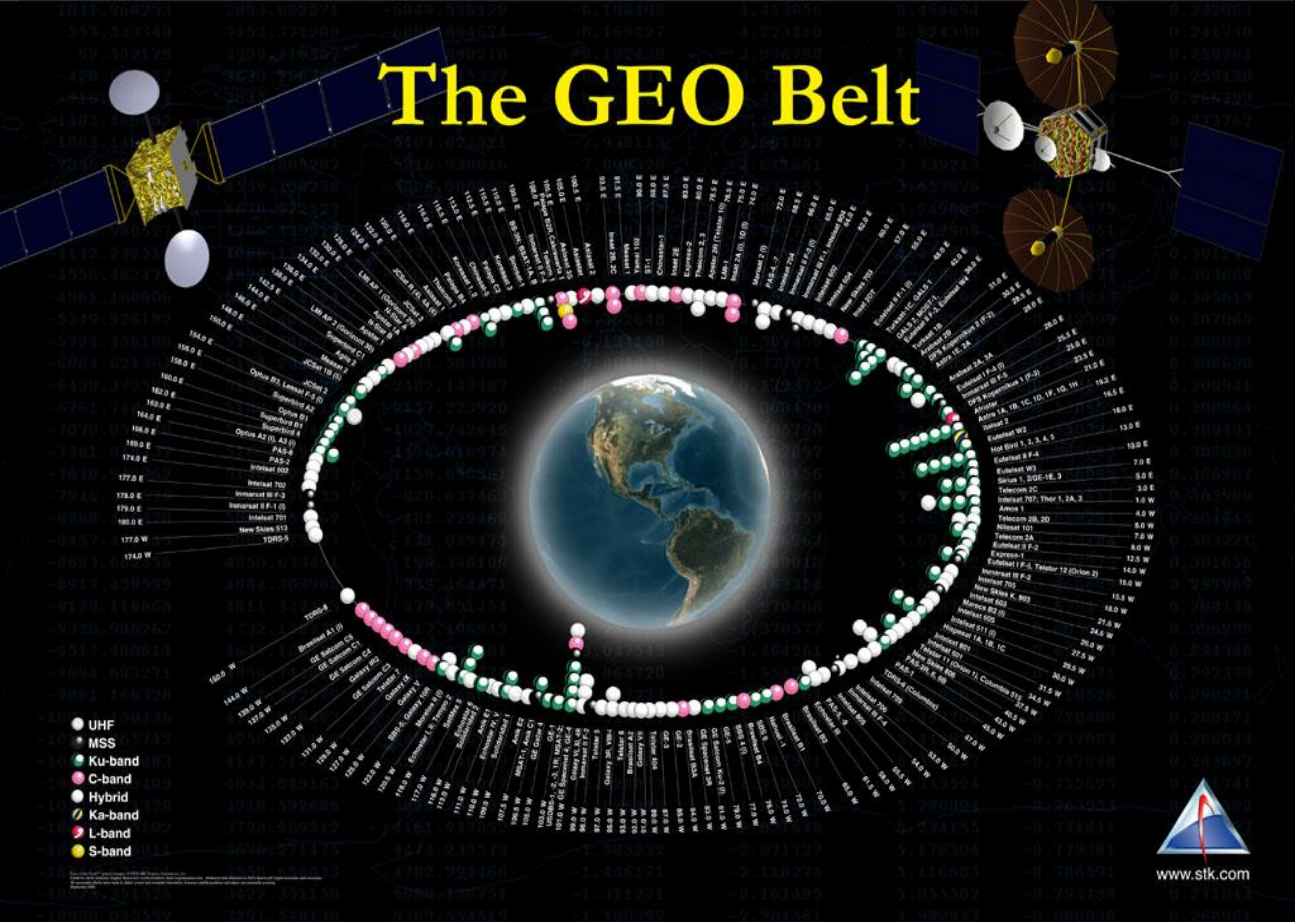
- The orbital slots issue is just one of the issues that the International Telecommunications Union (ITU) addresses.
- The frequencies on which the satellites broadcast are also regulated by the ITU.
- Satellite frequency regulation is important because satellites that broadcast on the wrong frequencies can interfere with neighbouring satellites or even terrestrial radio or television transmissions.
- Currently, the ITU has assigned about 87,000 frequencies to about 600 satellite networks in orbit (some of which are geosynchronous satellites).

FREQUENCY BANDS & SERVICES

Band	Frequency Range (Approx)	Major Services	Uses
L	1 – 2 GHz	BSS, MSS, RNSS	•INMARSAT/THURAYA mobile services •Digital Radio Broadcasting •GPS/GALLIEO Navigation
C	4 – 6 GHz	FSS	Commercial trunk applications and some VSAT
X	7 – 8 GHz	FSS, MSS	Military Communications
Ku	10 – 14 GHz	FSS, BSS	Commercial DTH, VSAT services
Ka	18 – 30 GHz	FSS, MSS	Military and Commercial

ORBITAL SLOTS IN GEOSTATIONARY ORBITS

1. Before 1983, the spacing of satellites between two geostationary orbits was set at 4^{o} and the smallest earth station antenna was 5m.
2. This was reduced to 2^{o} subsequently thus allowing for more satellites in space.
3. Nowadays the space between two satellites can be as low as 0.1^{o} especially in regions with high demand e.g. those covering America and Europe.
4. By 2018, there were 448 active geostationary satellites.



The GEO Belt
UHF
MSS
Ku-band
C-band
Hybrid
Ka-band
L-band
S-band
www.stk.com

GEOSTATIONARY ORBITS IN INCLINED ORBITS

Some older satellite, whose north-south station-keeping fuel has run out are in inclined orbits.

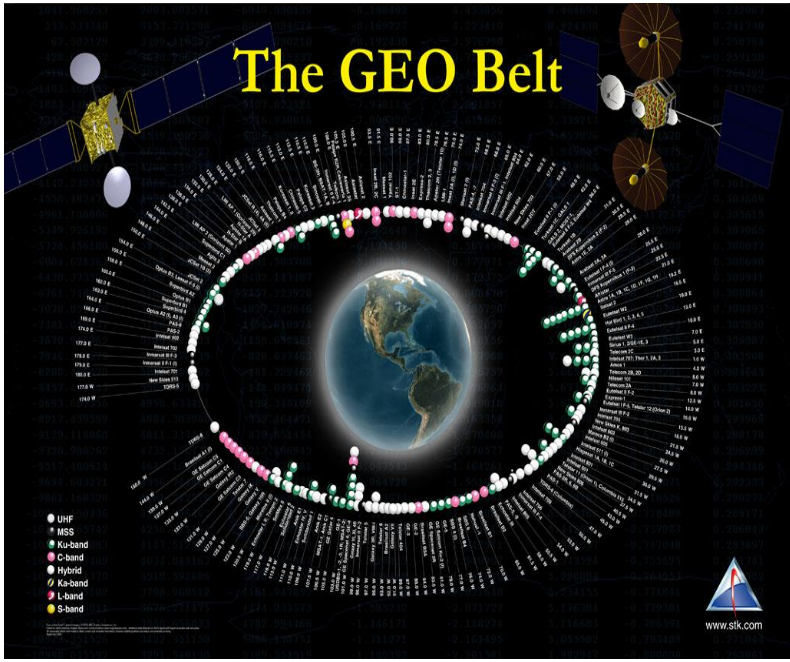
ID	COMMON NAME	ORBIT	INCL (DEG)
12061B	YAMAL 300K	-177.0	0.0
09008A	NSS-9	-176.9	0.0
13004A	TDRS 11	-174.4	4.6
02055A	TDRS 10	-171.0	6.0
91054B	TDRS 5	-167.7	14.6
00081B	AMC-8 (GE-8)	-139.0	0.0
06054B	AMC-18	-139.0	0.0
05015A	SPACEWAY 1	-138.9	0.1
18022A	GOES-17	-137.2	0.1
97046A	INTELSAT 5 (IS-5)	-137.0	4.6

SCARCITY OF ORBITAL SLOTS

1. As of 2002, there was a large backlog of applications for orbital slots (about 1,200 with an additional 400 to 500 coming in yearly), which creates a problem of satellites that exist on paper that may never be built.
2. With a dwindling number of orbital slots, firms and governments have a strong incentive to try to get slots whether or not they have the intent to launch a satellite right away.
3. This creates an administrative backlog and wastes slots when prospective satellite systems are not launched.

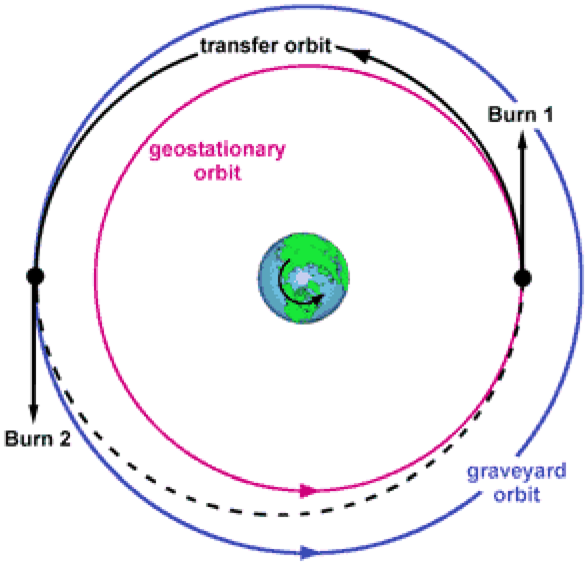
ABUSE OF ORBITAL SLOT ALLOTMENT SYSTEM

- Some countries are using the fact that they have a right to slots in space to their advantage by leasing these slots to firms in other countries.
- Tonga, for instance, secured the rights to six orbital slots and then auctioned them to the highest bidder.
- Many in the international community saw this as an abuse of the system.
- Other small countries, such as Gibraltar, Papua New Guinea, and Tuvalu have auctioned off orbital slots that they have obtained or are considering similar auction plans.



PROBLEMS CAUSED BY DEBRIS

1. Given the properties of the geosynchronous orbit, broken down satellites and other space debris tend to stay in orbit for a longer period of time.
2. This creates a space debris hazard where active satellites may be damaged or destroyed.
3. The usual procedure is to move expired satellites to the graveyard orbit.



Achieving a Graveyard Orbit
(not to scale)

PROBLEMS WITH ENFORCEMENT

1. The ITU has no way to actually enforce its rulings (the ITU acts to increase the efficiency of the system; each sovereign state regulates satellite launches, orbital slots, and frequencies)
2. Firms and countries can launch satellites into orbit without considering orbital slot issues and frequency issues.
3. This occurred in 1994, when China launched a satellite into orbit without the approval that had a high potential to interfere with neighboring satellites.
4. North Korea is a frequent offender in this regard.

REGULATION BY NATIONAL AGENCIES

What is coordination?

•An international (national) process of negotiation between administrations (operators) that enables mutually acceptable use of the orbital/spectrum resource.

Why do we coordinate?

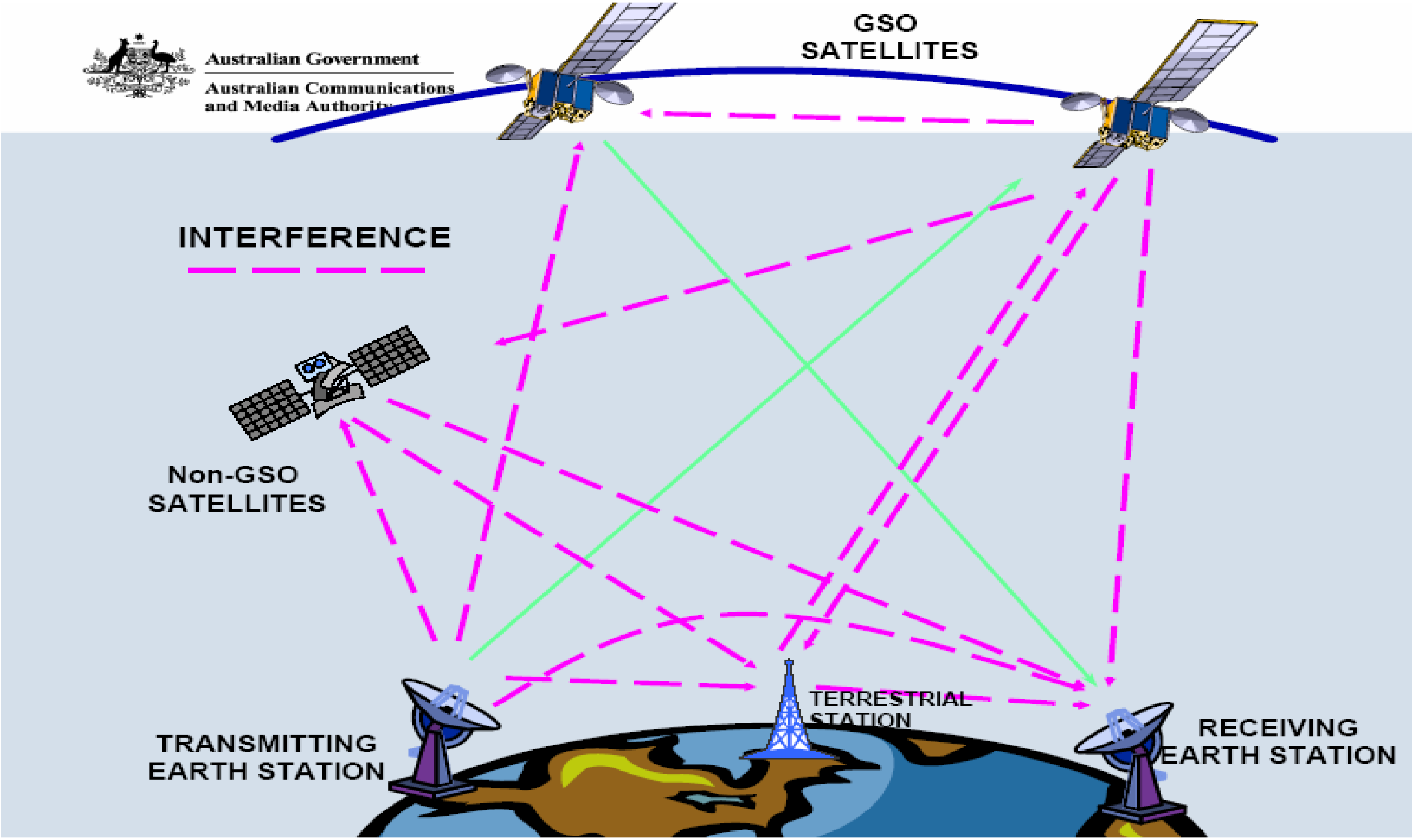
•The orbital/spectrum resource is finite.

•Required under international conventions to give all nations equitable access to the orbital/spectrum resource.

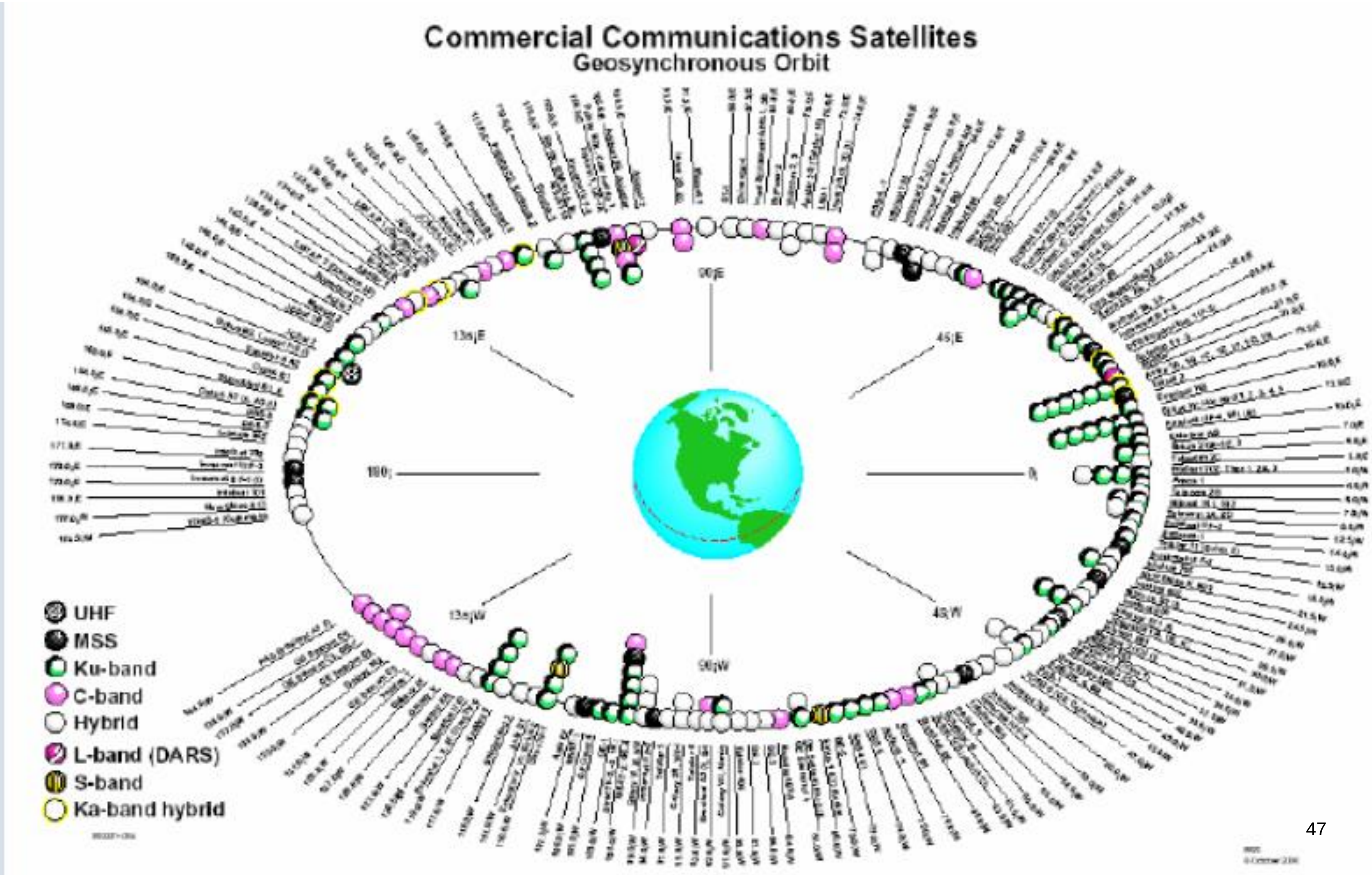
How do we coordinate?

•Through the International Telecommunication Union (ITU) satellite network filing and coordination process.

COORDINATION AVOIDS INTERFERENCE



NETWORK FILING AND COORDINATION



NETWORK FILING AND COORDINATION

Difference between a satellite network and a satellite.

Satellite Network

•The regulatory entity (filing) that is filed and coordinated through the ITU.

Satellite

•The actual satellite that is launched and operated.

NETWORK FILING AND COORDINATION

- A single physical satellite can operate under multiple licences, e.g.
  - FSS
  - Broadcasting
- Why have multiple filings on a satellite?
  - To simplify coordination
  - Allow operators to coordinate their payload

ITU COORDINATION

ITU

International Telecommunication Union

BR

Radiocommunication Bureau

Filing/Coordination procedure defined in:

•Radio Regulations

•Rules of Procedure

•Circulars

•etc.

GOALS OF SATELLITE COORDINATION

International Goals

- The aim is to provide (amongst other things) for **equitable** and **efficient** access to the spectrum/orbit resource

Two mechanisms of access to orbit / spectrum:

Coordination Approach

Efficient use

First come, first served for actual requirements

Planning Approach

Equitable access

Plan for future use

PROCEDURES FOR GAINING ACCESS TO SPECTRUM/ORBITAL RESOURCES

Coordination Procedure "First Come, First Served"

- Right is acquired through coordination with administrations concerned by actual usage
- **Efficient** spectrum / orbit management
- Also referred to as the 'unplanned bands'
- Most widely used procedure for gaining access to the spectrum/orbit resource

Plan Procedure

- Guarantee for **equitable** access to the spectrum / orbital resources
  - Spectrum set aside for future use by all countries
  - Predetermined orbital position & frequency spectrum
- Plans exist for both BSS and FSS
- Generally less widely implemented than the unplanned bands.

SATELLITE FILING PROCESS

BR Filing Process (Unplanned bands*):

1. **Advance Publication Information - API**

2. **Coordination Request - ‘C Notice’**

3. **Notification**

*A different process applies for the Planned Bands.

BR Filing Process

2. Coordination Request - 'C Notice'

- Operational parameters of network for proposed operation
  - Used by administration to negotiate with other administrations.
  - Determines precedence in unplanned bands.

SATELLITE FILING & COORDINATION

BR Filing Process

1. Advance Publication Information - API

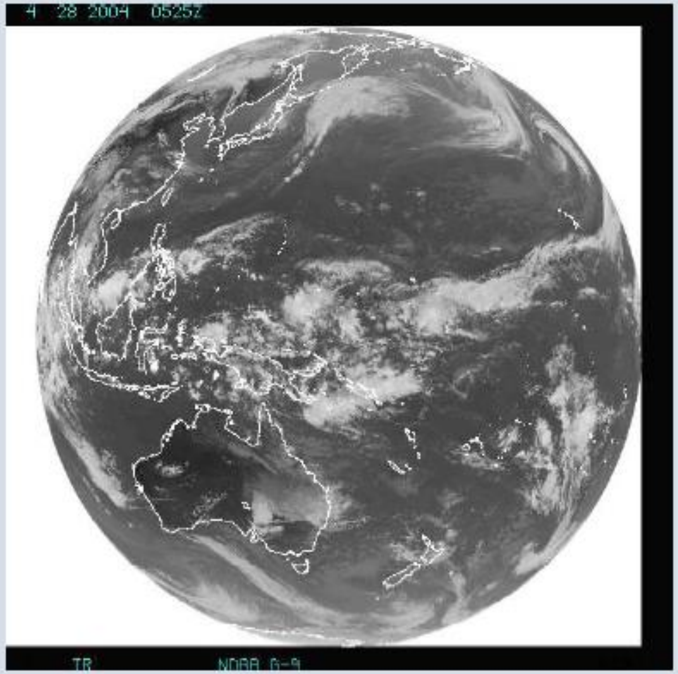
- Statement of intent to launch a space station
  - Sets a reference starting date for a satellite
  - No priority in being first to advance publish

SATELLITE FILING & COORDINATION

BR Filing Process

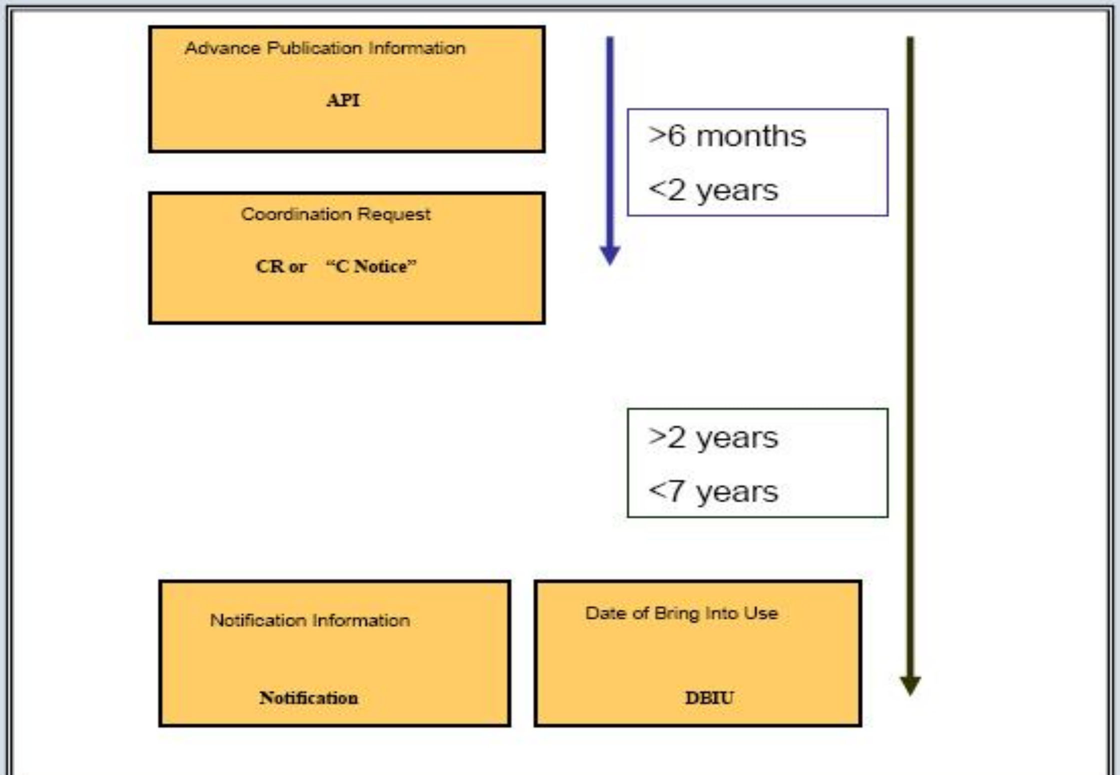
3. Notification

- Final step
- Recording of final operational parameters in the Master Register



Satellite Filing & Coordination

BR Filing Process:



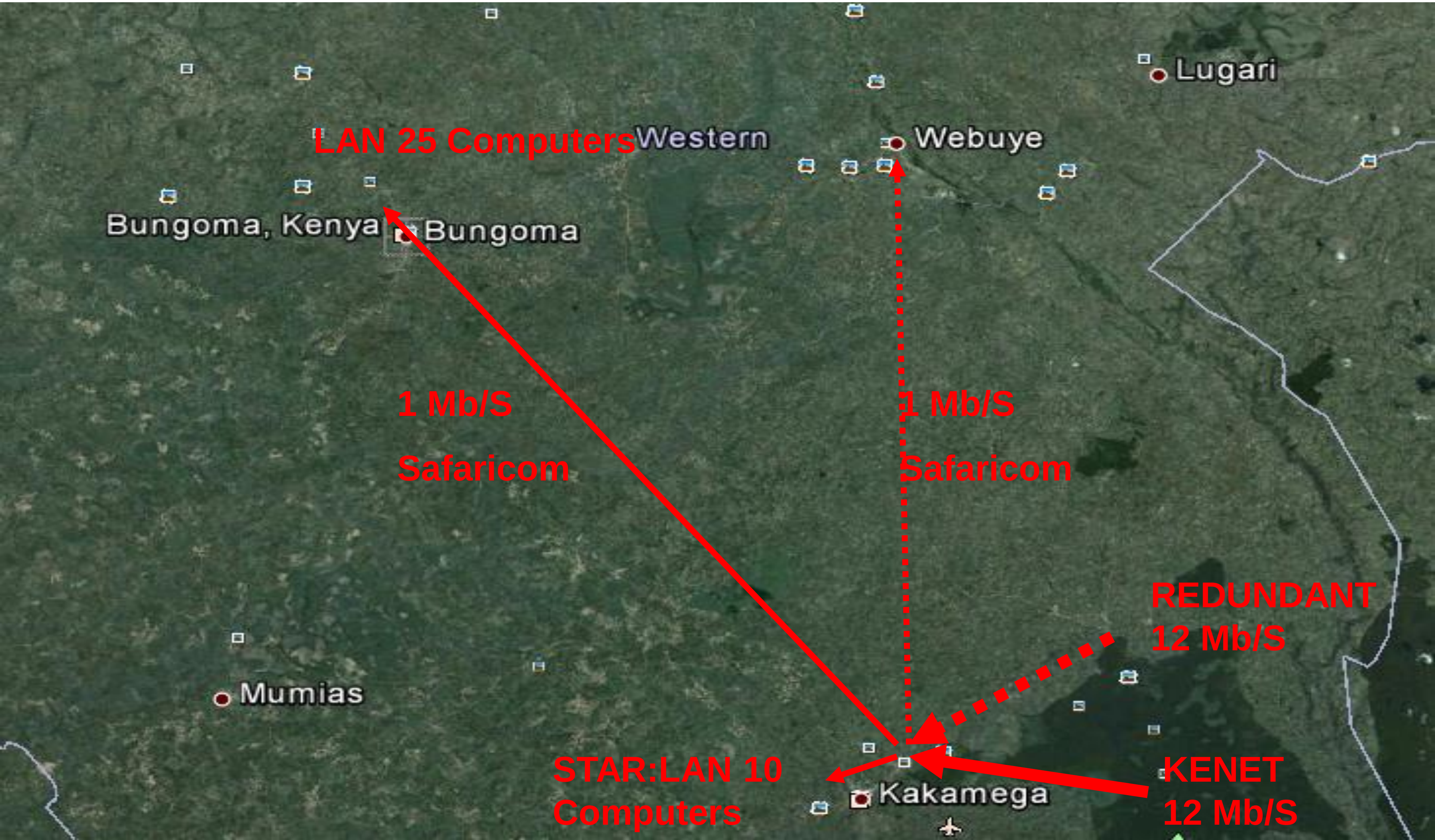
STUDY QUESTIONS

1. What are possible solutions to the problems of satellite orbital slots and frequencies?
2. What other types of satellites are being used to do some of the tasks that could be done by geosynchronous satellites?
3. Who is credited with inventing the idea of communications satellite?
4. What are the special properties of a geostationary satellite?

SATELLITE APPLICATIONS

METEOROLOGY

Why Space Imagery? (1)



Why Space Imagery? (1)

Why Space Imagery? (2)

Why Space Imagery? (3)

Brief History

- Satellite programmes that demonstrated enabling technologies and remote sensing principles ere are due essentially to NASA, and may be classified as:
  - ***TIROS*** programme, exploiting low orbits, essentially for meteorological imagery;
  - ***ATS*** programme, exploting the geostationary orbit, essentially for meteorological imagery;
  - ***Nimbus*** programme, exploiting low orbits, essentially to demonstrate remote sensing principle for a variety of application fields.

TIROS PROGRAMME

SATELLITE	LAUNCH	END OF SERVICE	HEIGHT
TIROS-1	1 Apr 1960	17 Jun 1960	720 km
TIROS-2	23 Nov 1960	24 Dec 1961	670 km
TIROS-3	12 Jul 1961	27 Feb 1962	780 km
TIROS-4	8 Feb 1962	19 Jul 1962	770 km
TIROS-5	19 Jun 1962	27 Nov 1963	750 km
TIROS-6	18 Sep 1962	12 Oct 1963	700 km
TIROS-7	19 Jun 1963	3 Jun 1968	680 km
TIROS-8	21 Dec 1963	1 Jul 1967	730 km
TIROS-9	22 Jan 1965	12 Jun 1968	1350 km
TIROS-10	2 Jul 1965	1 Jul 1967	790 km

TIROS 6 SATELLITE

View of TIROS-6.

Mass in orbit: 130 kg.

VCS (Vidicon Camera System)

- A TV camera equipped with various optical combinations:
  - Narrow-Angle (NA, 12.5°), resolution 0.3 km, 110x110 km2 [on TIROS 1 and TIROS-2]
  - Medium-Angle (MA, 76°), resolution 2.5 km, 720x720 km2 [TIROS-4, TIROS-5, TIROS-6]
  - Wide-Angle (WA, 104°), resolution 3.0 km, 1200x1200 km2 [on all satellites].

APT (Automatic Picture Transmission)

- A 108° camera with resolution 1.8 km at the sub-satellite point (s.s.p.) and **field of view of about 2000 km**.

MRIR (Medium Resolution Infrared Radiometer)

- Comprising two broad-band channels (0.2-4.0 μm and 5-30 μm) and three narrow-band (6.4-6.9,10-11 and 14-16 μm); **resolution 50 km.**
- Measuring solar-reflected radiation.

FPR (Flat Plate Radiometer)

- Comprising two broad-band channels (solar reflected radiation and total Earth + atmosphere SW and LW radiation); hemispheric view.

ATS PROGRAMME

SATELLITE	LAUNCH	END OF SERVICE
ATS-1	6 Dec 1966	1 Dec 1978
ATS-3	6 Nov 1967	1 Dec 1978
ATS-6	30 Apr 1974	3 Aug 1979

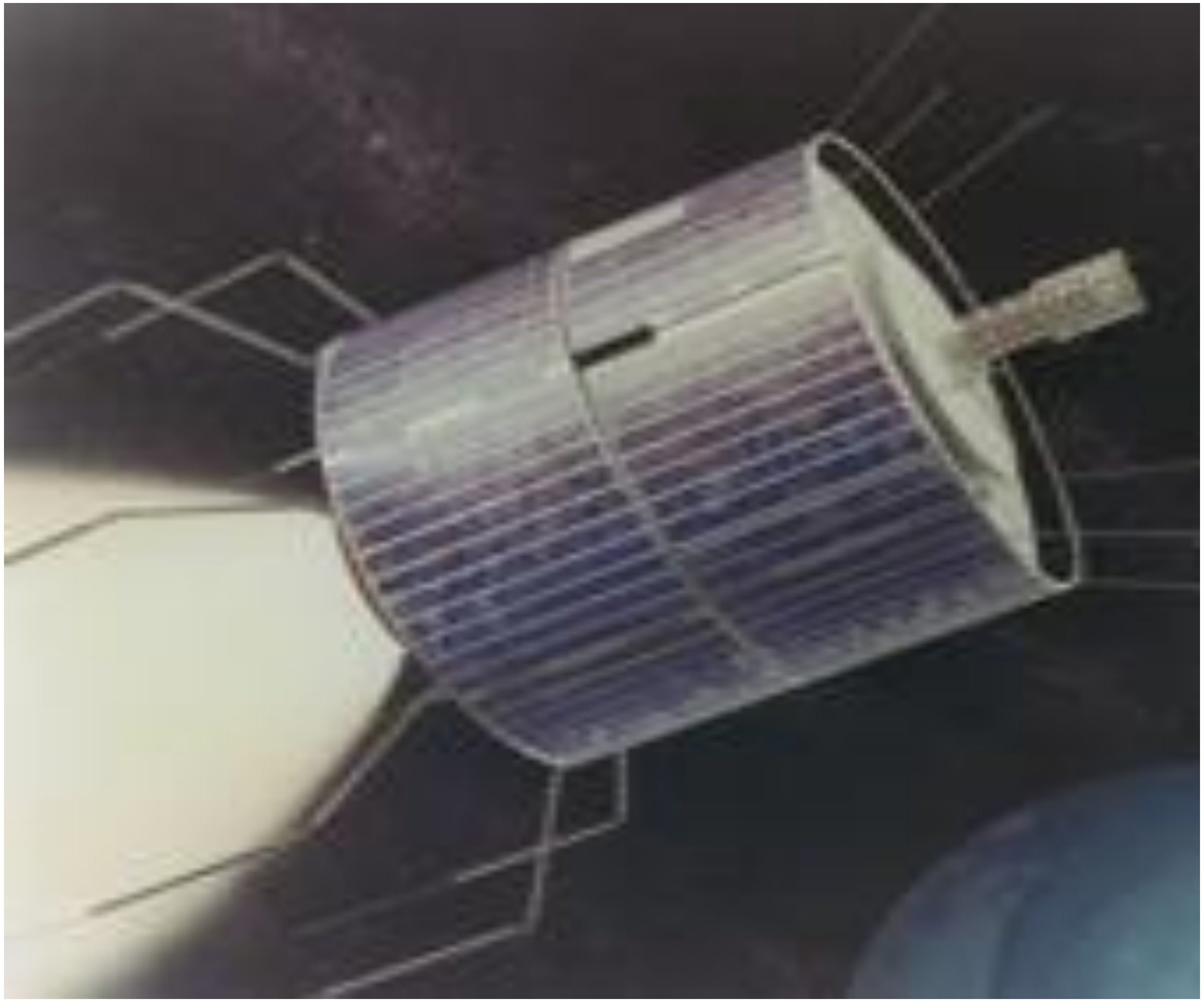
ATS-1

- Equipped with:
  - **SSCC** (Spin Scan Cloud Camera), with a single VIS channel, observing latitudes up to $\pm$ 52.5° with a resolution of 4.5 km s.s.p., each 22 min.

ATS-3

- Equipped with:
  - ***MSSCC*** *(Multi-color SSCC)*, with 3 channels (Red, Blue, Green), observing the full disk with a resolution of 3.5 km s.s.p., each 26 min.

ATS-3



View of ATS-3.

Mass in orbit: 365 kg.

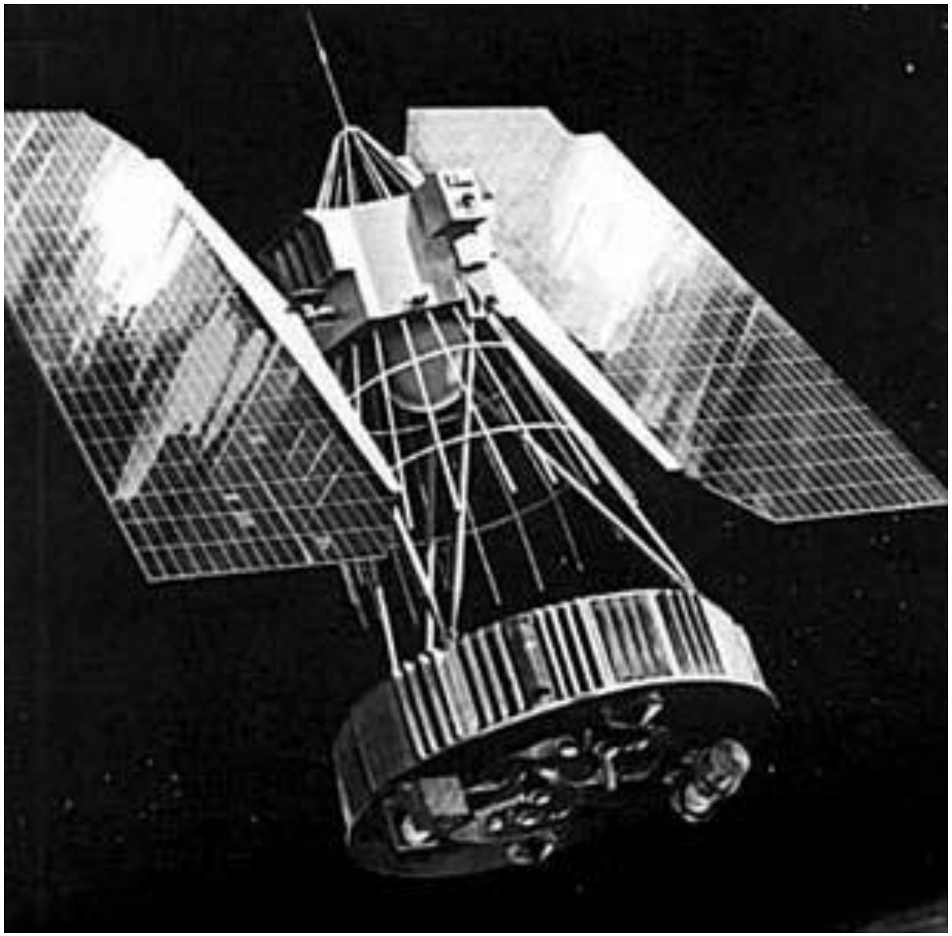
ATS-6

- Equipped with:
  - ***VHRR*** *(Very High Resolution Radiometer)*, 2-channel VIS/IR radiometer, 0.55-0.75 and 10.5-12.5 μm
  - A similar instrument, thereafter improved to three channels, is still used on the Indian INSAT geostationary satellites.

THE NIMBUS PROGRAMME

Satellite	Launch	End of service	Height
Nimbus-1	28 Aug 1964	23 Sep 1964	680 km
Nimbus-2	15 May 1966	17 Jan 1969	1140 km
Nimbus-3	13 Apr 1969	22 Jan 1972	1100 km
Nimbus-4	8 Apr 1970	30 Sep 1980	1100 km
Nimbus-5	10 Dec 1972	29 Mar 1983	1100 km
Nimbus-6	12 Jun 1975	29 Mar 1983	1100 km
Nimbus-7	24 Oct 1978	1 Aug 1994	947 km

VIEW OF NIMBUS - 1



View of Nimbus-1.

Mass in orbit: 375 kg.

APT (Automatic Picture Transmission)

- **IDCS (Image Dissector Camera System)** [Nimbus-3/4], were single-channel (VIS) cameras, **resolution 2.5 km** s.s.p. with real-time transmission capability that established a standard for certain aspects still valid nowadays

GOS (GLOBAL OBSERVING SYSTEM)

1. Composed of surface-based and space-based components.
2. Is coordinated by WMO as part of the World Weather Watch programme (WWW) while also supporting many other programmes.
3. In line with the strategy to implement the WMO Integrated Global Observing Systems (WIGOS), and in the wider context of the Global Earth Observation System of Systems (GEOSS)

CO-SPONSORED PROGRAMMES (1)

1. **WWW** (World Weather Watch)
2. **WCP** (World Climate Programme)
3. **WCRP** (World Climate Research Programme)
4. **GCOS** (Global Climate Observing System)
5. **AREP** (Atmospheric Research and Environment Programme)

CO-SPONSORED PROGRAMMES (2)

6. AMP (Applications of Meteorology Programme)
   - Agricultural Meteorology Programme
   - Aeronautical Meteorology Programme
   - Marine Meteorology and Oceanography Programme
   - Public Weather Services Programme;
   - HWRP (Hydrology and Water Resources Programme);
   - DRR (Disaster Risk Reduction Programme);
7. Education and Training, Technical Cooperation, and Regional Programmes

ACTIVITIES IN WEATHER & CLIMATE OBSERVATION

1. **Operation of meteorological satellites**.
2. **Specialised atmospheric** (for precipitation, radiation, chemistry, dynamics).
3. **Ocean and ice** (for topography; colour; sea surface temperature, salinity and wind; waves; sea ice).
4. **Land observation** (for the Disaster Monitoring Constellation, all-weather high-resolution monitoring).
5. **Space Weather** (solar activity, magnetosphere and ionosphere monitoring).

OPERATIONAL METEOROLOGICAL GEOSTATIONARY SATELLITE SYSTEM

- European Meteosat
- United States of America’s GOES
- Japanese Himawari (formerly GMS, currently MTSAT)
- Russian Electro (formerly GOMS)
- Chinese FY-2 to be replaced by FY-4
- Indian INSAT and Kalpana (formerly MetSat)
- Korean COMS.

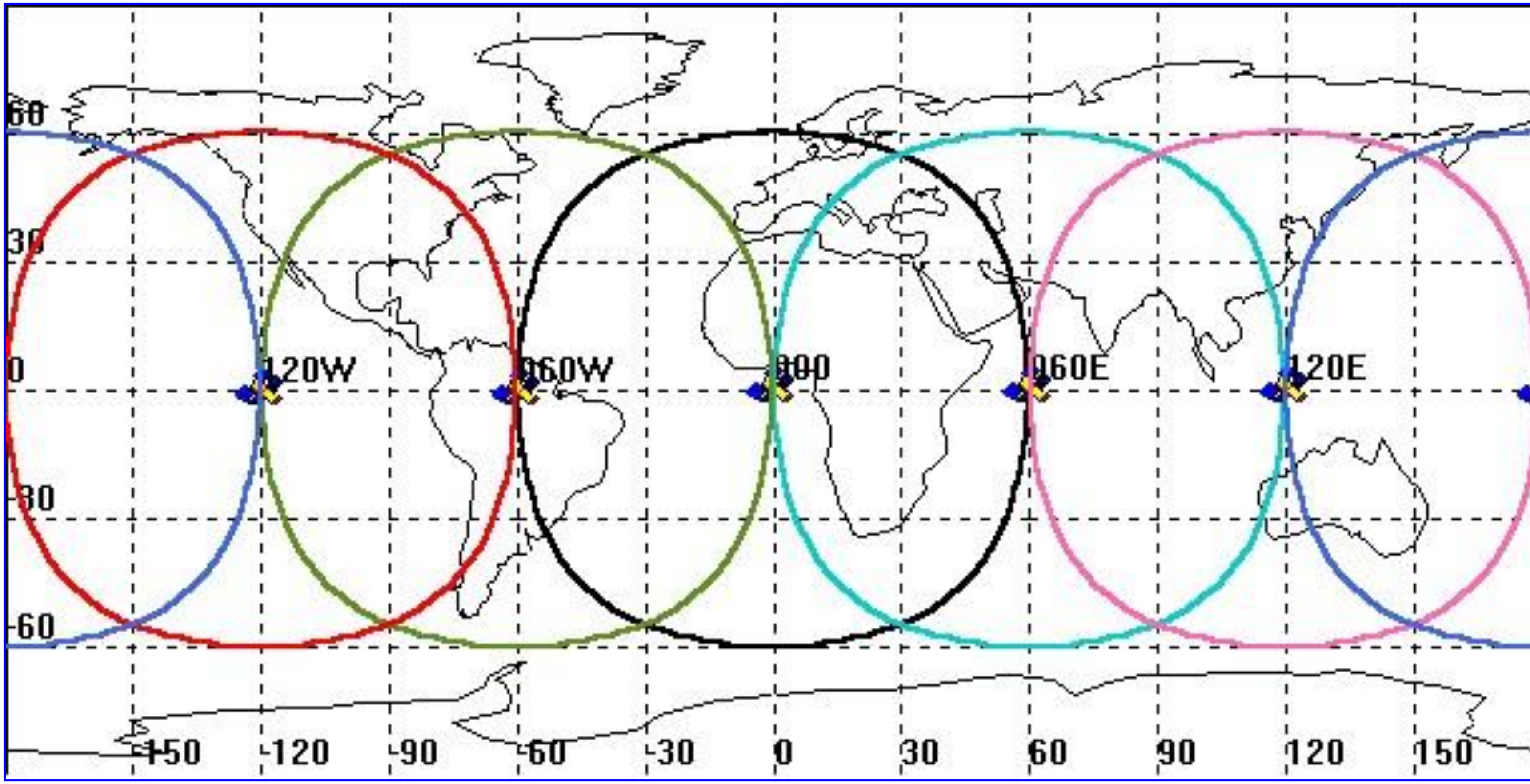
OPERATIONAL METEOROLOGICAL SUN-SYNCHRONOUS SATELLITE SYSTEM

1. United States of America's civilian POES
2. United States of America's military DMSP, actually also providing data for civilian use
3. EUMETSAT Polar System
4. Russian Meteor
5. Chinese FY-1 now replaced by FY-3.

OPERATIONAL HIGHLY ELLIPTICAL ORBITS SATELLITE SYSTEM

1. Russian Arctica
2. Canadian PCW

GEOSTATIONARY SATELLITE OBSERVATION



Coverage from six regularly-spaced geostationary satellites. The circles subtend a geocentric angle of 60°, considered a practical limit for quantitative observations. All latitudes between 55°S and 55°N would be covered.

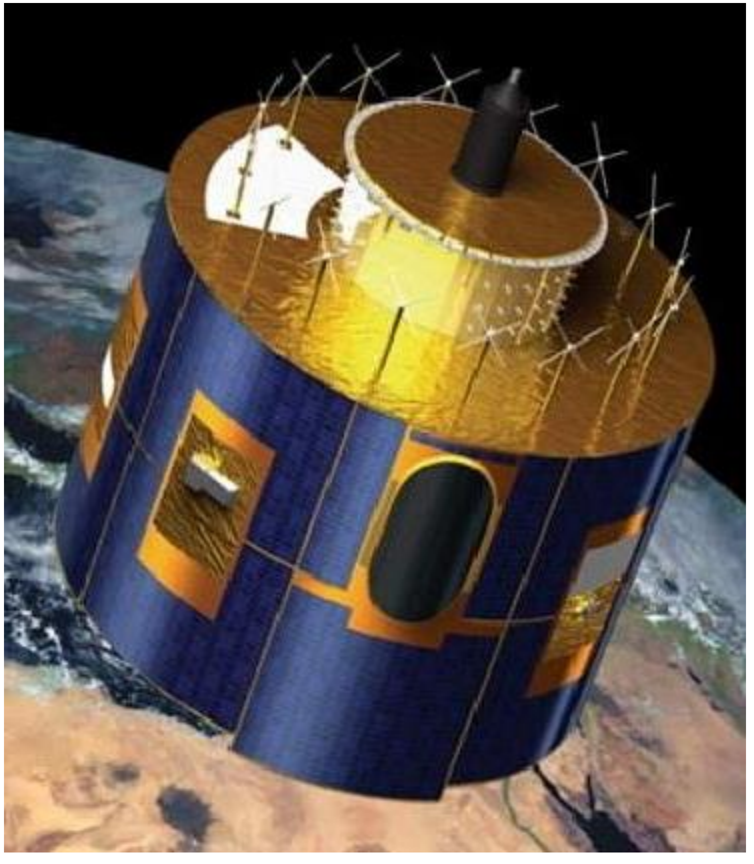
USES GEOSTATIONARY SATELLITES IN METEOROLOGY

1. to provide cloud imagery at 30 min intervals for the purpose of nowcasting
2. to derive wind vectors by tracking cloud or water vapour features, for the purpose of NWP.

CONCERNS FOR FUTURE GEOSTATIONARY SATELLITES

- **GEO Imagers** - Imagers of future geostationary satellites should have improved spatial and temporal resolution (appropriate to the phenomena being observed), in particular for those spectral bands relevant for depiction of rapidly developing small-scale events and retrieval of wind information.
- **GEO Sounders** - All meteorological geostationary satellites should be equipped with hyper-spectral infrared sensors for frequent temperature/humidity sounding as well as tracer wind profiling with adequately high resolution (horizontal, vertical and time).

METEOSAT SATELLITE STABILIZATION



All Meteosat satellites, both of the first series and planned are spin-stabilised.

METEOSAT PROGRAMME

Satellite	Launch	End of service
Meteosat-1	23 Nov 1977	24 Nov 1979
Meteosat-2	19 Jun 1981	2 Dec 1991
Meteosat-3	15 Jun 1988	22 Nov 1995
Meteosat-4	6 Mar 1989	8 Nov 1995
Meteosat-5	2 Mar 1991	6 Feb 2007
Meteosat-6	20 Nov 1993	15 Apr 2011
Meteosat-7	2 Sep 1997	≥ 2013
Meteosat-8	28 Aug 2002	≥ 2016
Meteosat-9	21 Dec 2005	≥ 2019
Meteosat-10	≥ 2012	≥ 2019
Meteosat-11	≥ 2015	≥ 2022
MTG-I1	≥ 2017	≥ 2025
MTG-S1	≥ 2019	≥ 2027
MTG-I2	≥ 2022	≥ 2030
MTG-I3	≥ 2026	≥ 2034

GOES PROGRAMME

Satellite	Launch	End of service	Position	Status
GOES-1	16 Oct 1975	7 Mar 1985	Not relevant	Inactive
GOES-2	16 Jun 1977	1 Jul 1993	Not relevant	Inactive
GOES-3	16 Jun 1978	1 Jul 1993	Not relevant	Inactive
GOES-4	9 Sep 1980	22 Nov 1988	Not relevant	Inactive
GOES-5	22 May 1981	18 Jul 1990	Not relevant	Inactive
GOES-6	28 Apr 1983	1 Jul 1989	Not relevant	Inactive
GOES-7	26 Feb 1987	11 Jan 1996	Not relevant	Inactive
GOES-8	13 Apr 1994	5 May 2004	Not relevant	Inactive
GOES-9	23 May 1995	15 Jun 2007	Not relevant	Inactive
GOES-10	25 Apr 1997	2 Dec 2009	Not relevant	Inactive
GOES-11	3 May 2000	5 Dec 2011	Not relevant	Inactive
GOES-12	23 Jul 2001	≥ 2012	60°W	Operational
GOES-13	24 May 2006	≥ 2015	75°W	Operational
GOES-14	27 Jun 2009	≥ 2016	105°W	Hot standby
GOES-15	4 Mar 2010	≥ 2020	135°W	Operational