Advanced Electronic Systems

Lecture 1

Introduction and History

Assoc. Prof. Basem M. ElHalawany

Course Info (Main Stream)

Title	Advanced Electronic Communication Systems
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Course Webpage	https://bu.edu.eg/staff/basem.mamdoh-courses/18483
References	Multiple references will be used: • Varsha Agrawal, Satellite Technology: Principles and Applications • Wayne Tomasi - Advanced Electronic Communications Systems • L.Frenzel - Principles of electronic communication systems • Recent Scientific Research Papers

Assessment 60/40

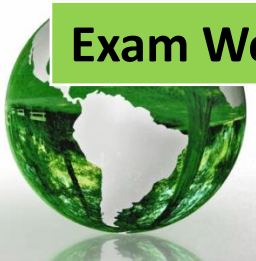
1. Final Term Exam (60)
2. Mid Term Exam (20)
3. Other Assignments (20)

Main Topics

1. Basics of Satellite Communication Systems
2. Recent Trends in Satellite Communication Systems
3. Public Switched Telephone Networks and IP Telephony

Schedule (Draft)

Topics	Week
Intro to Satellite Systems and Assignment Policies	1
Satellite Orbits	2:3
Satellite Coordinates and Look Angles	4
Satellite Launch Sequence and Launch Vehicles	5
Satellite Systems Components	6
Assignment Discussions and Delivery	7
Midterm	8th Week
Satellite System Link Models and Parameters	9-10
Global Positioning System (GPS)	11
Telephone system and Internet Telephony (VoIP)	12
Facsimile	13
Exam Week	14



☺ Assignment's Policies ☺

Recent Trends in Satellite Communication Systems:

- **LEO Satellites Constellations.**

- This part of the course targets the following skills:

1. Team-work
2. Self-motivation
3. Information gathering, filtering, organizing, and linking
4. Scientific and reports writing

- Your Tasks:

1. Team Gathering
2. Search for ((new)) References related to this topic (Books- IEEE, IET, Sciencdirect, Springer Papers)
3. Prepare a report on this topics at least 20 pages single columns

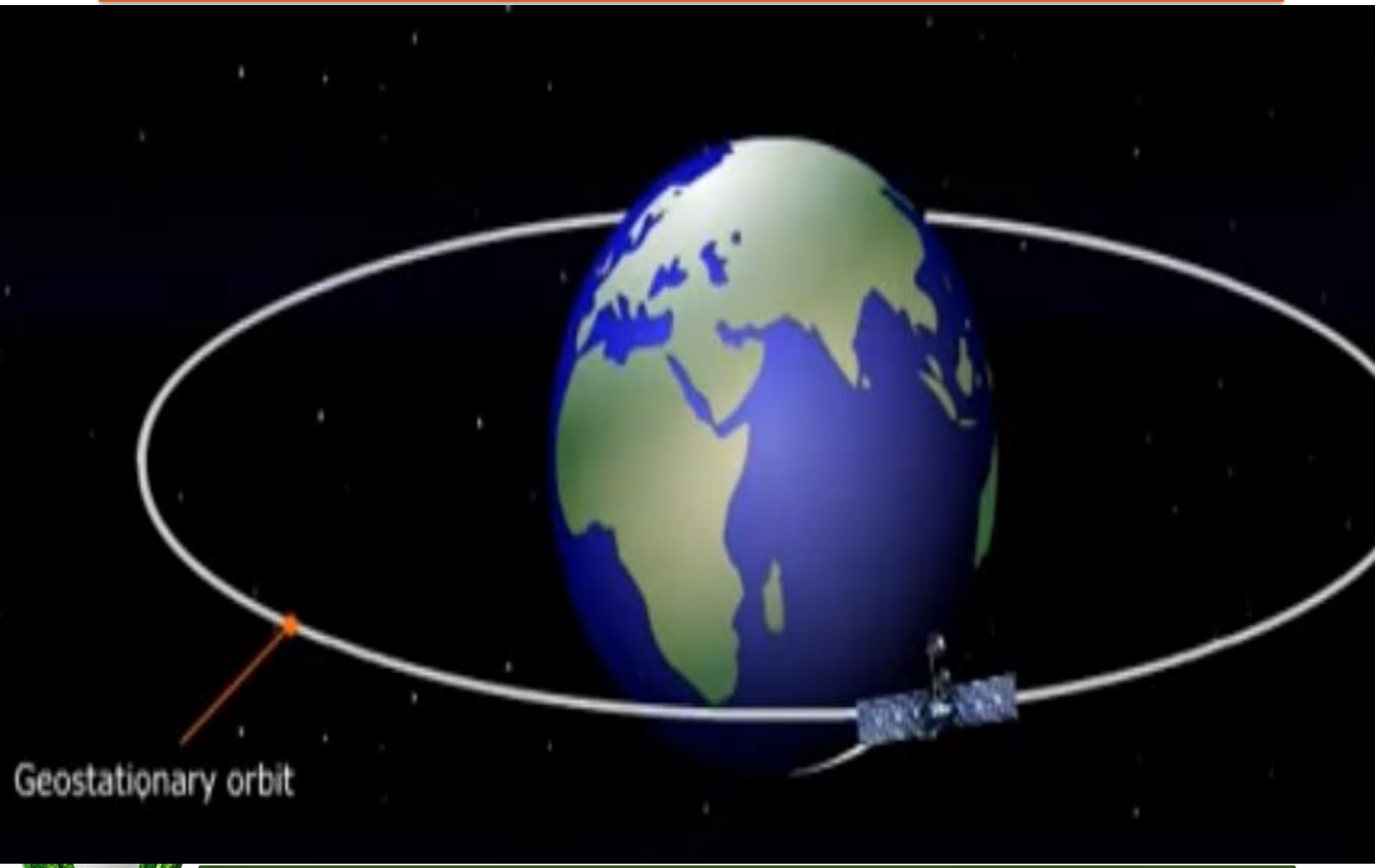
☺ Policies ☺

- Rules:

1. No plagiarism is allowed (each word in the prepared file is your own words- no exact copy and paste)
2. Each team will have a team leader
3. All used references must be cited and their files need to be attached to final assignment compressed file.
4. English language will be evaluated

☺ Good Luck ☺

Introduction to Satellite Communication System



➢ What is the meaning of "Satellite"?

- A satellite is a smaller object that revolves/rotates/orbits around a larger object in space (**celestial body**).
- A Satellites may be artificial or a natural body:
  - ✓ The earth and other planets are satellites rotating about the sun.
  - ✓ The moon is a satellite to the earth.

➢ What is the meaning of "Satellite" in Aerospace ?

- A satellite is a space vehicle (Spacecraft) launched by humans and orbits Earth or another celestial body.

Communicating through an artificial satellite first appeared in the short story titled: **"The Brick Moon"**
written by an American author Edward Hale
and published in 1869.

What is the meaning of “Communication Satellite”?

- **Aman-made electronic communication package placed in orbit around earth whose prime objective is to initiate or assist another (repeater) through space.**

Figure 1.1 Communication satellite

- **The first practical concept of Geostationary satellite communication was proposed Arthur C. Clarke in a paper titled “Extra-Terrestrial Relays: Can Rocket Stations Give World-wide Radio Coverage?” published in the 1945 issue of ”Wireless World” magazine.**
- **Clarke emphasized the importance of this orbit whose radius from the centre of Earth was such that the orbital period equaled the time taken by Earth to complete one rotation around its axis.**

Applications of Satellites

- **Satellites can be used for several applications including:**
  - Communication purposes
  - Global Positioning Systems (GPS)
  - Military Purposes (Spying and Missiles guidance)
  - Weather forecasting
  - Remote Sensing
  - Environmental Monitoring (Forest, Desert, Shores, etc.)
- **According to application, Satellites may be equipped with different types of sensors including:**
  - TV Cameras
  - Infra Red Sensors
  - Temperature Sensors
  - Multispectral scanners (MSS),
  - Very high resolution radiometer
  - Synthetic aperture radar (SAR)
  - Magnetometer

Size Classification of Satellites

- **Satellites can be classified into different types, However, the size is one of the most critical classification parameters.**

Table 1.1 Classification of satellites based on wet mass

Satellite class	Wet mass (kg)
Large	>1000
Medium	500–1000
Mini	100–500
Micro	10–100
Nano	1–10
Pico	0.1–1
Femto	<0.1

- **Wet mass** means the mass of the satellite including fuel.
- Mini, micro, nano, pico and femto satellites are collectively categorized as **small or miniature satellites.**

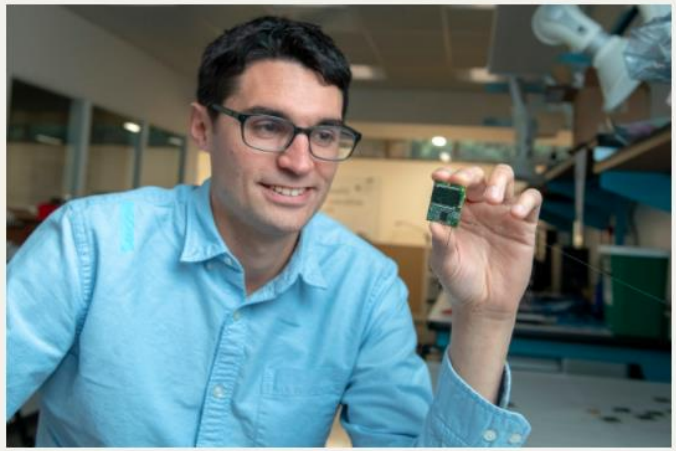
Size Classification of Satellites

- **The commercial space sector today is identified by geostationary communications satellites, which is usually large in size.**
- **On the other hand, We need small satellites for several purposes:**
  - Enabling missions that larger satellites could not accomplish including: Constellations for low data rate communications, In-orbit inspection of larger satellites, and University-related research
  - Need smaller and cheaper launch vehicles
  - Smaller satellites can be launched in multiple numbers and as piggybacks using excess capacity if larger launch vehicles are used.

Satellite swarm and Chipsats

- **Chipsats**: With advances in micro and nano technologies, it is today feasible to build satellite sub-systems and even the entire satellite itself on a chip (Femto Satellites or Chipsats).

- Zac Manchester holds a ChipSat, a device costing under $100 that is designed to work together with a swarm of similar gadgets to perform tasks that currently require large, costly satellites.



https://news.stanford.edu/2019/06/03/chip-size-satellites-orbit-earth/

Satellite swarm and Chipsats

- The smaller satellites are usually launched as groups of satellites (**satellite swarm**) designed to work together to perform tasks.
- Some designs require a **larger satellite**, known as the **'mother satellite or Mothership'**, for communication with ground controllers or for launching and docking with nano/femto satellites.

https://techcrunch.com/2019/06/04/kicksat-2-project-launches-105-cracker-sized-satellites/
https://youtu.be/I7xvQgClMf0

CubeSat Satellites

- A term commonly used with nano and pico satellites is '**CubeSat**'.
- CubeSat is a type of small satellite of **10 cm cube dimensions** and a mass that is not greater than 1.33 kg.

- A standard 10 × 10 × 10 cm basic CubeSat is also called a **1U** CubeSat, where 1U stands for **one unit**.
- CubeSats are **scalable** in increments of 1U **along one axis only.**
- Consequently, 2U, 3U and 4U CubeSats will have dimensions of 20 × 10 × 10 cm, 30 × 10 × 10 cm and 40 × 10 × 10 cm, respectively

History of Satellites

- It all began with an article by Arthur C. Clarke published in the October 1945 issue of Wireless World, which theoretically proposed the feasibility of establishing an uninterrupted communication service across the globe communication satellite in a geostationary orbit.
- The execution of the mission began with the advent of hot air balloons and rockets used for the purpose of the aerial observation of planet Earth from the upper reaches of Earth's atmosphere.
- The first of these A-4 rockets to carry scientific instruments to the upper atmosphere was launched in May 1946

The rocket carried an instrument to record cosmic ray flux from an altitude of 112 km.

History of Satellites

➢ Passive reflector as satellite:

- The simplest type of satellite is a passive reflector, which is a device that simply “bounces” signals from one place to another.
- A passive satellite reflects signals back to Earth, as there are no gain devices on board to amplify or modify the signals.
- The moon is a natural satellite of Earth, visible by reflection of sunlight and having a slightly elliptical orbit.

➢ Moon Passive Satellite:

- In 1954, U.S. Navy successfully transmitted the first message over this Earth-to-moon-to-Earth communications system.
- In 1956, a relay service was established between Washington, D.C. and Hawaii and, until 1962, offered reliable long-distance radio communications service limited only by the availability of the moon.
- Over time, however, the moon proved to be an inconvenient and unreliable communications satellite, as it is above the horizon only half the time and its position relative to Earth is constantly changing

Artificial Passive Satellites

Advantages:

- They do not require sophisticated electronic equipment on board, although they are not necessarily void of power.
- Some passive satellites require radio beacon transmitters for tracking and ranging purposes.
- A beacon is a continuously transmitted unmodulated carrier that an earth station can lock on to and use to determine the exact location of a satellite so the earth station can align its antennas.

Disadvantages:

- Inefficient use of transmitted power. For example, as little as 1 part in every 10^{18} of an earth station's transmitted power is actually returned to earth station receiving antennas.

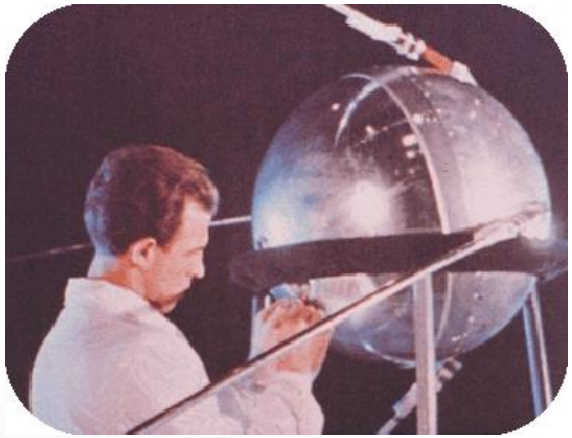
Early Artificial Active Satellites

- **An active satellite is capable of receiving, amplifying, reshaping, regenerating, and retransmitting information.**

- The United States and Soviet Union were the first two countries to draw plans for an artificial satellites in 1955.
- Within a span of just two years, Russians accomplished the feat and the United States followed quickly thereafter.

- **Sputnik 1 : was launched successfully by the Soviet Union in October, 1957.**

  - **58 cm diameter**
  - **4 antennas sending low-frequency radio signals at regular intervals.**
  - **Elliptical orbit with 96.2 minutes revolution.**
  - **Battery ran out in 22 days**
  - **Stay in orbit for 3 Months**
  - **It was designed to provide information on density and temperature of the upper atmosphere**



Early Artificial Active Satellites

- Sputnik-2 was launched by Soviet on 3 November 1957
- The satellite carried an animal, a female dog named Laika, in flight as the first living creature to orbit Earth.
- The mission provided information on the biological effect of the orbital flight.

- **The launches of Sputnik-1 and Sputnik-2 had both surprised and embarrassed the Americans as they had no successful satellite launch to their credit till then.**

EXPLORER

- Is launched by USA in 1958
- The first Sat. to detect the Van Allen radiation belt,
- Its batteries were exhausted after 111 days

Early Artificial Active Satellites

- Soviet experiences with the series of Sputnik launches and American experiences with the launches of the Vanguard and Explorer series .
- In 1960, a series of **experimental satellites** are launched for different applications:

✓ **Weather satellite** TIROS-1 (television and infrared observation satellite)
✓ Infrared surveillance satellite MIDAS (missile defense alarm system)
✓ Passive communications satellite Echo-1
✓ Active repeater communications satellite Courier-1B

Early Artificial Active Satellites

Figure 1.10 TIROS-1 (Courtesy: NASA)

TIROS-1 provided the first pictures of Earth

Figure 1.11 Echo-1 (Courtesy: NASA)

Echo-1 established communication between distantly located stations on Earth through a space-borne passive reflector.

Figure 1.12 Courier-1B (Courtesy: US Army)

Courier-1B established the active repeater concept.

Early Artificial Satellites

Experimental Non-geosynchronous Communication Satellites:

- Telstar and Relay Programs
- The mission objectives were to test the transmissions of television, telephone, facsimile and digital data.

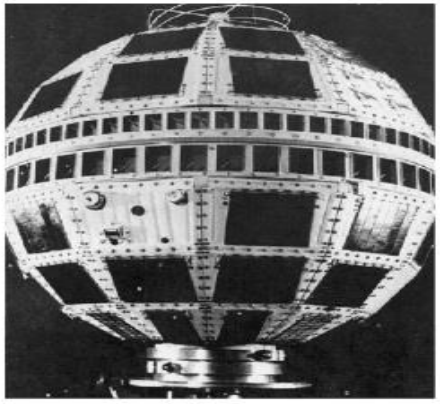


Figure 1.13 Telstar-1 (Courtesy: NASA)

Emergence of Geosynchronous Communication Satellites

- The golden era of geosynchronous satellites began with the advent of the SYNCOM (synchronous communication satellite) series of satellites
- SYNCOM-2 launched on 26 July 1963, became the first operational geosynchronous communication satellite.
- It was used to broadcast live the opening ceremonies of the Tokyo Olympics.

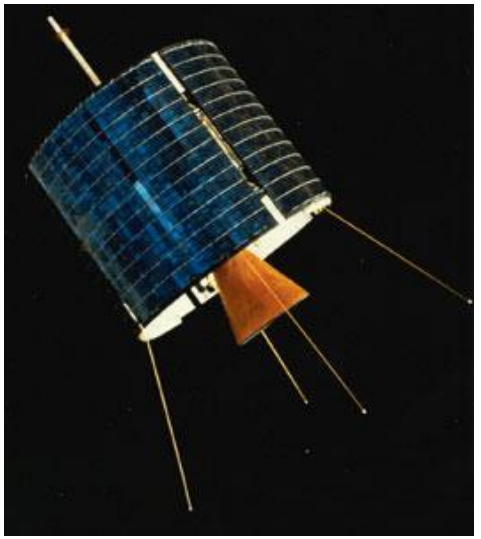
Figure 1.14 SYNCOM-2 (Courtesy: NASA)

Early Artificial Satellites

International Telecommunications Satellite Organization (INTELSAT)

- INTELSAT is formed in August 1964
- INTELSAT achieved a major milestone with the launch of the Intelsat-1 satellite,

Early Bird or Intelsat I



- The world's first commercial communications satellite launched in 1965 by USA
- It was placed in geosynchronous orbit (That meant it was always on position to provide line of sight communications between Europe and North America.)
- Early Bird didn't have a battery - and worked only when its solar panels were exposed to the sun.
- It provided 240 telephone circuits for connectivity between Europe and North America

Thank You