INT 437 WIRELESS AND MOBILE NETWORKS

Lecture 7

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RECAP

- Wireless transmission
- Medium Access Control

Mobile Communications Chapter 5: Satellite Systems

- History
- Basics
- Localization

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HISTORY OF SATELLITE COMMUNICATION

- 1945 Arthur C. Clarke publishes an essay about „Extra Terrestrial Relays“
- 1957 first satellite SPUTNIK
- 1960 first reflecting communication satellite ECHO
- 1963 first geostationary satellite SYNCOM
- 1965 first commercial geostationary satellite„Early Bird“ (INTELSAT I): 240 duplex telephone channels or 1 TV channel, 1.5 years lifetime
- 1976 three MARISAT satellites for maritime communication
- 1982 first mobile satellite telephone system INMARSAT-A
- 1988 first satellite system for mobile phones and data communication INMARSAT-C
- 1993 first digital satellite telephone system
- 1998 global satellite systems for small mobile phones

Applications

- Traditionally
  - weather satellites
  - radio and TV broadcast satellites
  - military satellites
  - satellites for navigation and localization (e.g., GPS)
- Telecommunication
  - global telephone connections
  - backbone for global networks
  - connections for communication in remote places or underdeveloped areas
  - global mobile communication
  - satellite systems to extend cellular phone systems (e.g., GSM or AMPS)

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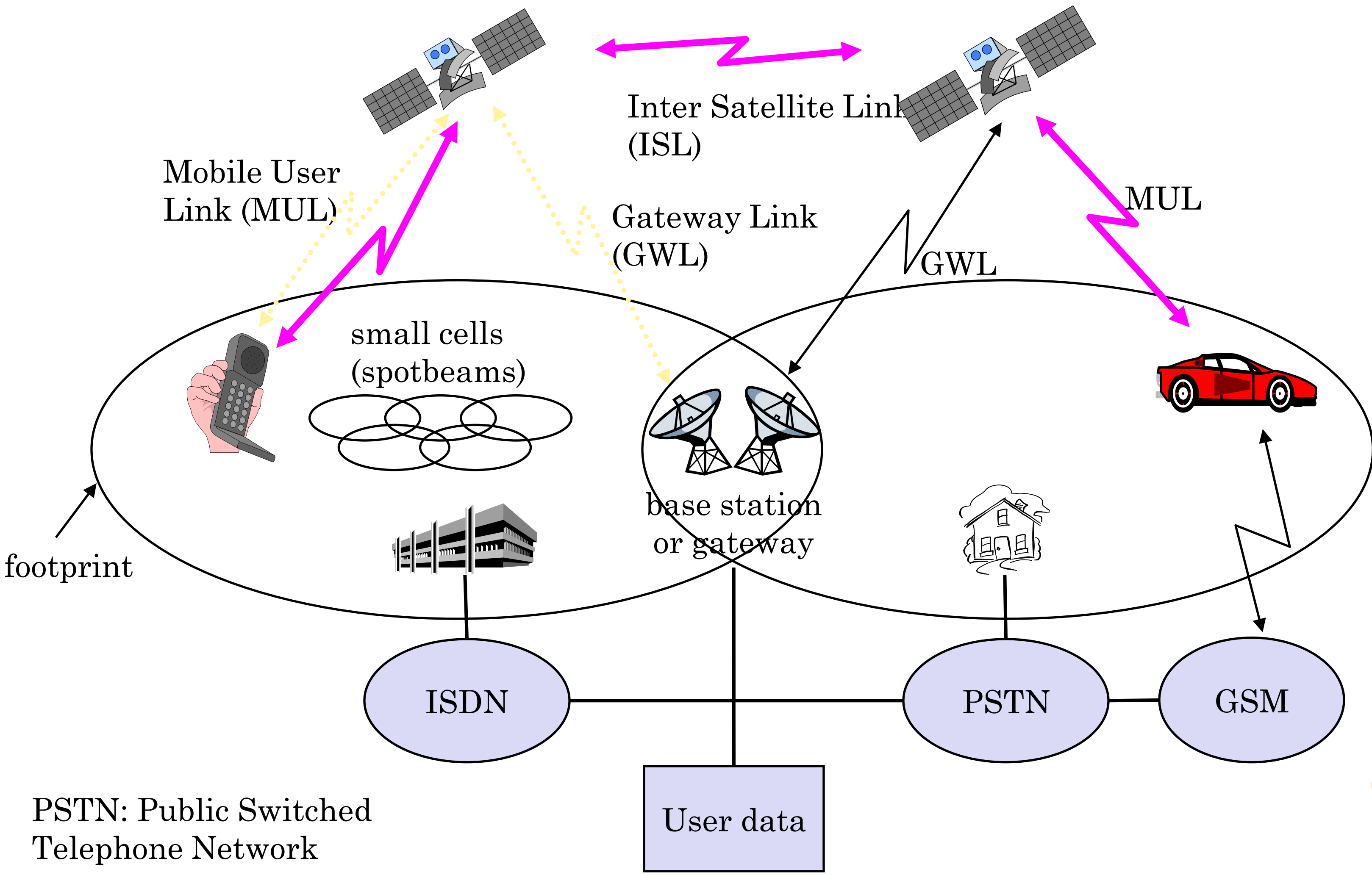
CLASSICAL SATELLITE SYSTEMS



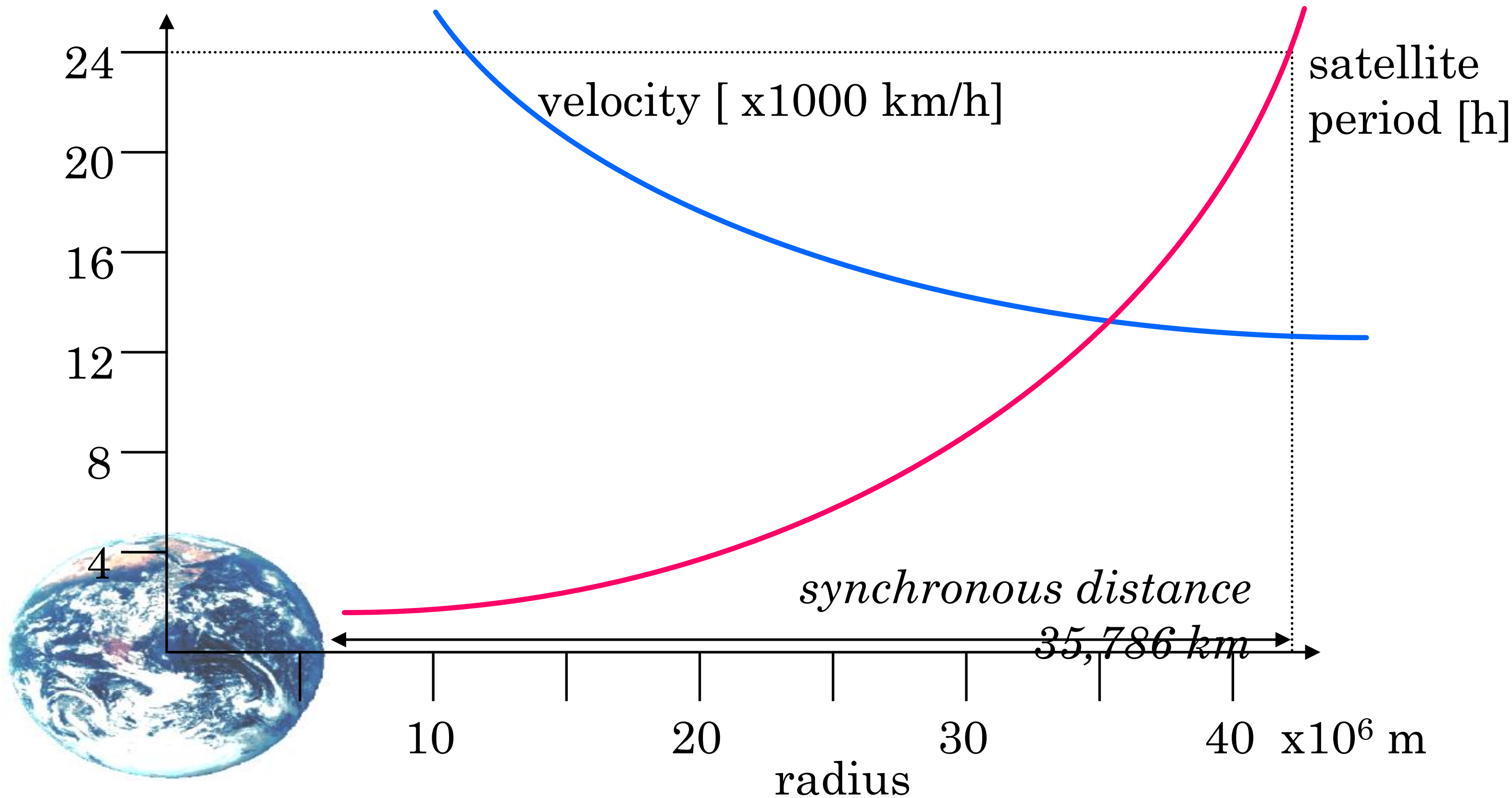
PSTN: Public Switched
Telephone Network

BASICS

- Satellites in circular orbits
  - Attractive force $F_g = m\ g\ (R/r)^2$
  - Centrifugal force $F_c = m\ r\ \omega^2$

  Where:
  - m: mass of the satellite
  - R: radius of the earth (R = 6370 km)
  - r: distance to the center of the earth
  - g: acceleration of gravity ($g = 9.81\ m/s^2$)
  - ω: angular velocity (ω = 2 π f, f: rotation frequency)
- Stable orbit
  - $F_g = F_c$ → $$r = \sqrt[3]{\frac{gR^2}{(2\pi f)^2}}$$

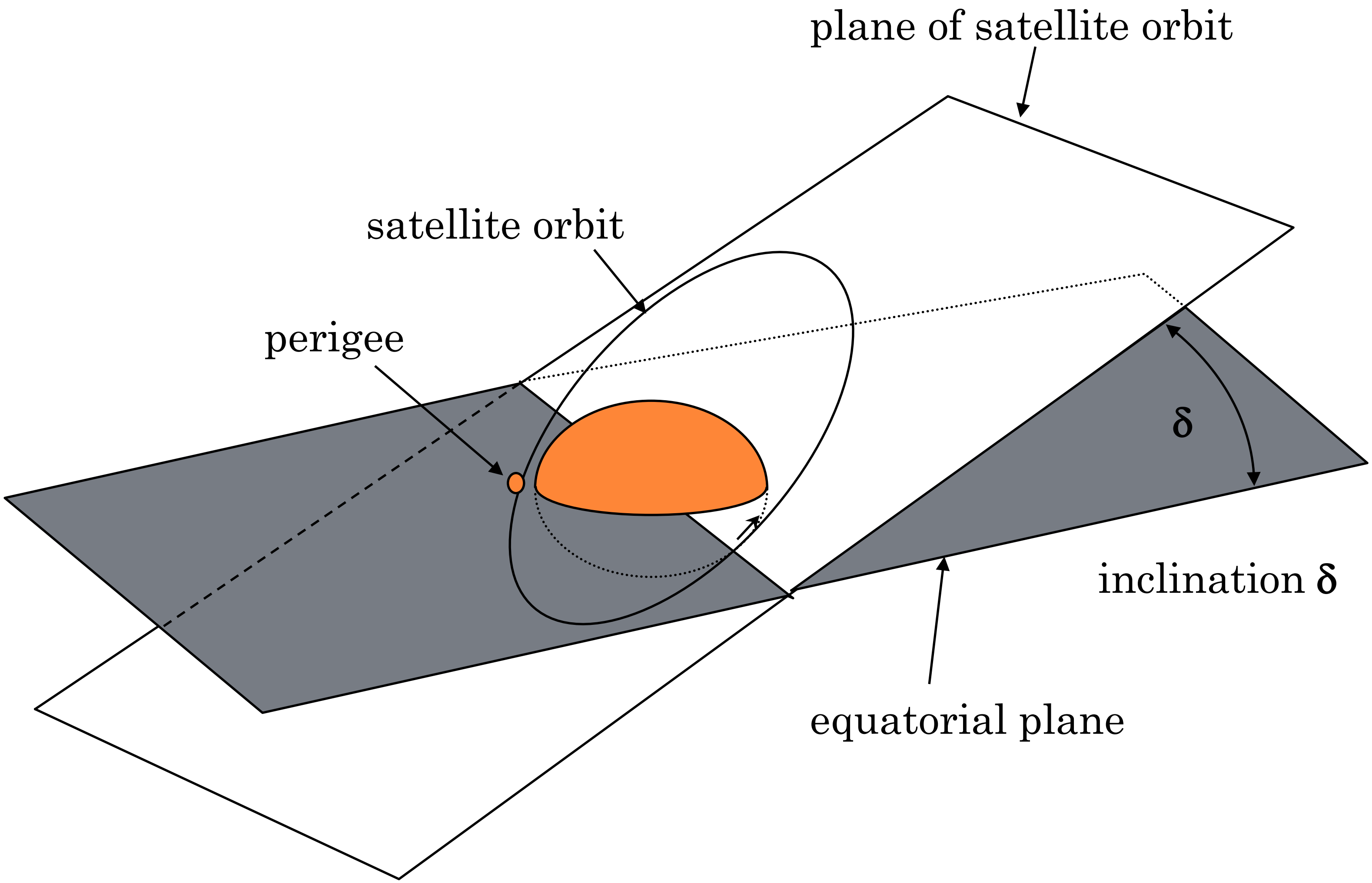
Satellite period and orbits



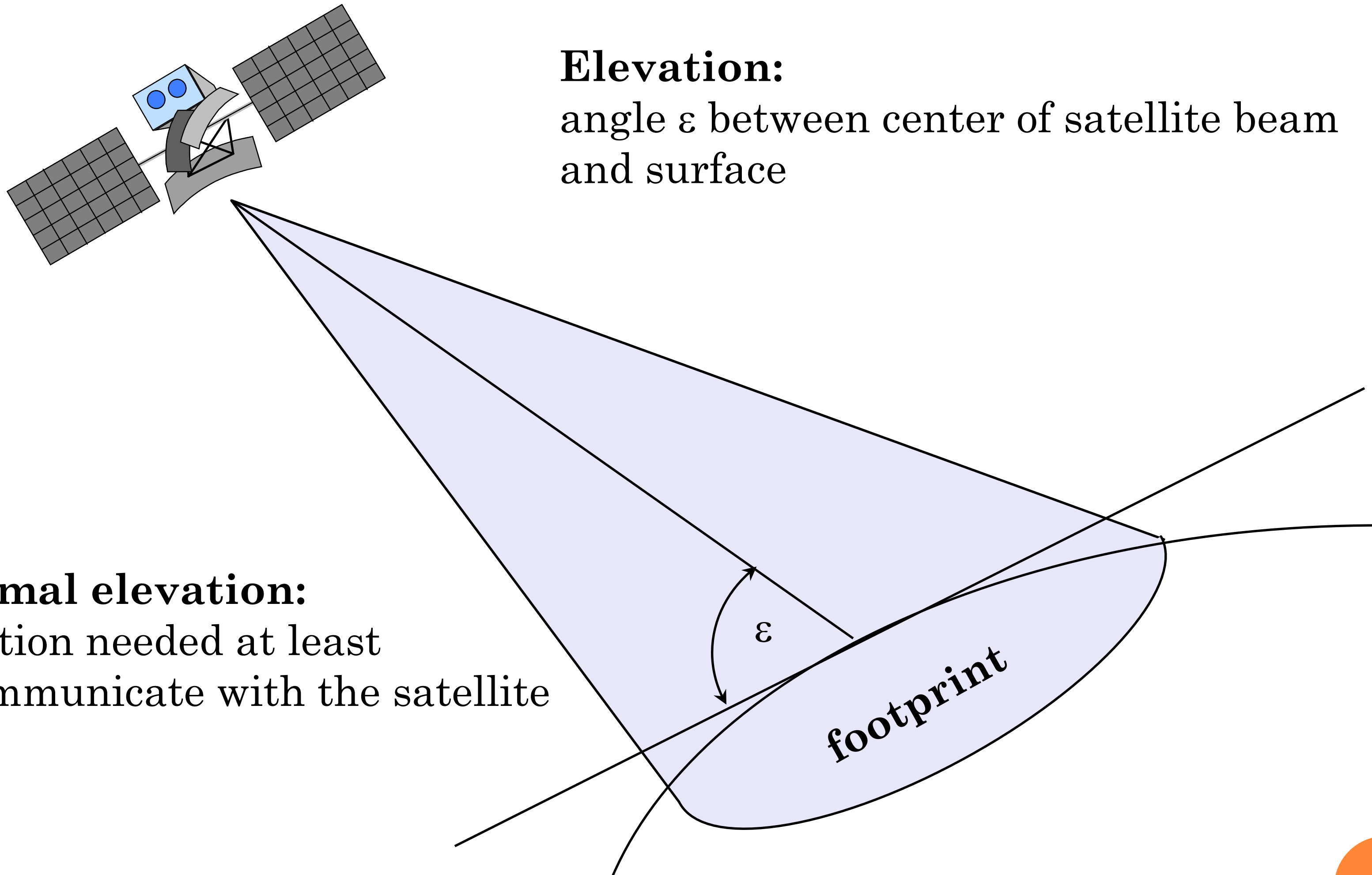
Basics

- elliptical or circular orbits
- complete rotation time depends on distance satellite-earth
- inclination: angle between orbit and equator
- elevation: angle between satellite and horizon
- LOS (Line of Sight) to the satellite necessary for connection
  ➔ high elevation needed, less absorption due to e.g. buildings
- Uplink: connection base station - satellite
- Downlink: connection satellite - base station
- typically separated frequencies for uplink and downlink
  - transponder used for sending/receiving and shifting of frequencies
  - transparent transponder: only shift of frequencies
  - regenerative transponder: additionally signal regeneration

INCLINATION



Elevation



Elevation:
angle ε between center of satellite beam and surface

minimal elevation:
elevation needed at least
to communicate with the satellite

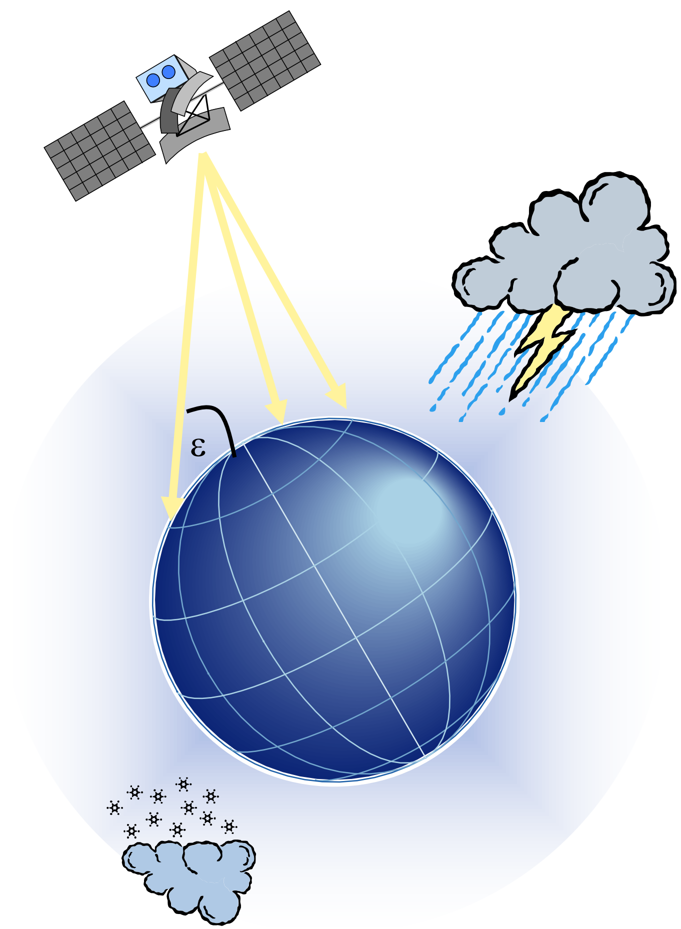
Link budget of satellites

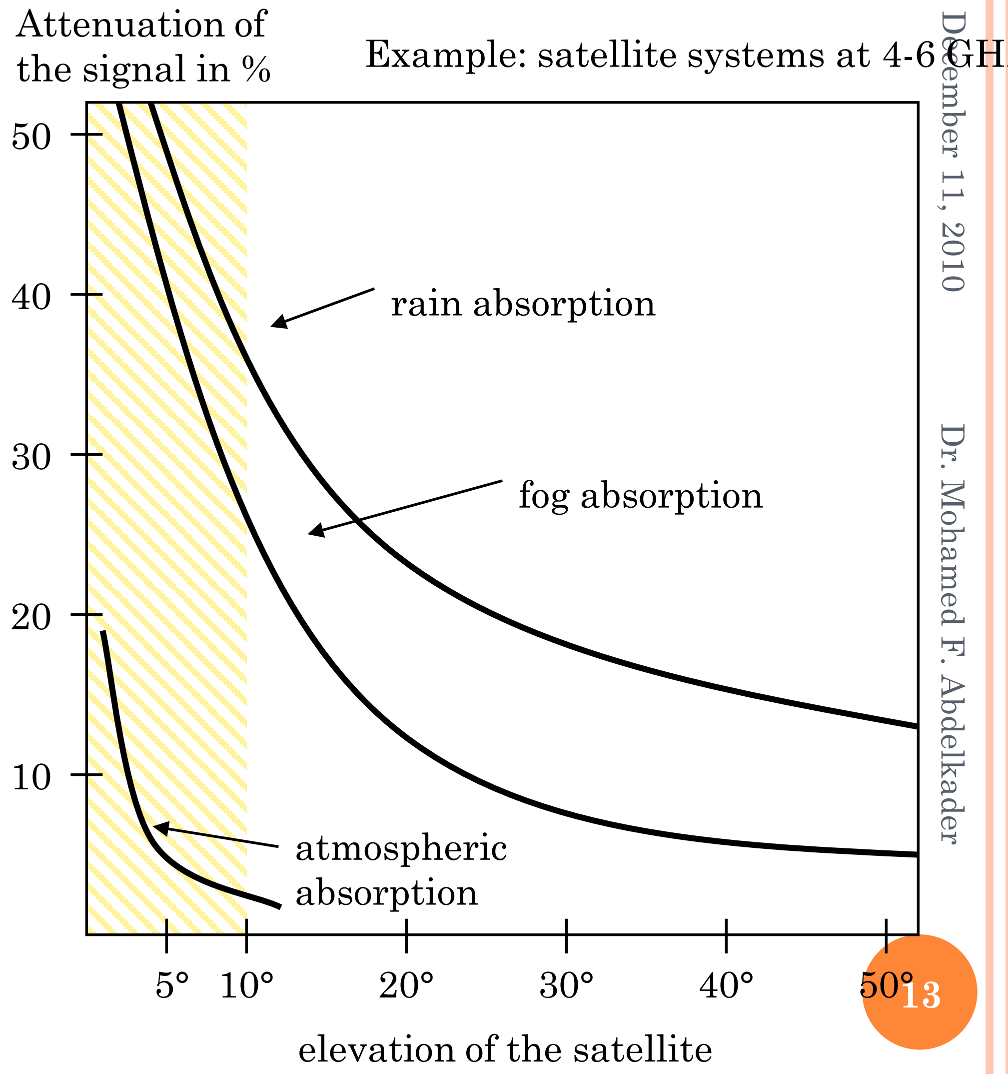
- Parameters like attenuation or received power determined by four parameters:
  - sending power
  - gain of sending antenna
  - distance between sender and receiver
  - gain of receiving antenna
- Problems
  - varying strength of received signal due to multipath propagation
  - interruptions due to shadowing of signal (no LOS)
- Possible solutions
  - Link Margin to eliminate variations in signal strength
  - satellite diversity (usage of several visible satellites at the same time) helps to use less sending power

L: Loss
f: carrier frequency
r: distance
c: speed of light

$$L = \left(\frac{4\pi r f}{c} \right)^2$$

ATMOSPHERIC ATTENUATION





ORBITS

- Four different types of satellite orbits can be identified depending on the shape and diameter of the orbit:
  - GEO: geostationary orbit, ca. 36000 km above earth surface
  - LEO (Low Earth Orbit): ca. 500 - 1500 km
  - MEO (Medium Earth Orbit) or ICO (Intermediate Circular Orbit): ca. 6000 - 20000 km
  - HEO (Highly Elliptical Orbit) elliptical orbits