B211 Internet Computing

Long-Haul Backbone Networks

Learning Objectives

1. Understand the basic physical backbone infrastructure used to connect the global network like the Internet.

2. Understand the relationship between these long-haul backbone networks and access networks that connects the users to the Internet.

Lecture Outline

- Data Signaling
- Terrestrial and Submarine Fiber-optic Backbones
- Satellites
- Connection to access networks.

Data Signaling

- Data can be transported through various means. The most common ones are:
    - Electrical signals through copper wires (twisted pairs or coaxial)
    - Light through optical fibers
    - Radio waves through satellites, and microwave dishes.
- In data networks (like the Internet), we use these methods to encode signals of 0’s and 1’s.
    - Eg in copper wires, one possible method is:
      high voltage = 1, no voltage = 0

Long-Haul Backbone Networks

- Most of the planet is covered by long-haul backbone networks which transports data
    - Between LANs
    - Between cities and regions
    - Between countries

- Over 95% of the data is carried by fiber optics cables
    - Terrestrial (over land)
    - Submarine (under sea)

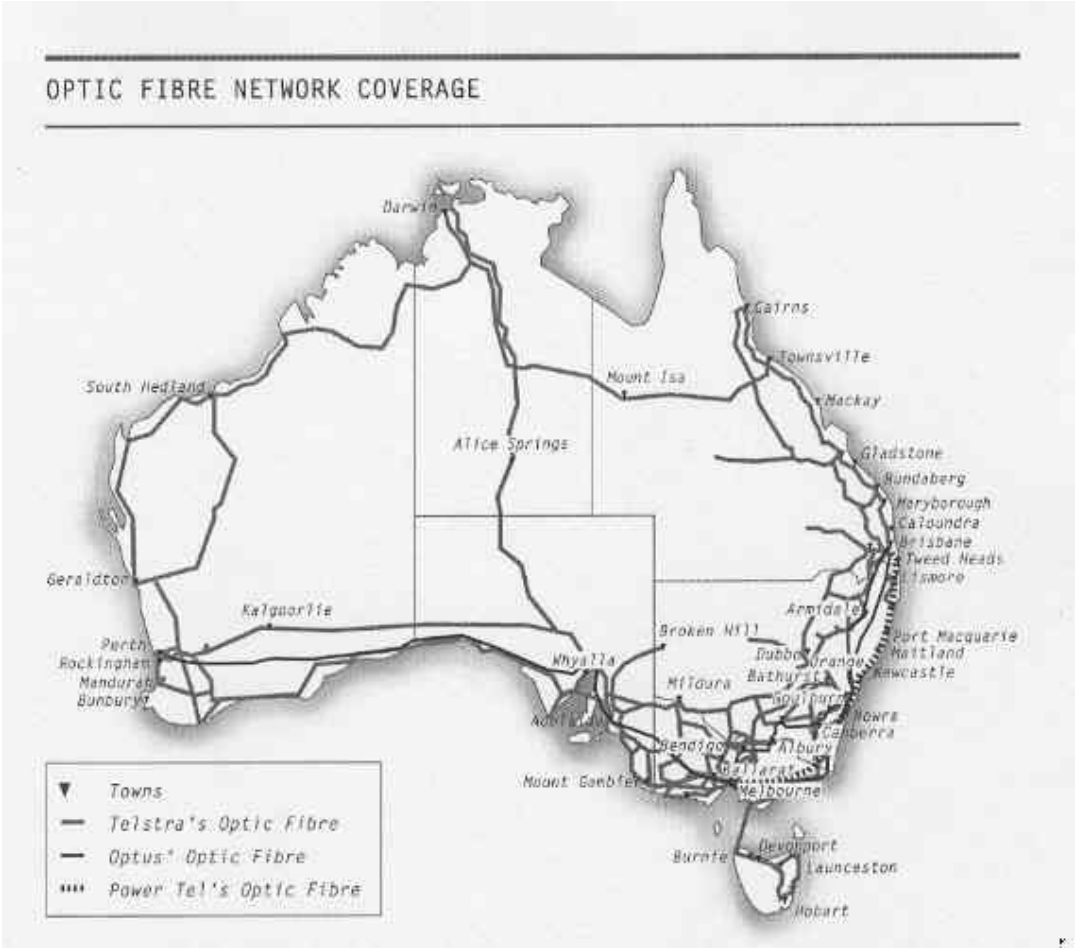
- The remaining are broadcast over satellites
    - GEO (Geosynchronous Earth Orbit)
    - LEO (Low Earth Orbit)

Long-Haul Backbone Networks

- Copper wires, due to it’s inability to carry clear electrical signals over long-distances without interference, is unsuitable for backbone networks.

Terrestrial Backbone Networks in Australia

Source: National Bandwidth Enquiry 2000
http://www.noie.gov.au/projects/information_economy/bandwidth/index.htm



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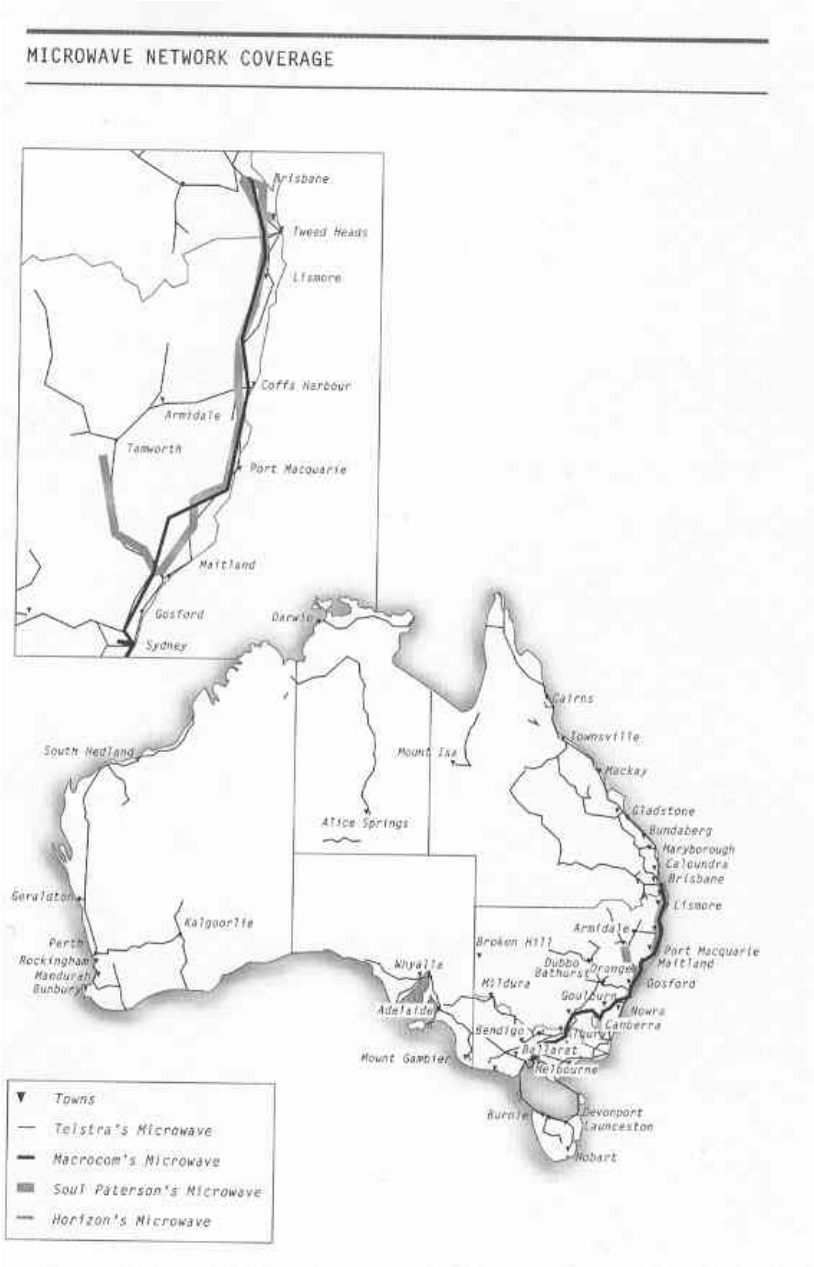
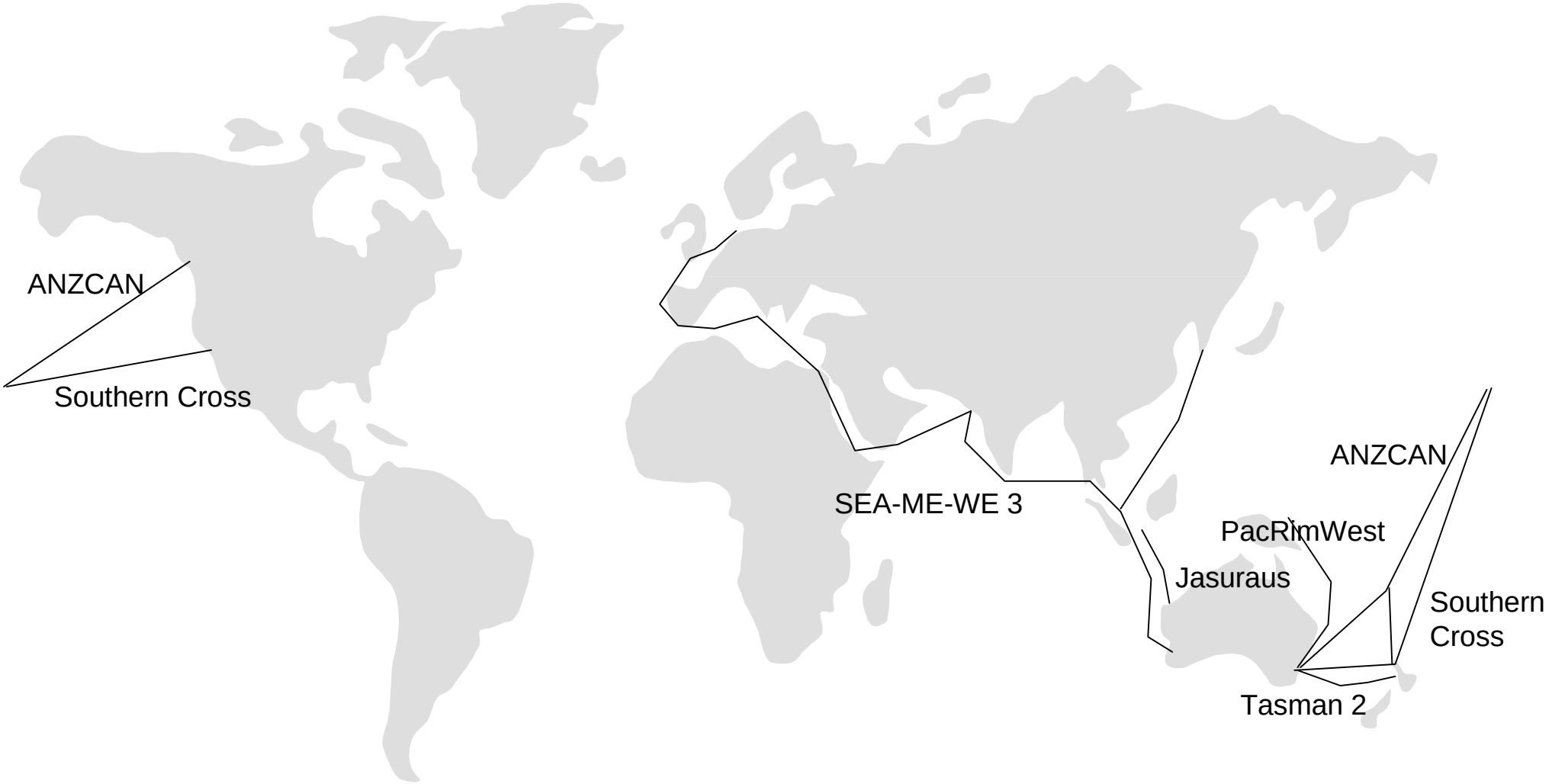
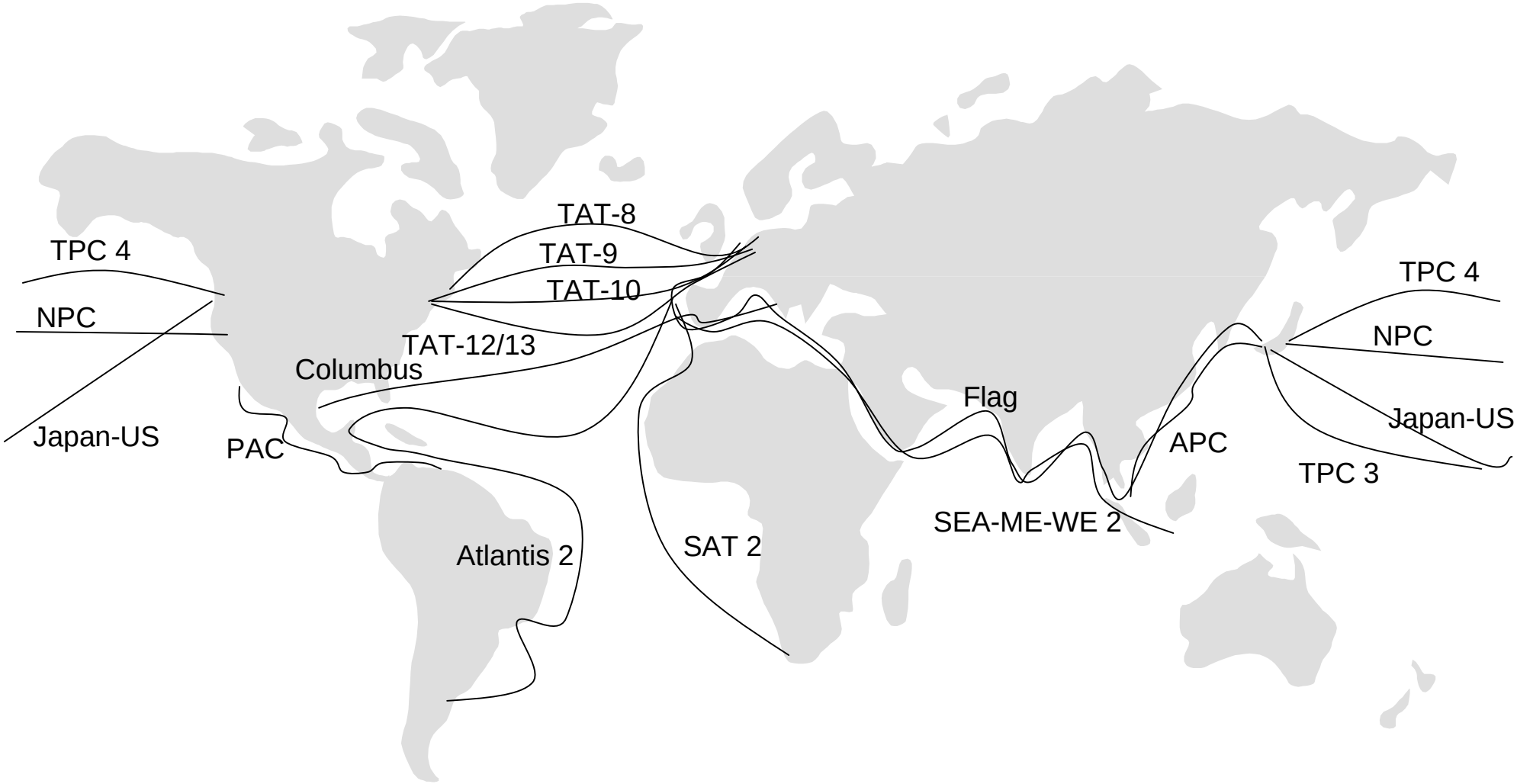


Some Major Global Submarine Cables Cables linked to Australia



Other Major Submarine Cables Around the World



All Major Global Submarine Cables linked to Australia

- The previous pages are only (very rough) sketches, and only shows a fraction of the submarine cables operating today.

- For a full list of submarine cables around the world, and their exact landing areas, see:

    - http://www.iscpc.org/ and http://www.iscpc.org/cabledb/cabledb.htm
    - http://davidw.home.cern.ch/davidw/public/SubCables.html - last updated March 2000, so is not completely up to date - but still a very good summary.

Planned Submarine Cables in the Near Future

IN THE PIPELINE: WEAVING THE OPTICAL WEB

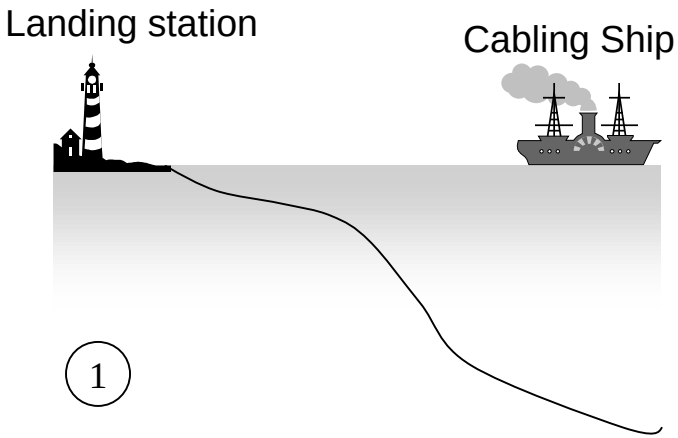
Transoceanic links: planned or under construction

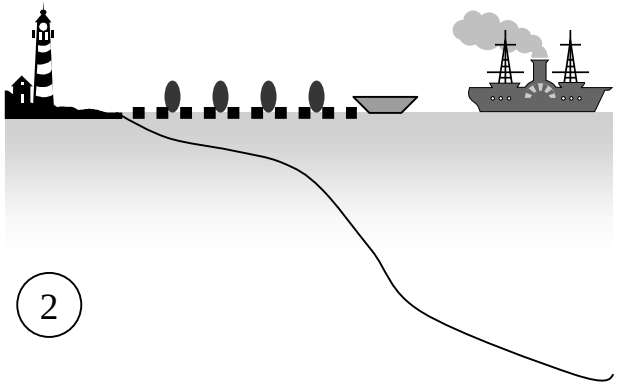
Name	Capacity (Tbit/s)	Submarine cable owners	Estimated cost (USD bn)
Atlantic			
TAT-14	0.64	Consortium	1.20
FLAG Atlantic-1	2.39	FLAG Telecom	1.50
360Atlantic	1.91	360networks	1.20
Project Yellow/AC-2	1.27	Global Crossing, Level 3, Viatel	1.10
TyCom Global Network	2.55	TyCom	tba
Pacific			
Pacific Crossing-1	0.16	Global Crossing, Marubeni	1.20
China–US Cable Network	0.08	Consortium	1.10
Japan–US Cable Network	0.40	Consortium	1.15
FLAG Pacific-1	5.09	FLAG Telecom	2.10
TyCom Global Network	6.00	TyCom	tba
360Pacific	6.00	360networks	tba
Asia–America Network	tbd	tbd	tbd

Source: Michael Ruddy, independent analyst

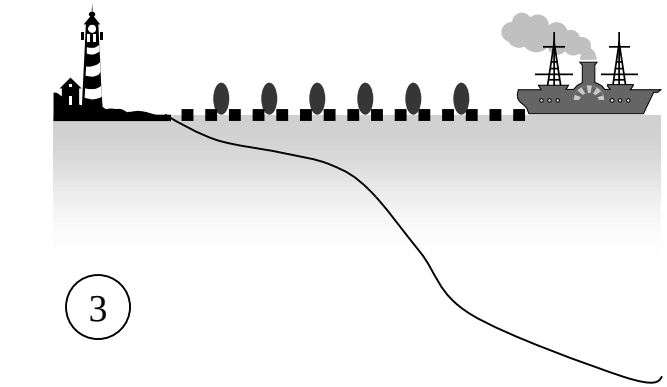
Source: Fiber Systems International, Vo 2 No 1, Feb 2001

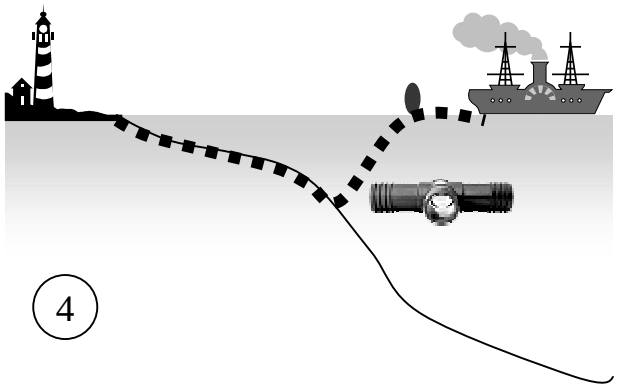
Installing Submarine Cables





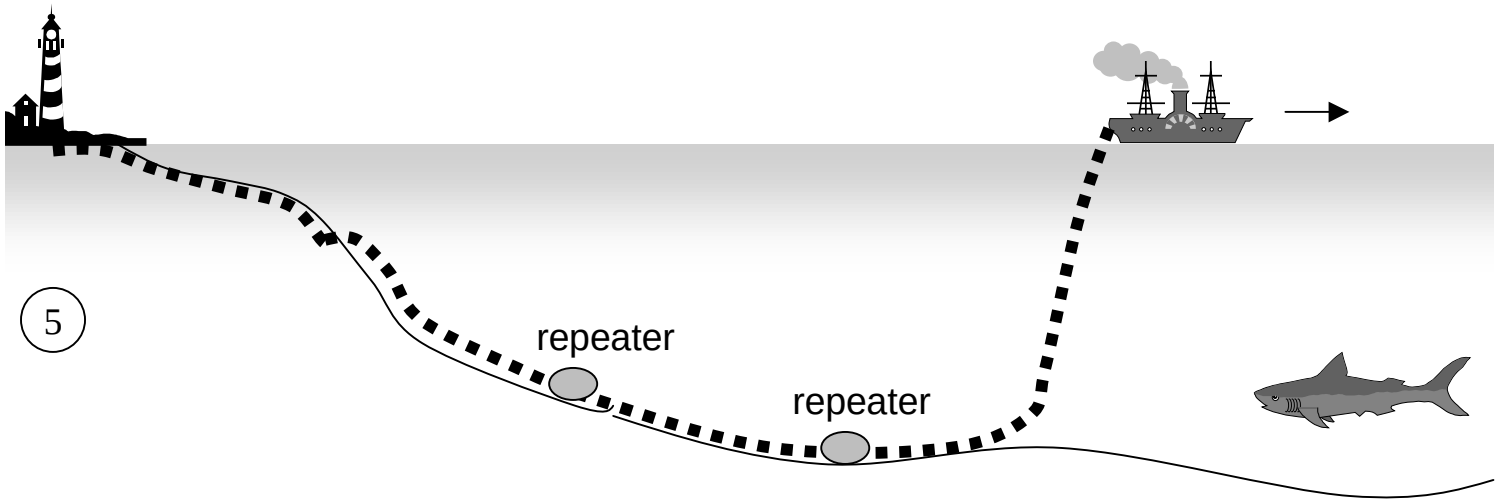
Boat pulls cables out to ship, supporting the floating cables with buoys.





Cables released from buoys. Divers and small submersible vehicles bury the cables up to a certain depth.

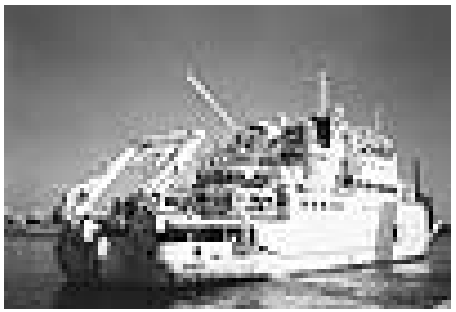
Installing Submarine Cables



Ships lays the cables across the ocean. Cables are exposed on the deep sea-bed.

- At the other side of the ocean, steps 1-4 happens again, and the cable is connected by the ship.

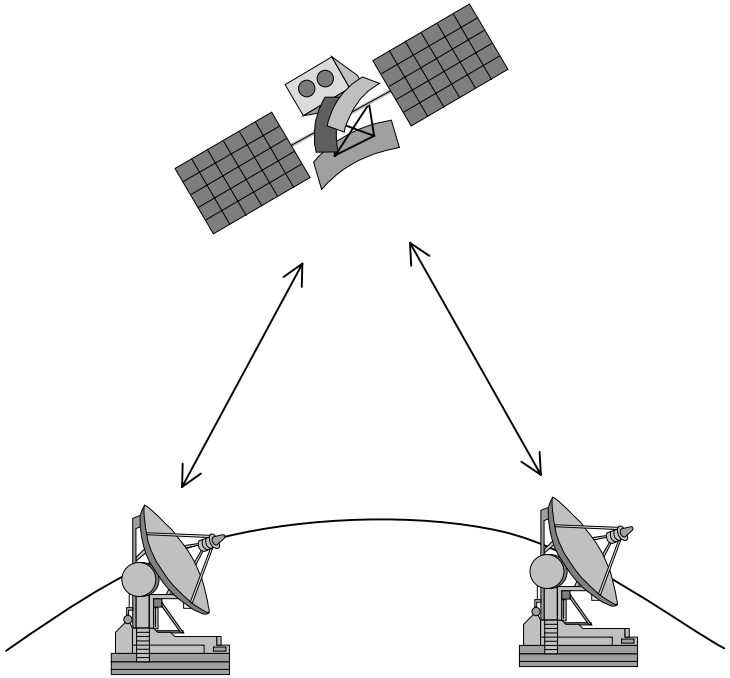
Installing Submarine Cables

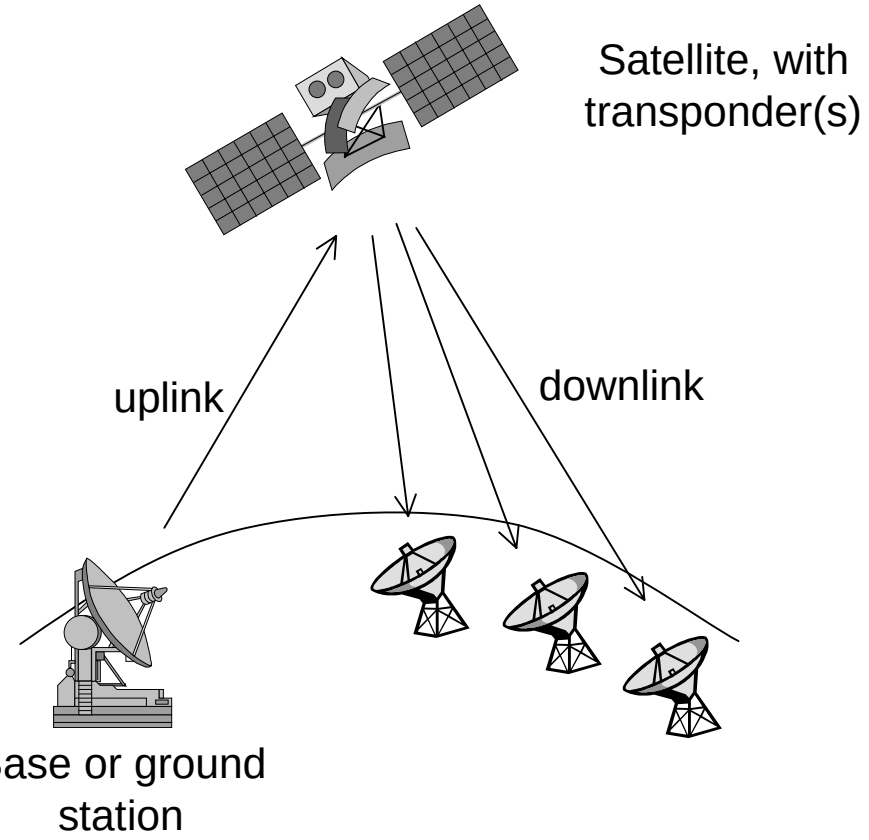


- If you have high-bandwidth Internet access, you can view flash animations of submarine cabling engineering (eg. install, repair) at http://www.alcatel.com/submarine

Image sources: *Fiber System International* magazine, www.southerncrosscables.com and www.diveweb.com and www.tycomltd.com.

Satellites




Satellite, with transponder(s)
uplink
downlink
Base or ground station

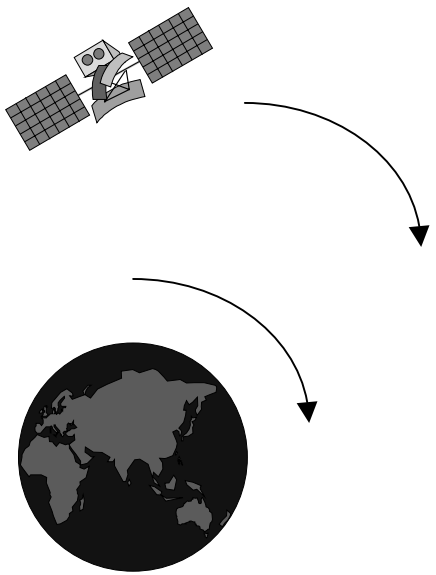
Satellites

- Satellites by its nature is is principally used for ***broadcasts***, rather than point-to-point communication.

- We do use satellites are used from point-to-point communication like providing Internet services.

    - They can be good for areas wishing to bypass congested fiber-optic lines.
    - They are also good in giving access to rural areas very far away from main fiber-optic backbones - it is more cost effective to use satellites than install fiber-optic cables over very long distances.

Geosynchronous Earth (GEO) Satellites



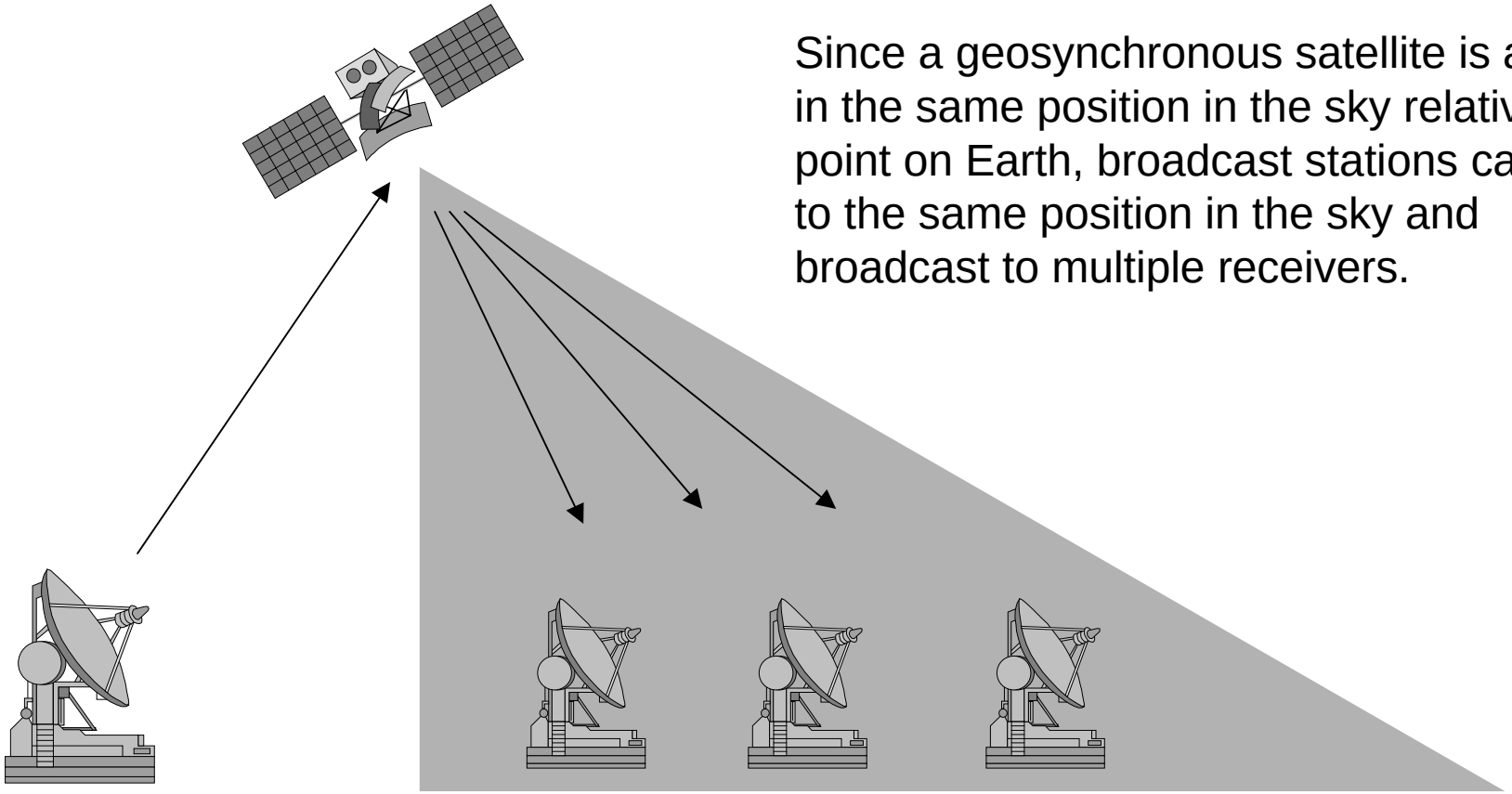
- Satellite at an orbit (height of 35,600km from surface) where it is moving at about the same speed as Earth's rotation (23 hour 56 minutes per rotation).
- Therefore the satellite stays almost stationary relative to a position on Earth.
- There is only one such orbit around the Earth, directly over the equator.

Geosynchronous Earth Satellites

- Geosynchronous satellites are NOT EXACTLY *geostationary*
    - That is, they are NOT over exactly the position on Earth all the time, although some operators claims them to be so - it is very hard to maintain a consistently geostationary orbit due to effects from the moon and sun.
    - They are usually several tens of minutes faster/slower than a perfect geostationary orbit.

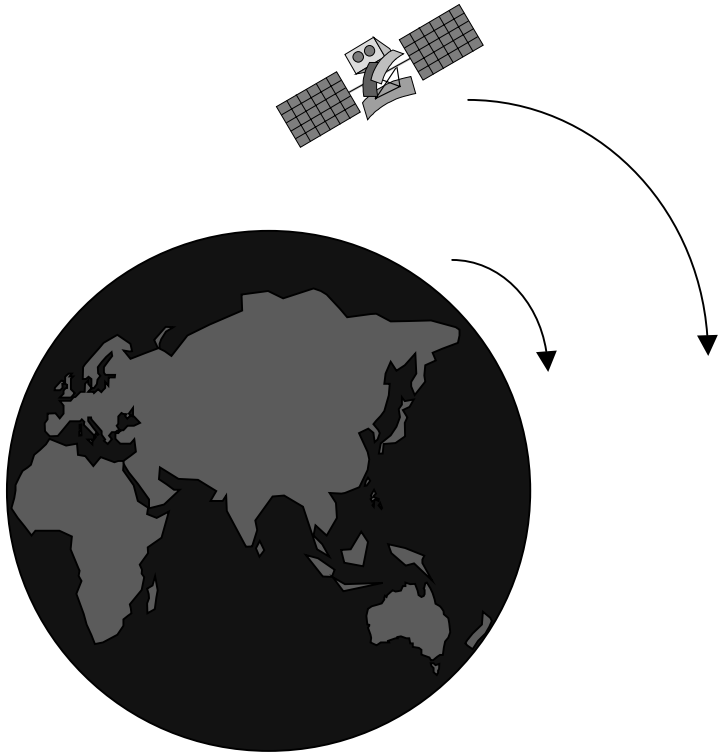
- When the life of a satellite is over (usually about 10 years), they are moved to a higher or lower orbit to avoid collisions with other operational satellites.

Geosynchronous Earth Satellites



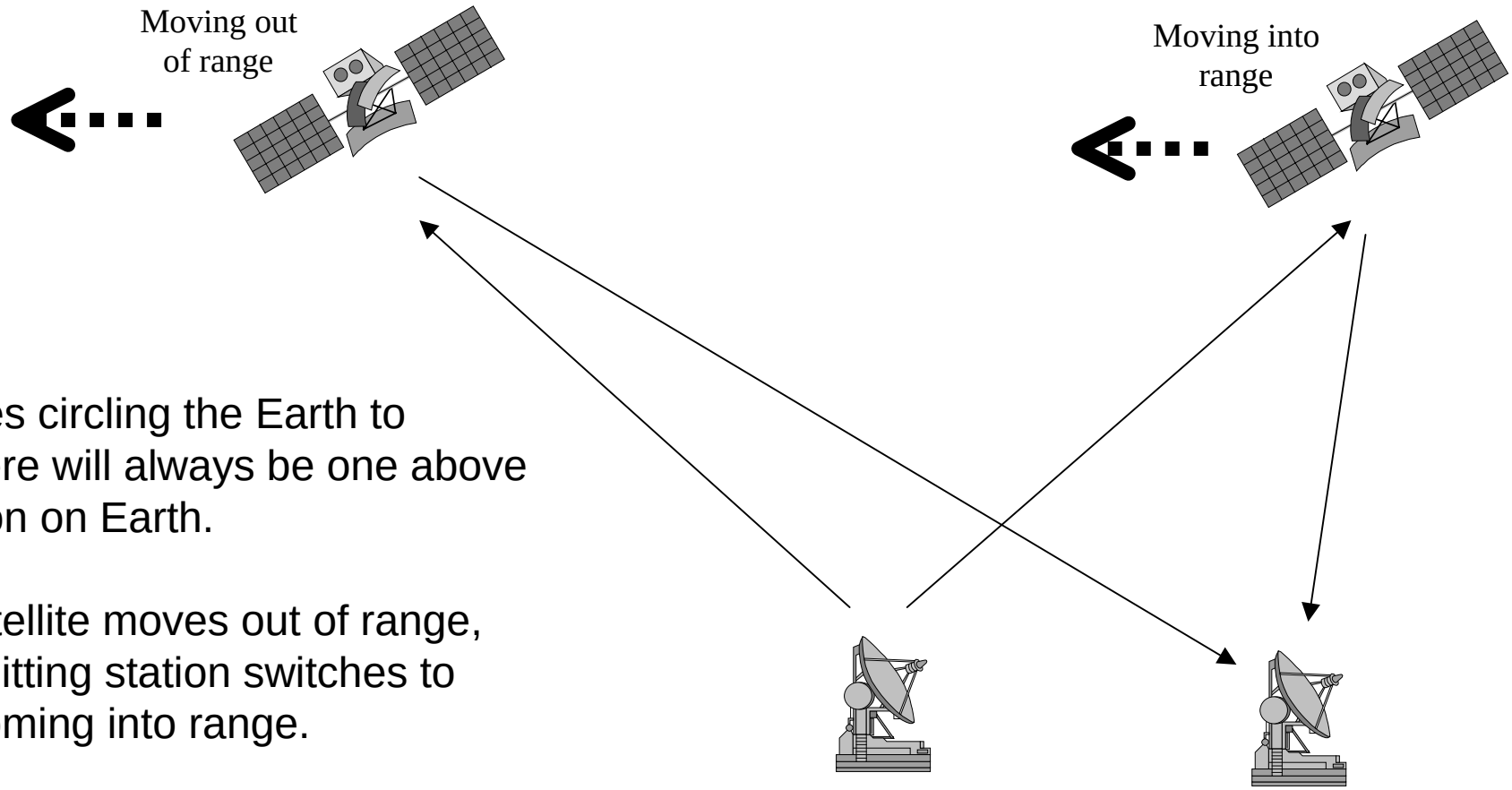
Since a geosynchronous satellite is always in the same position in the sky relative to a point on Earth, broadcast stations can point to the same position in the sky and broadcast to multiple receivers.

Low Earth Orbit (LEO) Satellites



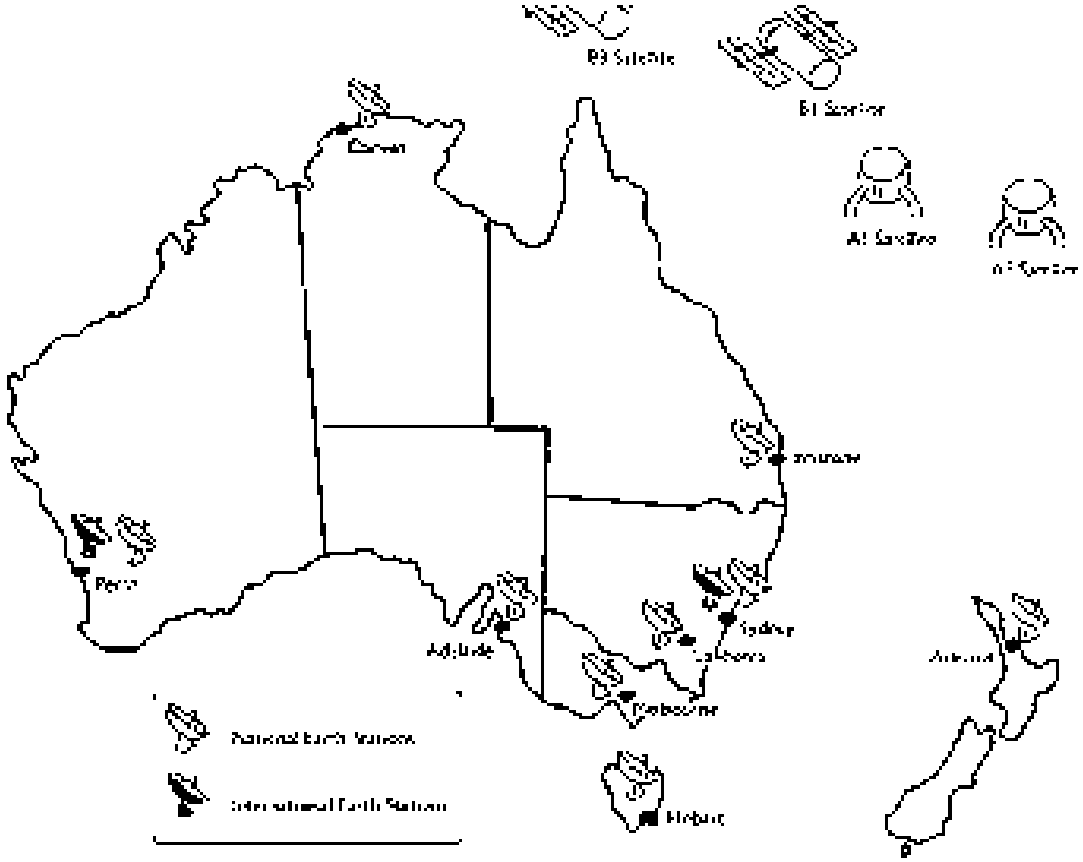
Satellite at a much lower orbit, and therefore needs to move at a much higher speed relative to Earth's rotation to maintain orbit.

Example LEO Satellites: The Iridium Project



- 66 satellites circling the Earth to ensure there will always be one above any position on Earth.
- As one satellite moves out of range, the transmitting station switches to another coming into range.

GEO Satellites over Australia: Optus's Satellites and Base Stations

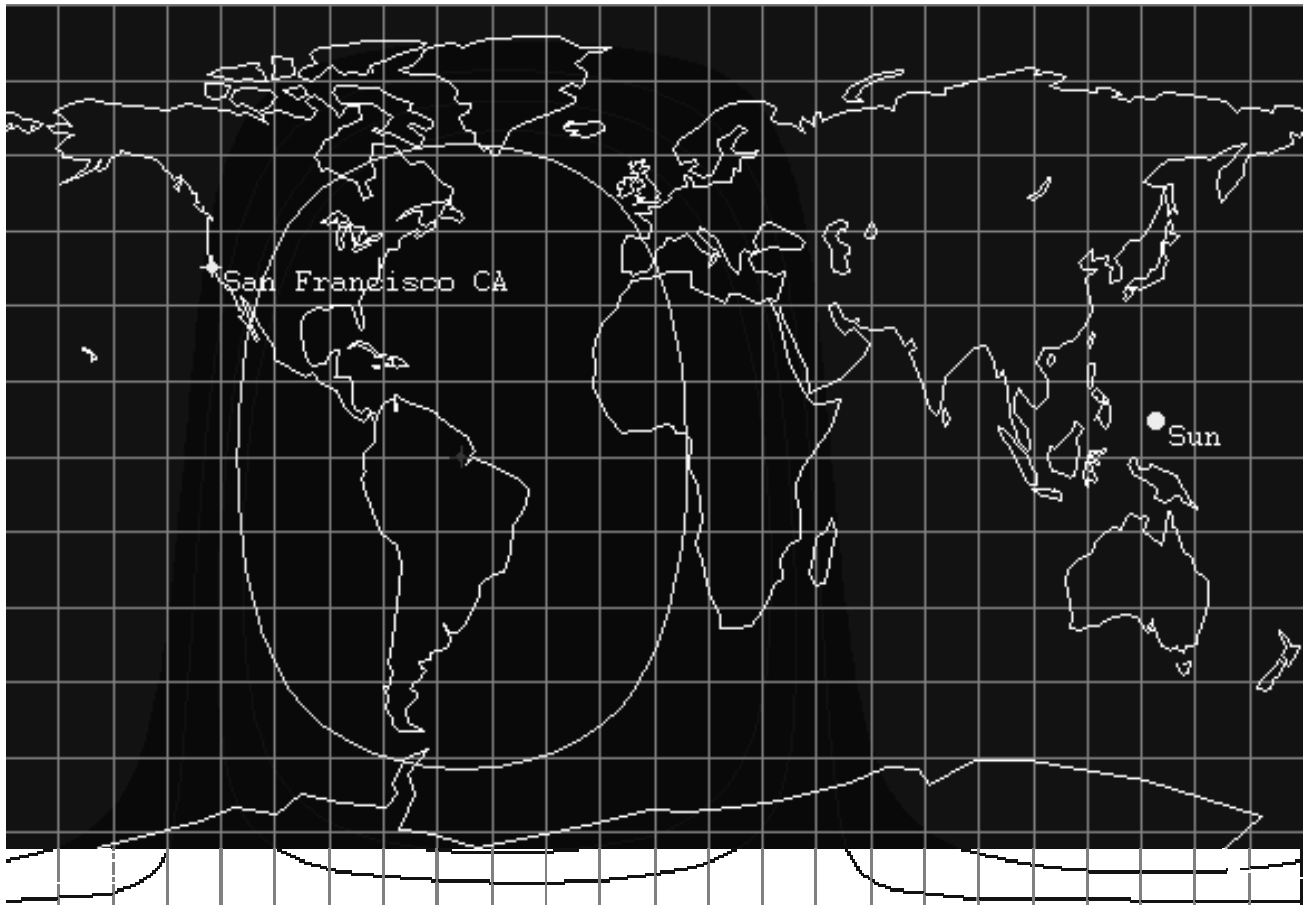


Source: http://www.enterprise.cwo.com.au/00/00h.asp

Example Satellites Around the World

- IntelSat
    - Ref: http://www.intelsat.com
    - At longtitude 60°E, 62°E, 64°E, 66°E, 83°E, 110.5°E, 174°E, 176°E, 180°E, 304°E, 307°E, 310°E, 325.5°E, 328°E, 330°E, 332.5°E, 335.5°E, 342°E, 359°E
- InmarSat I-VI
    - Ref: http://www.inmarsat.com
- For a list of current satellites, and their up-to-the-second positions in the sky, see:
    - http://satellite.netliberte.org/

Example GEO Satellite coverage: IntelSat F7-6



Source: http://www.geocities.com/CapeCanaveral/Hangar/1668/orbits.htm

Connecting Users to the Global Network

- We cannot have individual homes and offices connecting directly to main network backbones.
    - Buying a main backbone connection from a carrier is a very costly investment.
    - Technically, it is not feasible to have a switch every few meters in a main backbone cable to connect to another home.
- Therefore, we have ISPs (Internet Service Providers) build their LANs (Local Area Networks) and they connect their LANs to major backbones.
- Users then pay ISPs for a connection to their LANs, and hence, a connection to the global network.

In the next lecture...

- In the next lecture, we will talk about the **access network** infrastructure that connects users to the global backbones.