

LEO Satcom Systems

Dr Stuart Eves

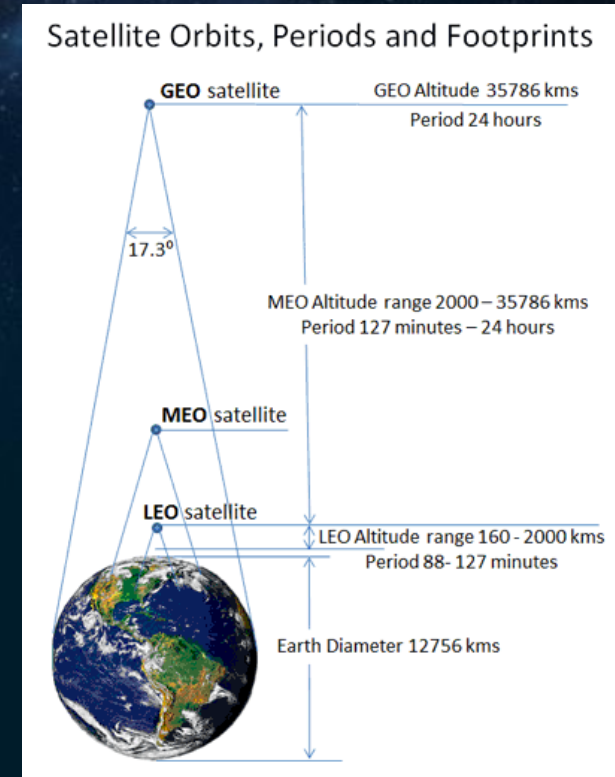




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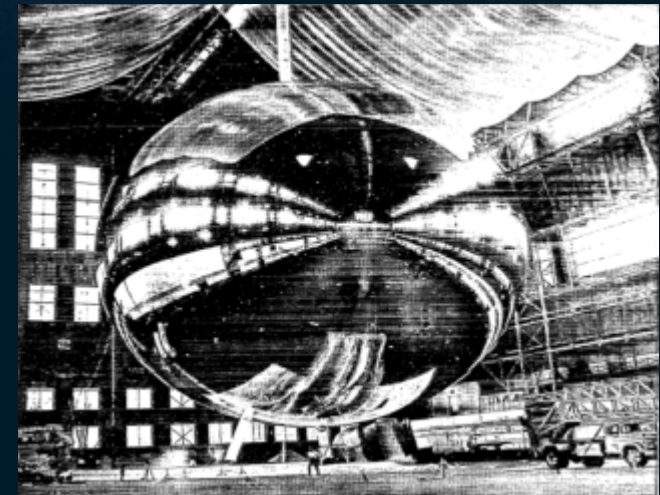
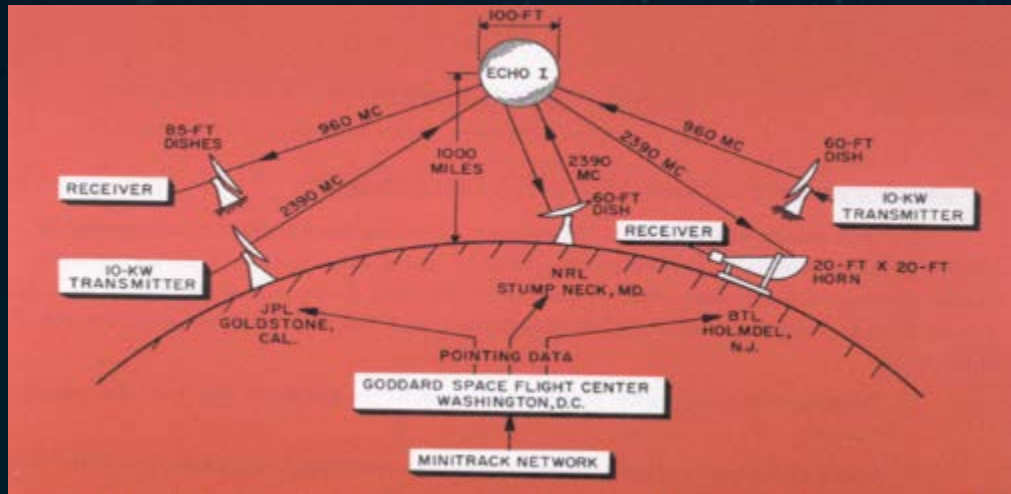
Summary

- Satellite communications has been exploited since the 1960's
- LEO, HEO and GEO orbits have been used for differing reasons
- The use of satellite communication systems is becoming increasingly "tactical" or "personal" in both the military and civil domains
- As a result, there is renewed interest in LEO systems



Passive satellite communications

- Passive RF systems were explored in the 1960's
- The Echo-2 experiment was used to reflect communications signals

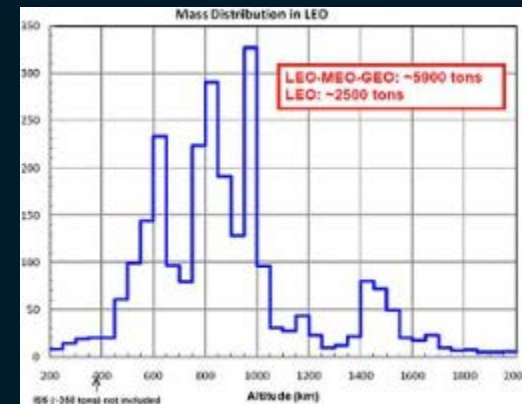
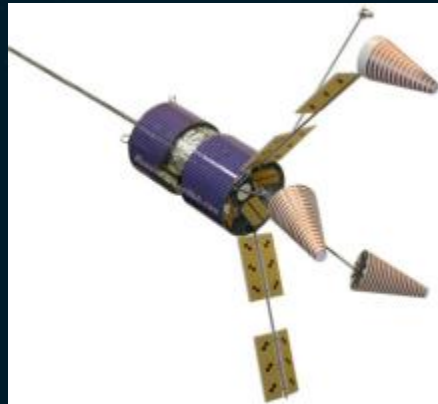
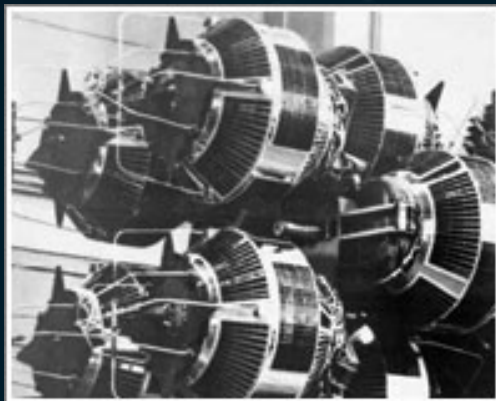


Russian LEO Communications Systems

- Starting in the 1960's the Russians launched several hundred short-lived store-and-forward communications satellites into LEO
- Used for LPI/LPE burst communications, these Strela satellites now make a significant contribution to the LEO debris population



Cosmos 2251-type



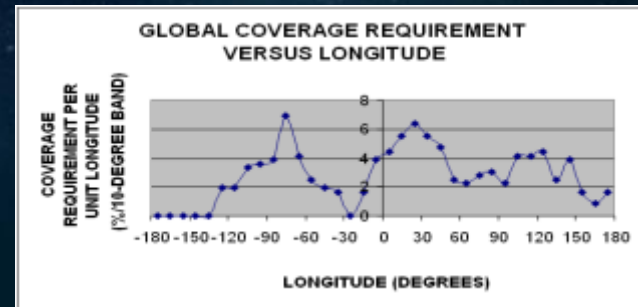
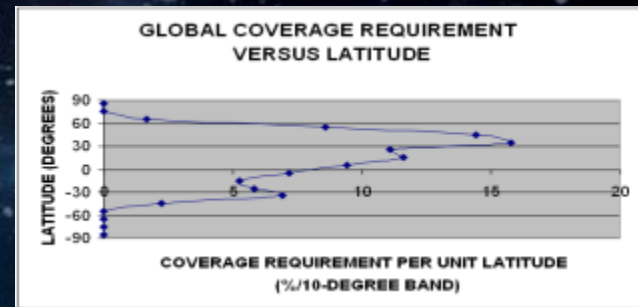
- The early 1990's saw a surge of interest in multi-satellite constellations in low Earth orbit to support small mobile user terminals around the globe





Communications Coverage Requirement

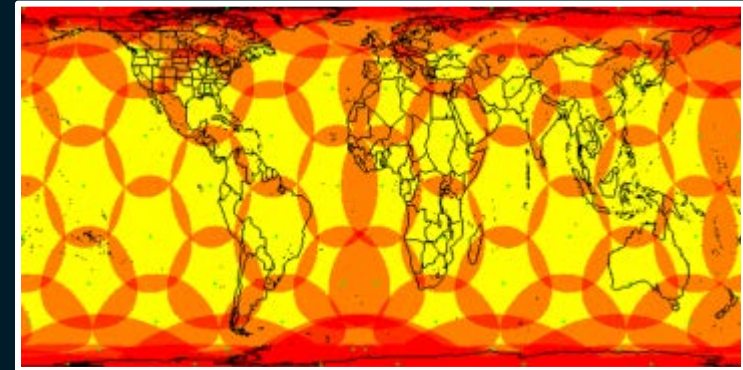
- Question: Where exactly is the requirement?
- Answer: Roughly 60° N to 60° S with an 85%-15% bias to the Northern hemisphere
- Question: Can this be delivered by a satellite constellation?
- Answer: Yes, with various levels of success



Iridium Usage Plot

Iridium

- Mobile users make extensive use of the Iridium LEO communications network
- This system's inter-satellite links allow real-time communications to hand-held terminals

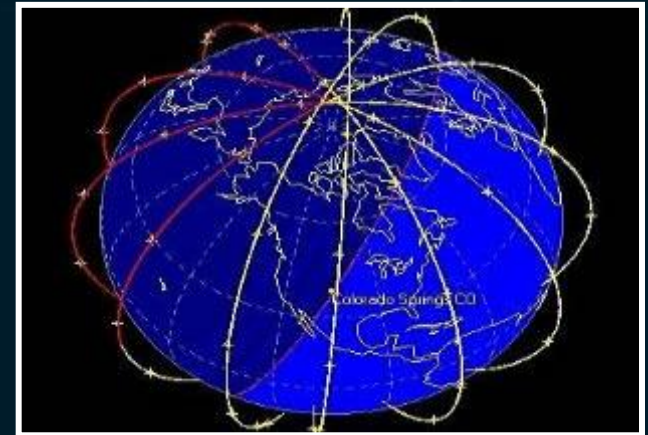


Iridium's Lessons Learned

- It's not a good idea to have all of your satellites in perfectly circular, truly polar orbits, as they end up passing uncomfortably close to one another over the poles
- You can save yourself a lot of investment in satellite hardware by using a slightly higher orbit with a larger field of view of the Earth
- It's a good idea to investigate the locations of defunct Russian satellites

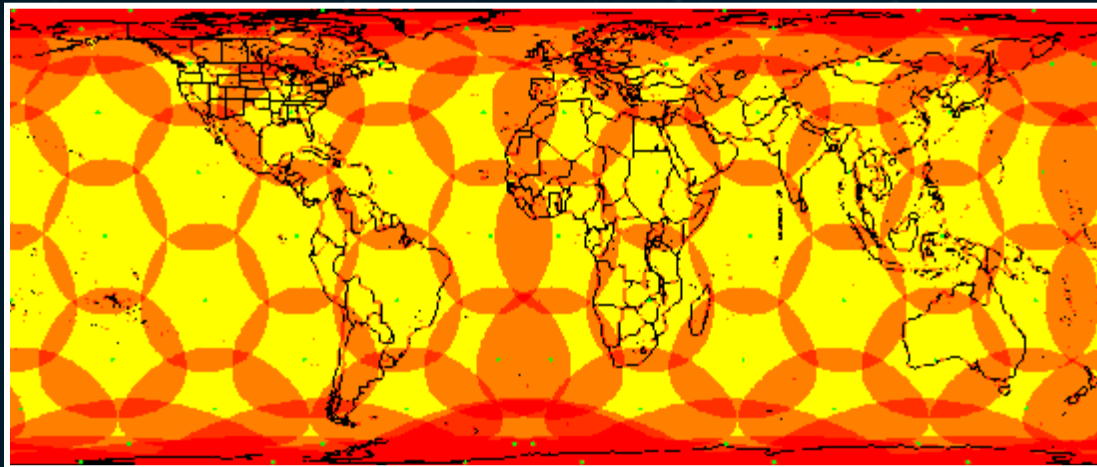
Iridium

- 66 (originally 77) satellites
 - 6 (7) planes, 11 satellites in each
- 86.4 (originally 90) degrees inclination
- Altitude 780km (originally 765km)
- Global coverage
- 100% of Earth's surface



Asymmetric Plane Spacings

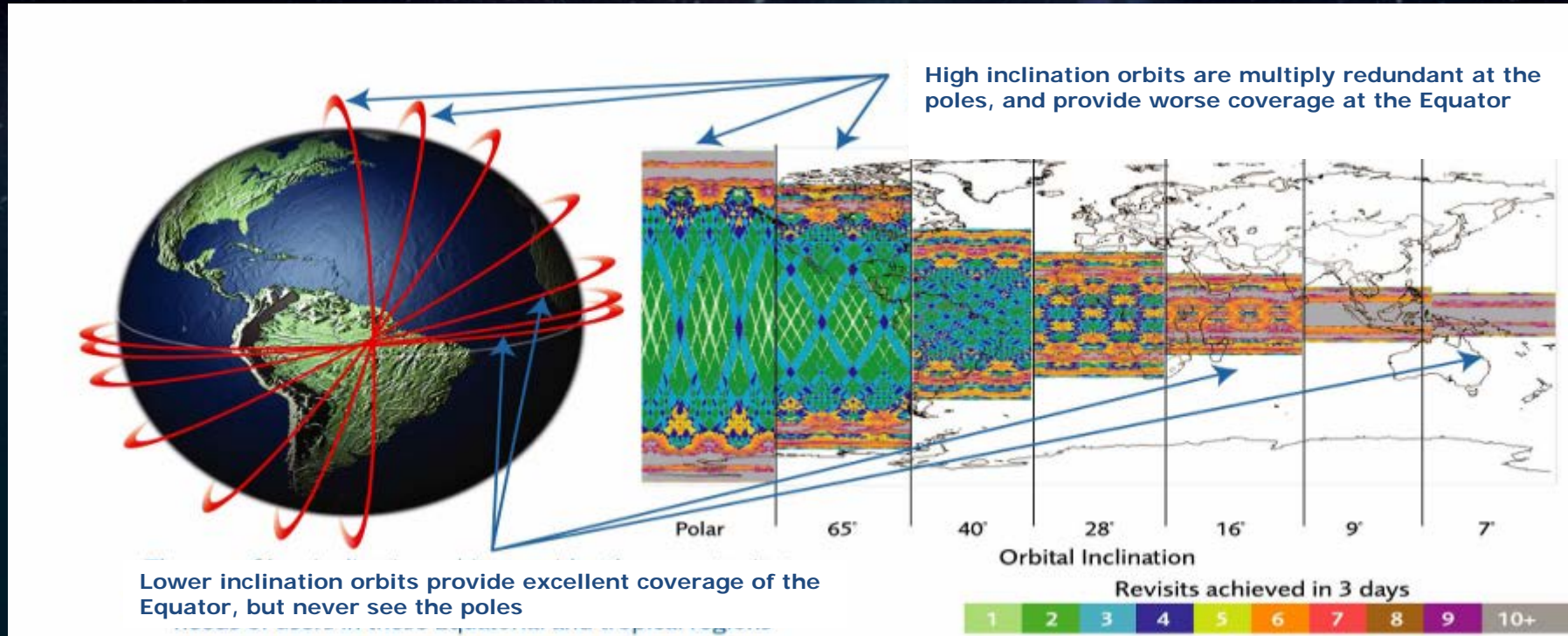
- Iridium planes 1-5 are spaced at more than 30 degrees
- The separation between Planes 1 and 6 is less than 30 degrees
- This is the constellation “seam”, where satellites in these adjacent planes are travelling in opposite directions



Iridium Lessons Not Learned?

- Iridium are currently planning their replacement constellation, Iridium-Next
- In addition to their communications function , the Iridium satellites will also carry receivers to monitor aircraft safety transmissions
- Despite the fact that their current operational orbit is full of debris from the Iridium 33 collision, and two other Iridium satellites now have debris objects associated with them, they plan to use the same orbital altitude for their new satellites

The Use of Lower Inclination Orbits

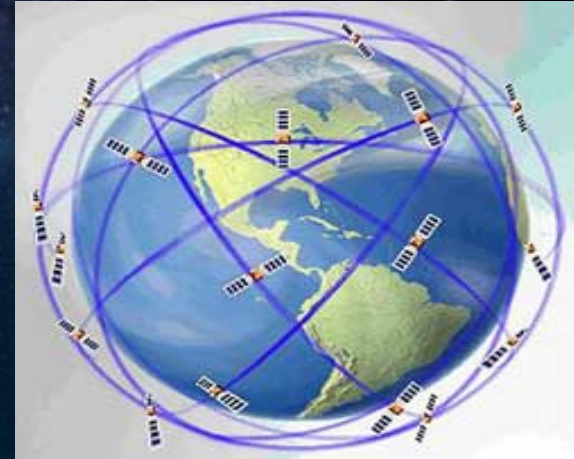


- Using lower inclination orbits for some of the constellation can save a lot of satellites

Globalstar



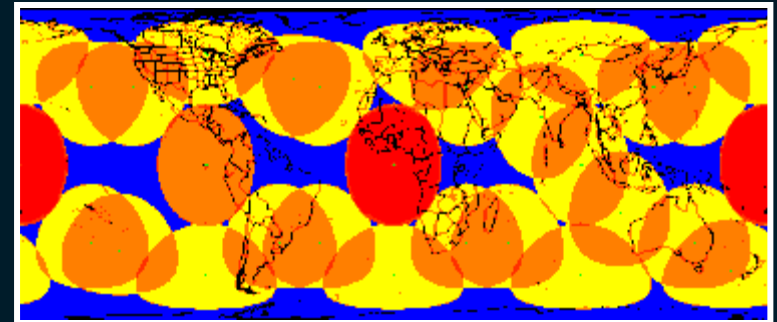
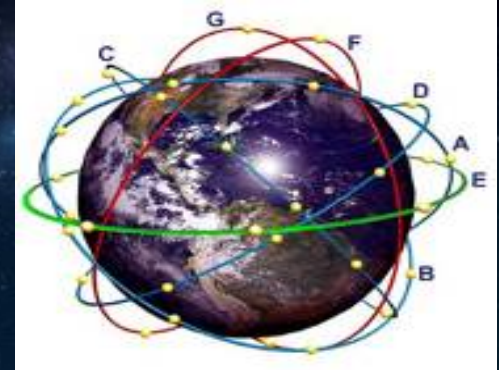
- 8 planes, 6 satellites in each
- 52 degrees inclination
- Altitude 1410 km
- Coverage of 70 N to 70 S
- 80% of Earth's surface



Orbcomm

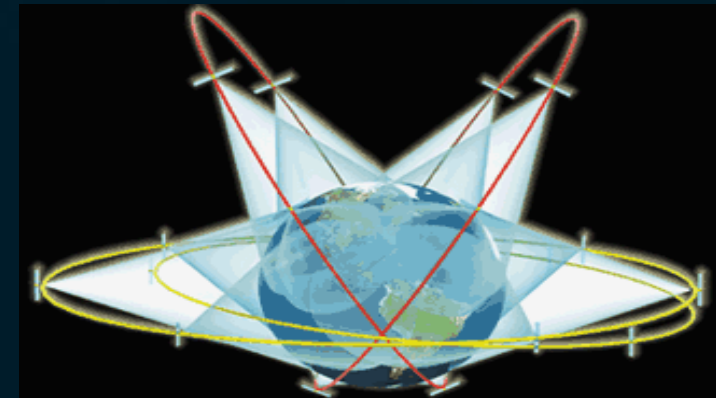
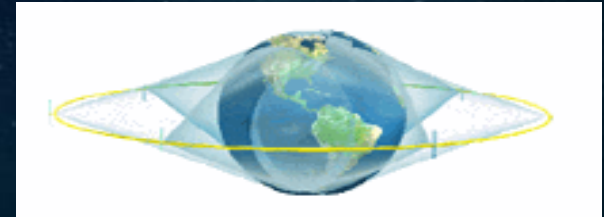
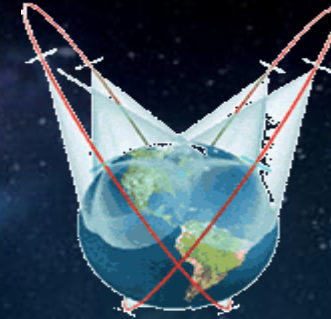


- Up to 36 satellites
 - 24 in 45 degree inclination orbits at 780 km altitude
 - 3 planes with 8 satellites in each
 - more in polar orbits at 785 km
- Unlike Iridium, Orbcomm has no inter satellite links
- Hence cheaper satellites but more investment needed in ground infrastructure
- Not always real time



Ellipso

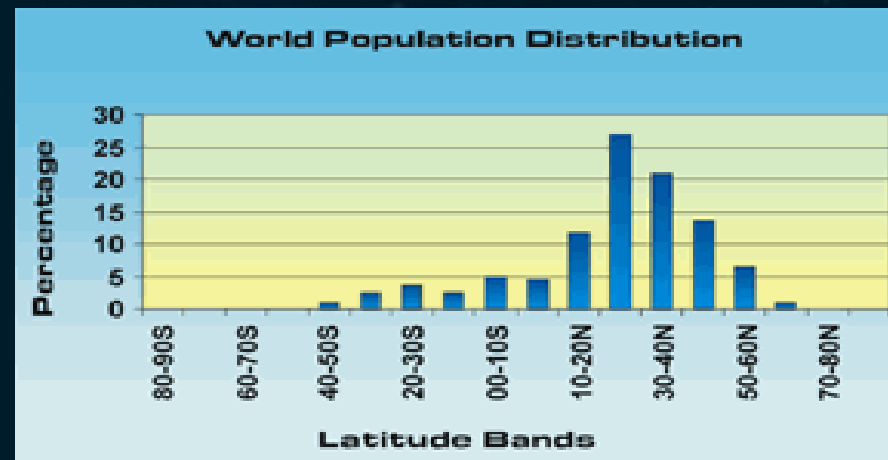
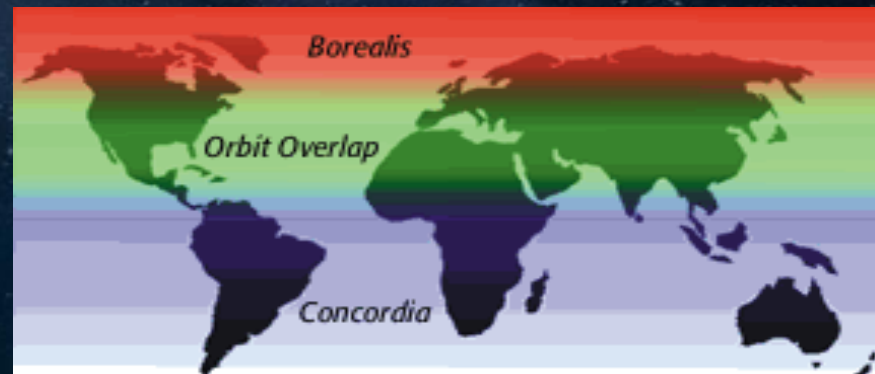
- Ellipso was an elegant orbit design
.....but never launched
- Borealis
 - The Borealis elliptical orbit constellation is designed to provide coverage of the northern temperate latitudes. This constellation is based on the use of 10 satellites in two elliptic orbital planes. Borealis orbits are inclined at 116.6 degrees. They have apogees of 7,605 km perigees of 633 km, and a three-hour orbital period. The apogees are near the northern extremity of the orbits.
- Concordia
 - The Concordia constellation provides coverage from 50 degrees south latitude to 50 degrees north latitude, with a focus on tropical and southern areas that the Borealis satellites do not reach. The initial complement of seven Concordia satellites was to be deployed in an circular equatorial orbit at an altitude of 8,050 km with a launch of 4 satellites and a subsequent launch of the remaining three.





Matching Coverage to the Requirement

- The Ellipso coverage is tailored to match the capacity requirements over the globe
- 17 satellites are required
- The orbits are “quite hot” from a radiation point of view!





Future Communications Terminals

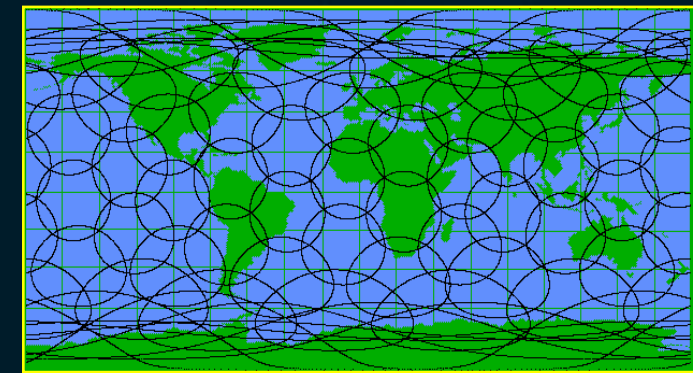
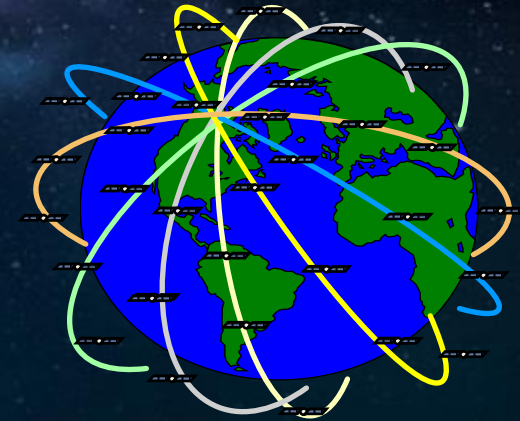
- Individual users will be able to benefit from leading commercial satellite terminal technologies:-
 - Small and light
 - Easily portable
 - Low power
 - Omni-directional, (no pointing requirement)
 - Higher data rates
 - GPS/Galileo enabled
 - Real time communications
 - Stored communications
 - Low cost (through mass production)



Inter-Satellite Link (ISL) Networks



- The power and value of PC computers was massively enhanced when they were networked in the “World Wide Web”
- Similarly, the true value of satellites, (especially small satellites, the PC’s of space), will be realised when they are fully “networked” via inter-satellite links into a “space wide web”
- In the future, it will be conventional to provide inter-satellite links for all satellites



Rapid Communications?

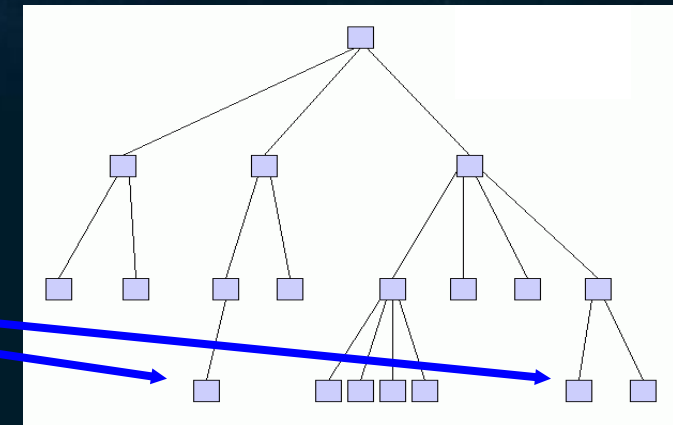
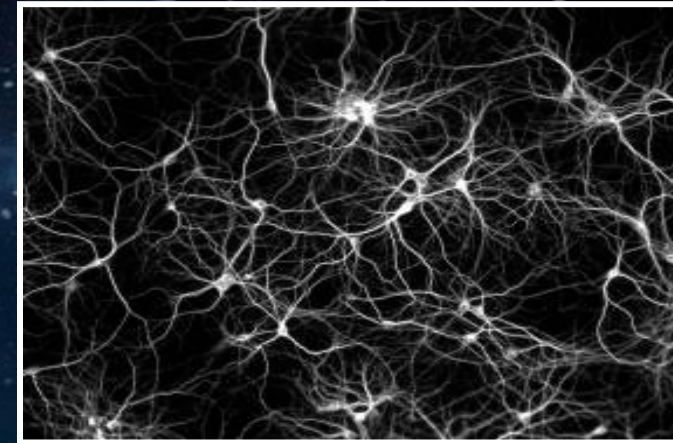
- High-capacity store and forward communications e.g. the Canadian Cascade concept
- An issue is the potential latency of such systems relative to fibre-optic alternatives



Optimal Networks

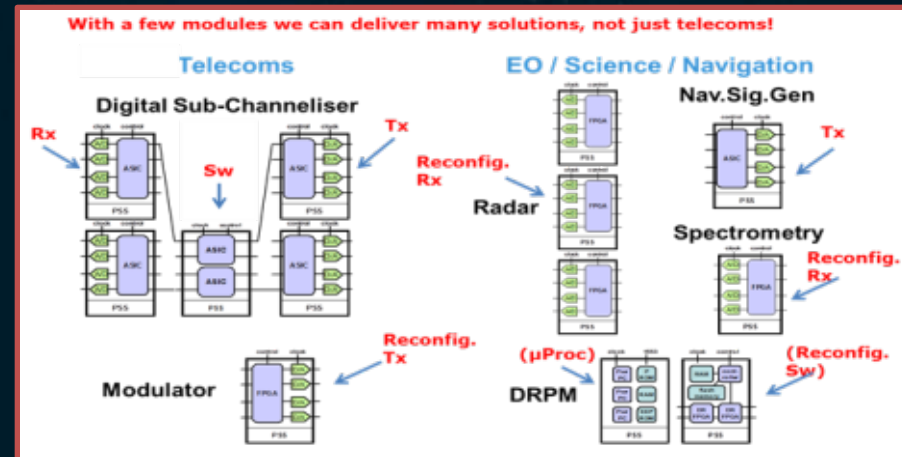
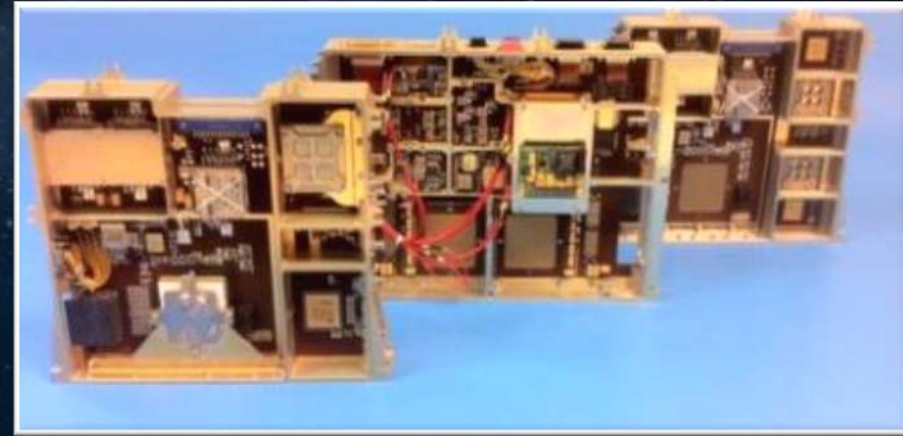


- The most efficient networks have both short-range and long range links
- A variety of natural systems, including neurons are interlinked in this fashion
- Only about six links are required to connect any two locations in a network of billions of nodes
- Much more efficient than traditional tree networks
- Six links required to connect these two adjacent nodes
- Implies future communications architectures will need to use LEO and GEO satellites for both short range and long range links



Trend Towards On-board Processing

- The ability of advanced on-board processing to route communications traffic, will increase capacity, improve cueing, and allow future systems to provide far greater capabilities



Mega-Constellations

- Systems such as OneWeb are being designed to providing video streaming to personal terminals
- 648 + satellites
- 1200km altitude
- 20 orbital planes
- In service by 2019?
- Global coverage by interlocking satellite footprints
- Data rates of 50Mb/s
- Small, low-cost user terminals talk to the satellites, and emit LTE, 3G and WiFi to the surrounding areas, providing high-speed internet access for everyone



Will constellations be more profitable this time?



Thank You