Presentation Outline

- Historical Overview
- Radio Fundamentals
- US Developments in PCS
- Mobile Data
- Satellite Systems
- Problems with existing schemes
- Wireless Overlay Networks
- US Government Research Initiatives

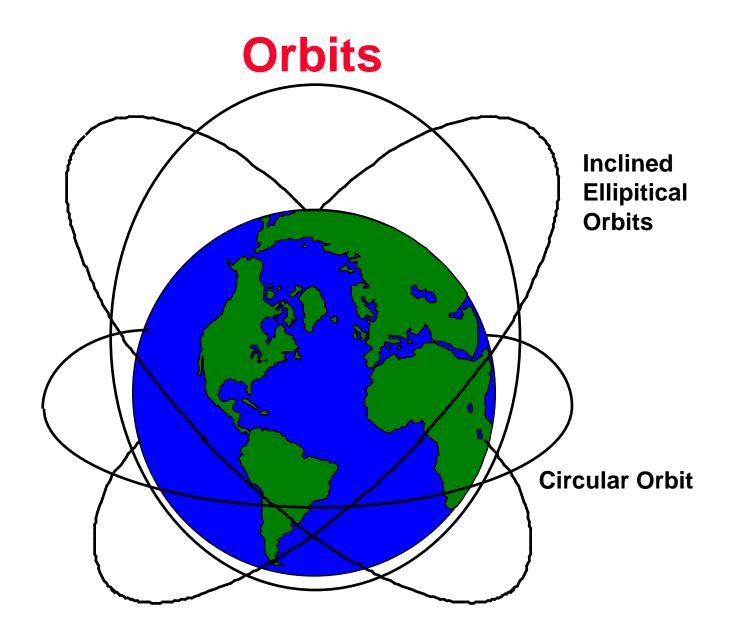


- Like cellular systems, except that the base stations (i.e., satellites) move as will as mobile devices
- Satellite coverage attractive for areas of world not well served by existing terrestial infrastructure: ocean areas, developing countries



- Geostationary Systems
 - INMARSAT
 - MSAT
- Big "LEO" Systems
 - ARIES
 - ELLIPSO
 - IRIDIUM
 - ODYSSEY
- Little "LEO" Systems
 - Orbcomm
 - LEOSAT
 - STARNET
 - VITASAT







What's Wrong with GeoSync?

- 35786 km orbits imply long transmission latencies, on order of 250 ms for one-way, 500 ms round trip
- Makes error detection/retransmission strategies difficult to use
- Does not provide good coverage at high latitudes (80 degrees) or urban areas at medium latitudes (40 degrees



What's Wrong with Low Earth Orbit?

- Short visibility from any point on earth demands potentially large constellations
- Satellite lifetime dramatically reduced when low orbiting
- These two attributes affect the economics of LEO satellite systems
- Radiation effects reduce solar cells and electronics lifetimes
 - Van Allen radiation belts limit orbit placement

» Belt 1: 1500-5000 km

» Belt 2: 13000-20000 km



IRIDIUM

- Motorola
- Voice, Data (2.4 kbps), Fax, Location Services
- 66 satellites in 6 polar orbits (780 km)
- 48 spot beams per satellite forming "cells"
- Satellite-to-satellite links as well as to ground
- FDMA uplink, TDM downlink
- Supports satellite handoff during calls



ODYSSEY

- TRW
- Voice, Data (9.6 kbps), Fax, Location Services
- 12 satellites, 4 in each of 3 orbital planes
- Medium earth orbit: 10370 km
- CDMA access techniques
- No handover between satellites, because of long satellite visibility from ground
- Steering antenna scheme also eliminates need for spot beam handovers



GLOBALSTAR

- Loral, Qualcomm
- Voice, Data (9.6 kbps), Fax, Location Services
- 48 satellites, inclined orbits, 1400 km
- No satellite handovers, elliptical spot beams insure long coverage of mobile user
- CDMA access techniques
- ARIES, similar proposal from Consellation
- ELLIPSO, 15 satellites in elliptical orbit plus 9 in equalitorial circular orbits



Teledesic

- Major Investors: Bill Gates. Craig McCaw
- 21 orbital planes, 40 satellites per plane, 840 satellites total(!!)—\$9 billion to deploy
- 700 km, circular orbits
- Voice/Data upto 2 Mbps
- Unique flower-shaped satellite with sophisticated phase array antennas



| SYSTEM | INMARSAT M | MOBILSAT | ODYSSEY | IRIDIUM | GLOBAL- STAR | ARIES | ELLIPSO | ORBCOMM |
|-------------------------------------|----------------|---------------------|---------------------|---------------------|---------------------|-------------------|----------------------|---------------------------|
| Applicant | Comsat, etc. | AMSC | TRW | Iridium, Inc. | Loral Qualcomm | Constell ation | Ellipsat Corp. | Orbital Sciences |
| System Type | Geosatellite | Geosatellite | Meosatellite | Big Leo Sat | Big Leo Sat | Big Leo Sat | Big Leo Sat | Little Leo Sat |
| Purpose | Voice, Data | Voice, Data | Voice, Data | Voice | Voice | | | Data, Paging |
| Vendors, Partners | Magnavox, etc. | Hughes, Telesat | TRW | Motorola, etc. | RBOCs, PTTs | Constell Comms | Harris, Fairchild | Champion, etc. |
| Type of Portable Formfactor | Briefcase | Pocket Telephone | Pocket Telephone | Pocket Telephone | Pocket Telephone | | | Handheld Data Terminal |
| Fixed Infra- structure Needed | Gateways | Gateways | Gateways | Gateways | Gateways | | | Gateways |
| Comm Type | Digital | Digital | Digital | Digital | Digital | | | Digital |
| Geographic Coverage | Worldwide | N. America | Worldwide | Worldwide | Worldwide | | | Worldwide |



| SYSTEM | INMARSAT M | MOBILSAT | ODYSSEY | IRIDIUM | GLOBAL- STAR | ARIES | ELLIPSO | ORBCOMM |
|-----------------|----------------------|-----------|---------|---------|-----------------|--------|------------|----------|
| Two-Way | Yes | Yes | Yes | Yes | Yes | | | Yes |
| PSTN Access | Yes | Yes | Yes | Yes | Yes | | | via PDNs |
| # of Satellites | 4 | 2 | 9 to 12 | 66 | 48 | 48 | 6, then 24 | 26 |
| Orb Alt (km) | 36,000 | 36,000 | 10,370 | 780 | 1414 | 1020 | 580/7800 | 765 |
| Orb Type/Locs | 18,55W; 63W, 139W | 62W, 139W | | Polar | | | Elliptical | |
| Launch Date | 1980s | 1995 | 1998 | 1996 | | | | 1996 |
| Service Date | 1988 | 1996 | 1999 | 1998 | 1997 | | | 1997 |
| Freq Band | L-Band | L-Band | L-Band | L-Band | L-Band | L-Band | L-Band | UHF, VHF |



| SYSTEM | INMARSAT M | MOBILSAT | ODYSSEY | IRIDIUM | GLOBAL- STAR | ARIES | ELLIPSO | ORBCOMM |
|---------------------|-------------|-------------|---------------|-----------------|-----------------|-------------------|-----------------|----------------------|
| Frequencies | 1.6 GHz | 1.6-1.7 GHz | 1.6, 2.4 GHz | 1.6, 2.4 GHz | 1.6, 2.4 GHz | 1.6, 2.4 GHz | 1.6, 2.4 GHz | 137, 149, 400 MHz |
| Access Method | FDMA | FDMA | FDMA/ CDMA | FDMA/ TDMA | FDMA/ CDMA | CDMA | CDMA | |
| Latency (2-way) | 500 ms (rt) | 500 ms (rt) | ~120 ms (rt) | ~10 ms (rt) | ~10 ms (rt) | | | ~10 ms (rt) |
| Price (Handheld) | \$20-30,000 | \$2-4,000 | \$250-450 | \$200- 2000 | \$700-1000 | \$1500 | \$600 | \$50-350 |
| Price (Airtime) | ~\$5.50/min | \$1.50/min | \$0.65/min | \$3.00/min | \$0.30/min | \$30.00/ month | \$0.50/min | \$50.00/month |

