

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



Mobile Satellite Systems

- 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 terrestrial infrastructure: ocean areas, developing countries

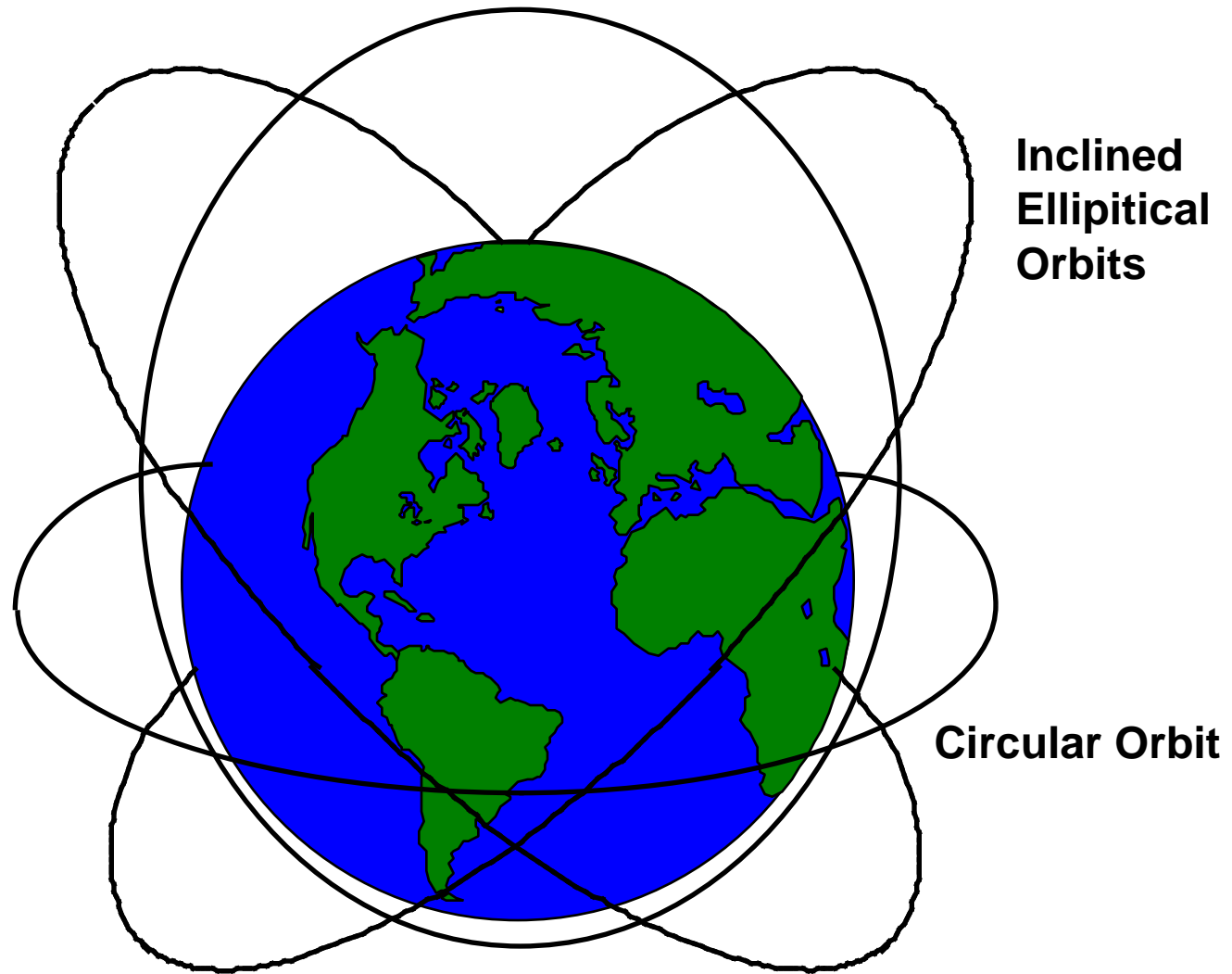


Mobile Satellite Systems

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



Orbits



**Inclined
Elliptical
Orbits**

Circular Orbit



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 equatorial 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**



Mobile Satellite Systems

SYSTEM	INMARSAT M	MOBILSAT	ODYSSEY	IRIDIUM	GLOBAL-STAR	ARIES	ELLIPSO	ORBCOMM
Applicant	Comsat, etc.	AMSC	TRW	Iridium, Inc.	Loral Qualcomm	Constellation	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	Constellation Comms	Harris, Fairchild	Champion, etc.
Type of Portable Formfactor	Briefcase	Pocket Telephone	Pocket Telephone	Pocket Telephone	Pocket Telephone			Handheld Data Terminal
Fixed Infrastructure Needed	Gateways	Gateways	Gateways	Gateways	Gateways			Gateways
Comm Type	Digital	Digital	Digital	Digital	Digital			Digital
Geographic Coverage	Worldwide	N. America	Worldwide	Worldwide	Worldwide			Worldwide



Mobile Satellite Systems

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



Mobile Satellite Systems

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

