An Introduction to Satellites

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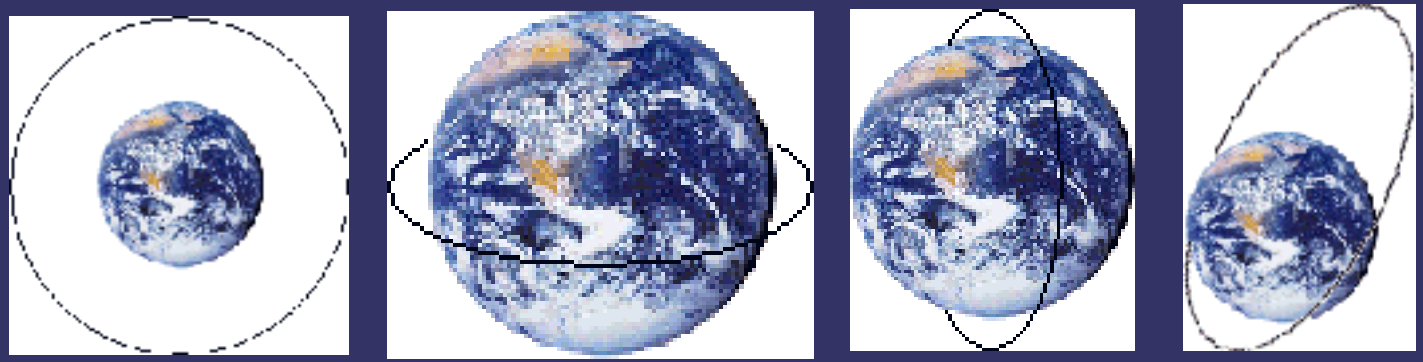
SIGMil 10/08/05

Overview

- Background Info
- Finding Satellites
- Playing with a few
- Amateur Satellites
- Communications Satellites
- Weather Satellites

Satellite Orbits

- GSO + GEO 36000km 24 hr period
- LEO 300-1000km 90 min.
- MEO
- HEO
- ELL
- Inclination/Eccentricity



Types

- Weather
  - Imaging
- Communications
  - Telephone Circuits
- Applications
  - Internet/Television/Radio
  - Voice/Data/Messaging
- Navigation
  - GPS
- Earth Observation
  - Imaging/Mapping
- Educational/Experimental

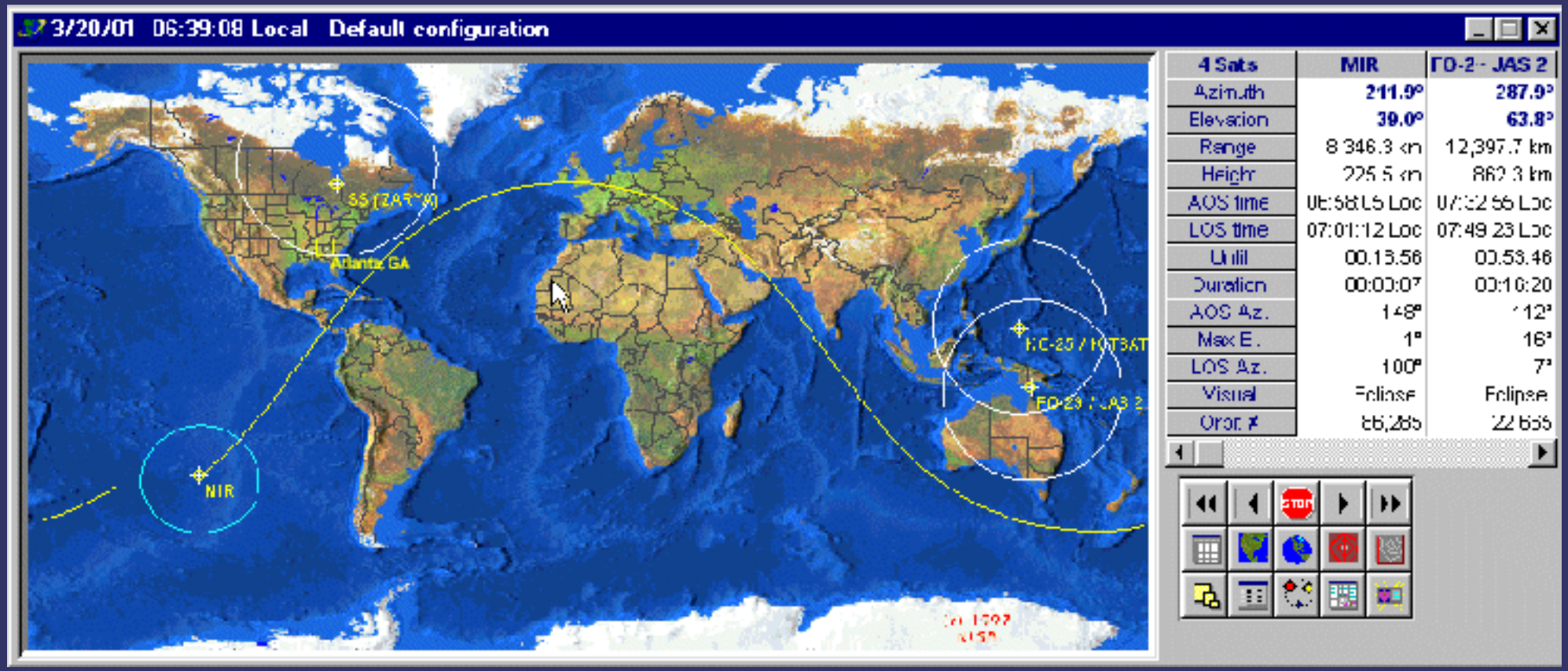
Finding Satellites

- Space Surveillance Network
  - NORAD's US Space Command
    - 24 sites worldwide
    - Radar and Optical
    - Catalog all objects > baseball
    - 8,500 actively tracked, 600 are operational satellites
  - Records
    - International Designation
      - YEAR-LAUNCHNUMBER-PIECE
    - NORAD Catalog Number
    - Keplerian Elements
  - Publicly accessible!
    - http://www.space-track.org + http://celestrak.com/

Satellite Tracking

- Keplerian Elements
- Tracking Programs
  - Linux
    - predict
    - gpredict
    - ktrack
  - Windows
    - Nova
    - Orbitron
  - Online
    - Jpass and Jtrack by NASA

Nova Demo

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NASA (2-line) format
AO-07
1 07530U 74089B   05278.76369668 -.00000028  00000-0  10000-3 0 04930
2 07530 101.6139 322.6547 0012204 021.1380 339.0194 12.53570782413503
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Amateur/Educational Satellites

- AMSAT
- University Projects
- CubeSat

AMSAT (Organization)

- Amateur/Ham radio
  - Build satellites
  - Frequency coordination
    - Anything in space on ham radio bands
  - Provide up-to-date information
- Over 35 years at least 50 such satellites
  - 17 currently operational at various levels
  - Voice on ISS
  - PACSAT/BBS type systems
  - Pull down telemetry
  - APRS
- How to find/use one?

AMSAT as information source

AMSAT-OSCAR 51 (Echo or AO-51)

Analog Uplink	145.920 MHz FM (PL - 67Hz) 145.920 MHz FM QRP (no PL) 1268.700 MHz FM (PL - 67Hz)
Analog Downlink	435.300 MHz FM 2401.200 MHz FM
PSK-31 Uplink	28.140 MHz USB
Digital Uplink:	145.960 MHz 9600 bps, AX.25 1268.700 MHz 9600 bps AX.25
Digital Downlink:	435.150 MHz 9600 bps, AX.25 2401.200 MHz 38.400 bps AX.25
Broadcast Callsign	ECHO-11
BBS Callsign:	ECHO-12
Launched	June 29, 2004

Status: Operational

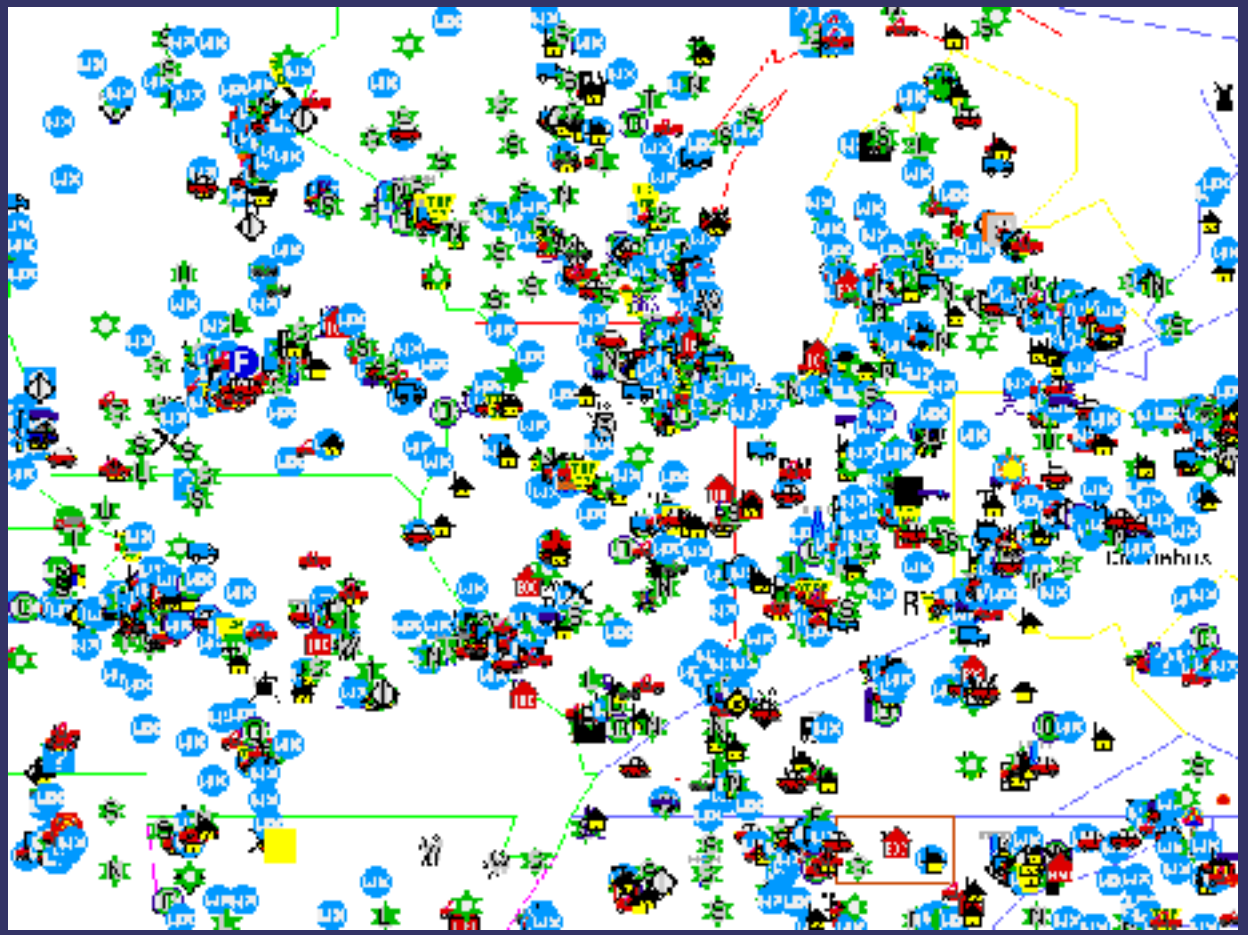
AMSAT-OSCAR 51 or Echo as it is more commonly known is a FM satellite carrying 4 VHF receivers, 2 UHF transmitters, a multimode receiver and a 24-GHz transmitter. It can handle voice and FSK data up to 76.8Kbps. Echo was launched in a low, sun synchronous polar orbit approximately 850 km high. You must transmit a 67 Hz PL tone in order to access the Echo voice repeater.

Please note the change in operational phone downlink frequency to 435.300 MHz

For more information, see

- The Echo Project Page
- The Echo Schedule and News

APRS over AMSAT Sats

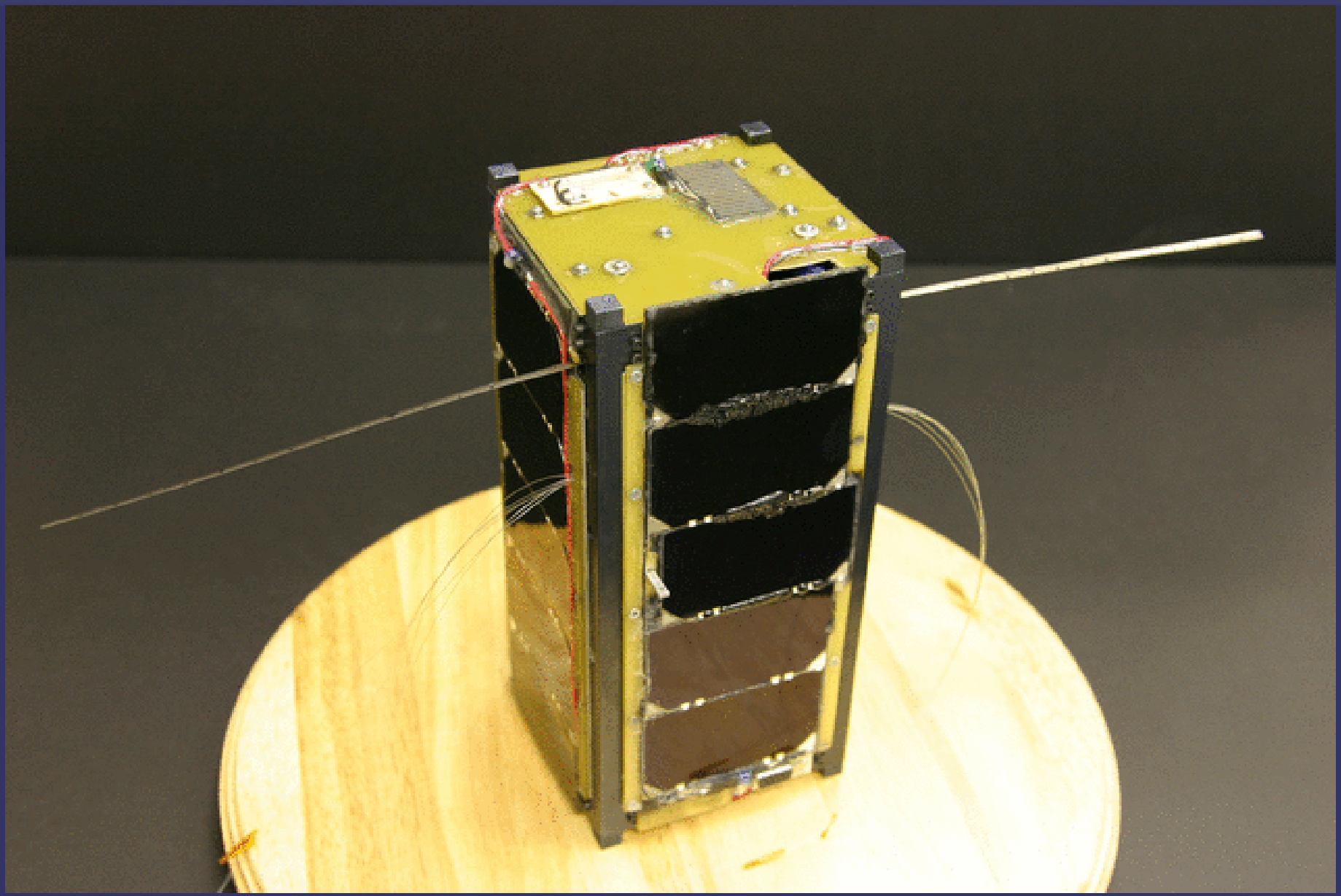


Cubesat

- “Nano”/”Pico”/”Micro” Satellites
- Cubesat is Mechanical Specification
  - Stanford + Cal Poly
  - Single Cube: 1kg 10cm x 10cm x 10cm
- Anybody can build and launch their own
  - At least 6 such cubesats floating around
    - University projects
    - Industry Research projects
  - At least 15 more on the way...
- Arrange integration and launch coordination
  - Find rides DNEPR, SpaceX, NASA...
  - DNEPR 2005 is 40,000 USD /kilo
- UIUC has one, designing a second

Mike's Satellite

- Sitting on ground...
  - January 2006 from Kazakhstan
- Onboard
  - Torque Coils
  - Thrusters
  - Camera
  - Photo Multiplier Tube
- Processing
  - 7 mhz RISC SBC, 1 MB RAM, 8 MB Flash
  - In house OS, Drivers, Comm Protocols, FS
- Communications
  - 2-watts 437.5mhz AX.25 1200 bps



How do I play?

- Lots out there to be played with...
  - All satellites on ham bands must be “open”
  - Security is an annoyance.... so no one does it
- Simple
  - Radio Scanner + Computer
  - Demodulation w/ soundcard+AX.25 in software
- Medium
  - 2-way radio 100-200 MHz & 400-500 MHz
  - Directional antenna (rotor/hand)
  - Computer (Soundmodem or hardware TNC)
  - Technically ham license. (Easy)
- Keep in mind (~15 min) pass durations...

Old School Communications

- COMSAT (1964)
  - Communications Satellite Corporation
  - Results in
    - INTELSAT
      - Circuits for carriers
      - Series of INTELSAT Satellites
    - MARISAT
      - Services to navy and maritime
    - COMSAT
      - Television

Old School Communications

- INMARSAT (1976)
  - International Maritime Satellite Organization
  - Have 11 Satellites
  - Voice, Data, Messaging
    - Service sold as INMARSAT A, INMARSAT B....
  - Some service up to 144 kbps
  - Used by Boats, airplanes, journalists
- MSAT (LandSat/MarineSat)
  - Marine, Aeronautical, Fixed
  - Coverage limited to North America
  - 800 mhz

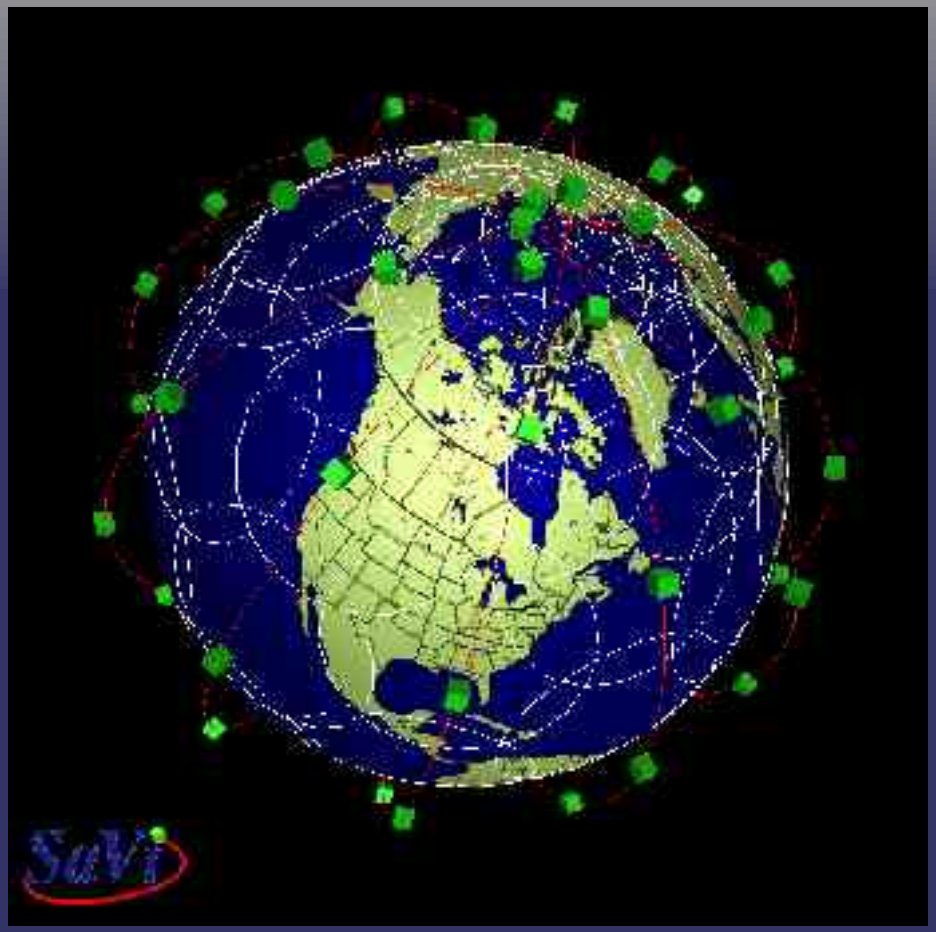

INFOSAT

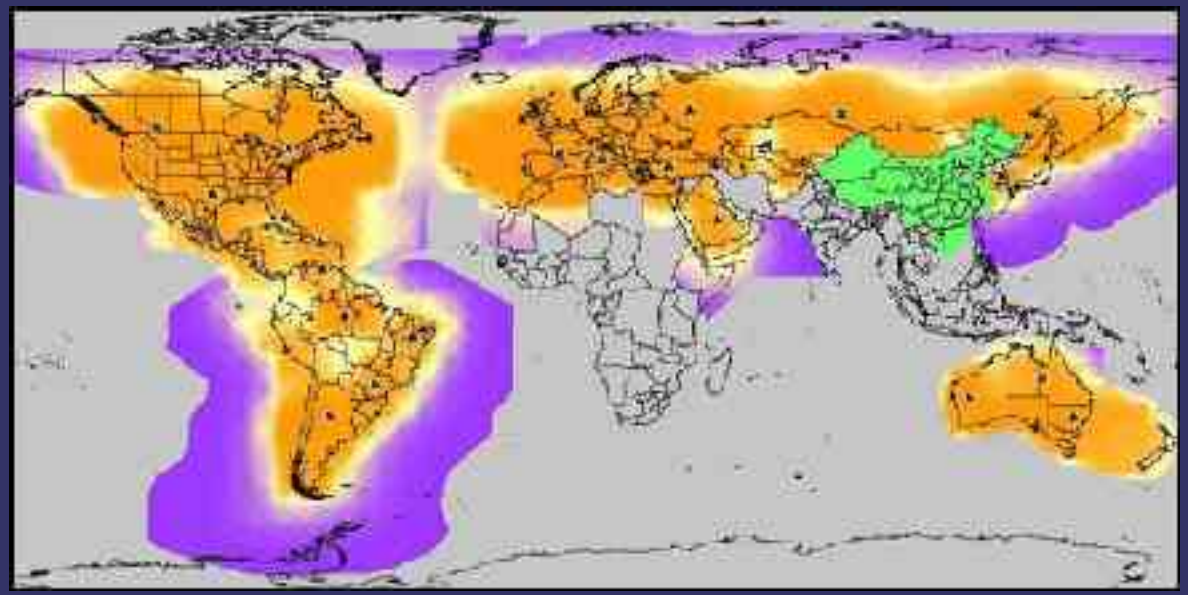
New School - Iridium

- Constellation of 66 LEO satellites (1998)
- Used heavily by Department of Defense
- 2400 baud voice/data
  - GSM for authentication
    - SIM Cards
  - Snooping seems hard
    - Signaling and vocoder proprietary
    - Frequency hopping
  - Routing
  - Iridium Security Modules
- Cost to you?
  - Phone ~1500 USD
  - ISM ~3000 USD
  - $1-$2/minute

New School - Globalstar

- Constellation of 48 LEO satellites
- Voice/Data/Messaging
  - 9600 bps
  - CDMA
- Satellites simply act as bent pipes
  - Needs ground station
- Cost to you?
  - Phone ~650 USD
  - 0.15-1.50 per minute
- Combo phones
  - Satellite, CDMA 800, AMPS


SuVi

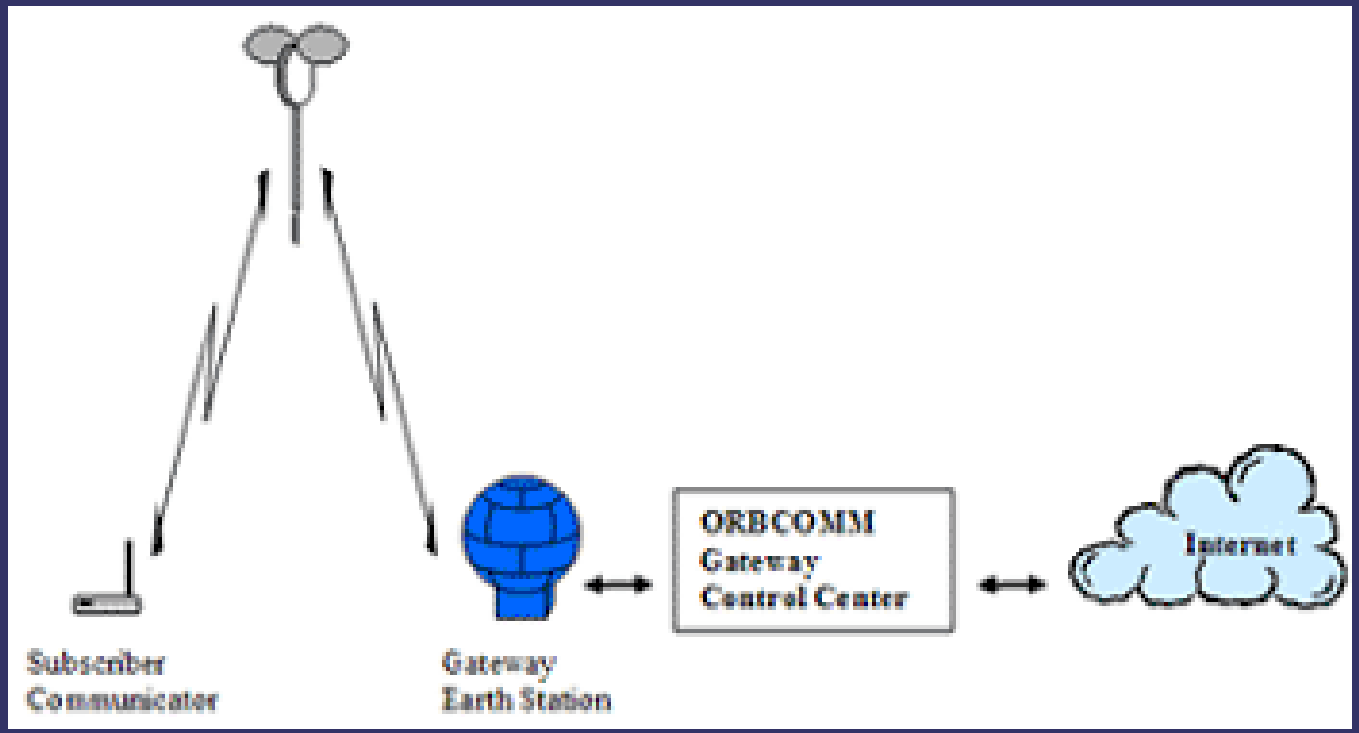


ORBCOMM

- Low bandwidth messaging services
  - 2-way paging for space
- ~30 Sats in LEO Orbit
  - Terminals
    - 800-1200 USD
    - 5 Watts VHF
    - Uplink 2.4 kbps 148-150mhz
    - Downlink 4.8 kbps 137-138 mhz
    - Satellite control somewhere in 400 mhz...
- Huge amount of resellers
  - Interesting partnerships with VeriChip
  - Not car tracking/onstar though....

Playing with ORBCOMM?

- Snooping should be easy...
- Interfaces to GCC
  - SMTP, Web, “Internet”, Leased Line, Dial-up



Weather

- NOAA
  - GOES 9, 10, 12
  - NOAA 12,14,15,16,17,18
  - Constantly streaming data
  - Services
    - Automated Picture Transmission (APT)
    - Weather Facsimile (WEFAX)
    - High Resolution Picture Transmission (HRPT)
  - Receive data yourself
    - APT at ~137 MHz is easiest
    - Radio scanner
    - Software


NOAA 18

There's MUCH more

- AMSAT, Communications, Weather
- Very very small sample of what's up there
  - Satellite Radio
  - MPEG TV
  - DSS TV/Internet
- All been from user view
  - But these satellites have UL/DL's for control...
- Future seems to be in Application + Small Satellites