



# SATCOM-SIG Workshop

*Proceedings of The SDR09 Technical Conference  
and Product Exposition*

3 December 2009

Bob Schutz  
SDRF SATCOM-SIG Chair





Dawn of the Space Age – Sputnik October 1957  
First Manmade Satellite to Orbit the Earth



Most distant spacecraft to leave our solar system –  
Voyager-1 September 1977



## ICO Satellite Launched April 2008



# SATCOM-SIG Workshop Agenda

## Session 1: Architectures for SATCOM Systems – Commercial & Defense

- “The Inmarsat Roadmap for SDR in Future Mobile Satellite Terminals” – Eyal Trachtman
- “NASA CONNECT Project” – Thomas Kacpura
- “Converging MILSATCOM with the GIG” – Llewellyn (Don) Means
- “Government Reference Architecture (GRA) for SATCOM Terminals” – Thomas Rittenbach

## Session 2: SATCOM Systems and Implementations

- “Adaptive Architectures for Space Based Communication Systems” – Dr. Vince Kovarik
- Exploiting the Link: Improving CubeSat Communications through the use of Software Defined Radios” – Prof. James Cutler
- “SDR and CR in Satellite Communications” – Claus Krohn Vesterholt and Cyrus Sy

## Panel Discussion: Satellite Communications and the SDR Forum.

# Why a SATCOM-SIG?

## **Address the unique constraints imposed on Satellite Communications**

- Both physical and man made

## **Exploit the unique benefits Satellite Communication with Software Defined and Cognitive Radio technology**

**As scientist we know we are constrained by the  
laws of physics - As engineers we know we can  
often select which of those laws constrain us**

# Communications

## **George Bernard Shaw**

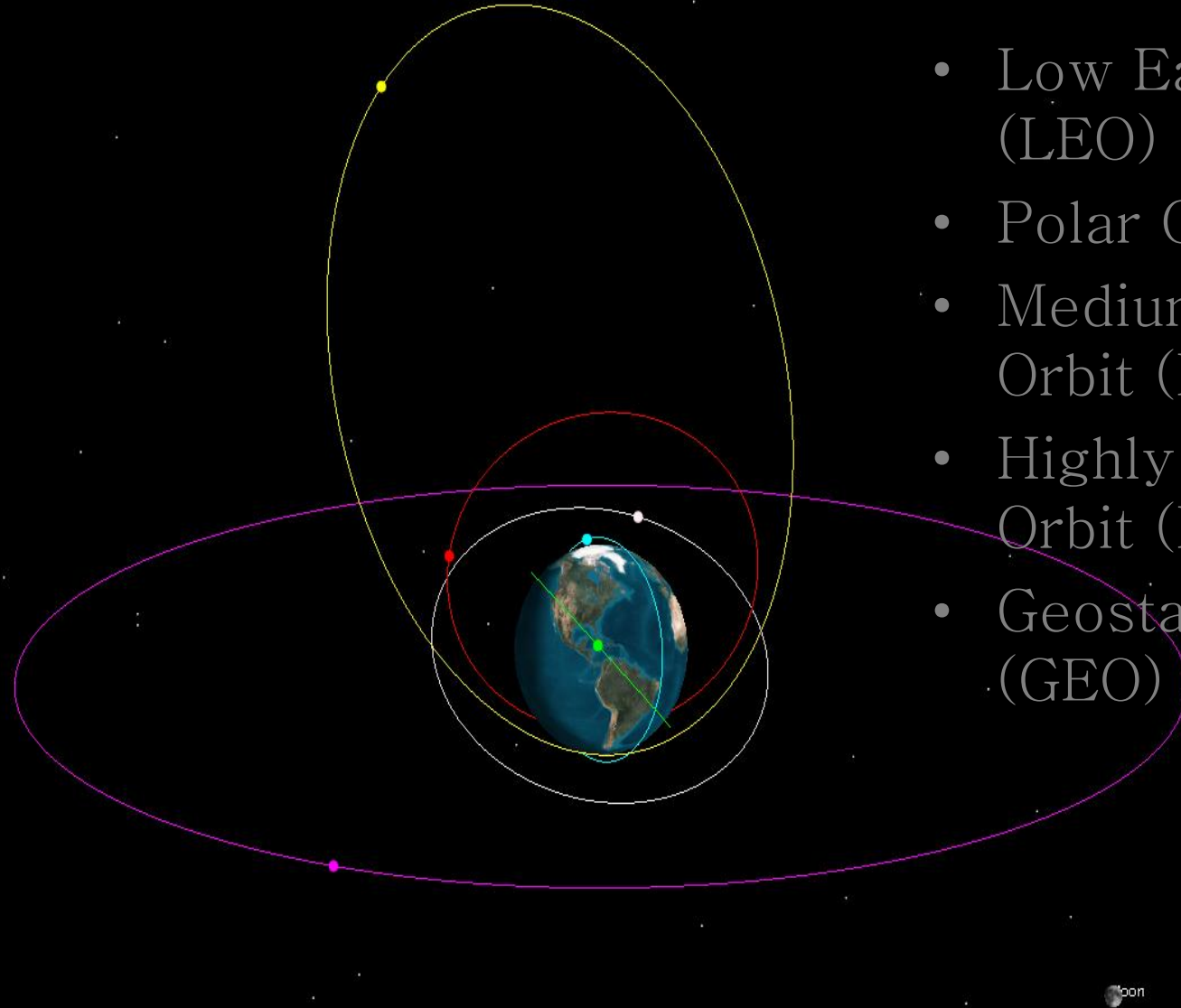
“The problem with communication...  
is the *illusion* that it has been  
accomplished.”

## **Robert McCloskey**

“I know that you believe you understand  
what you think I said, but I’m not sure  
you realize that what you heard is not  
what I meant.”

## **- Communication -**

Communication only occurs when  
information is understood.

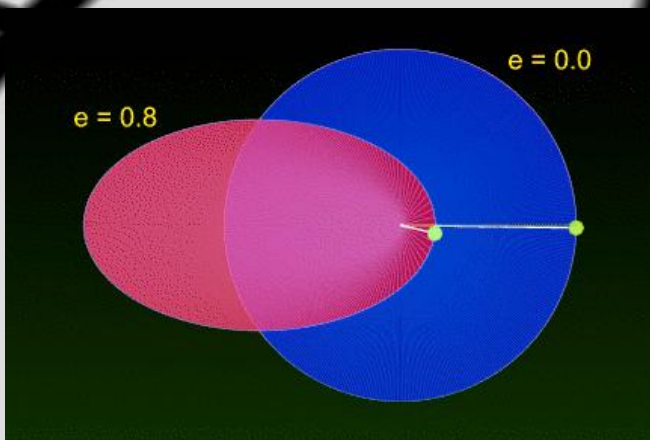
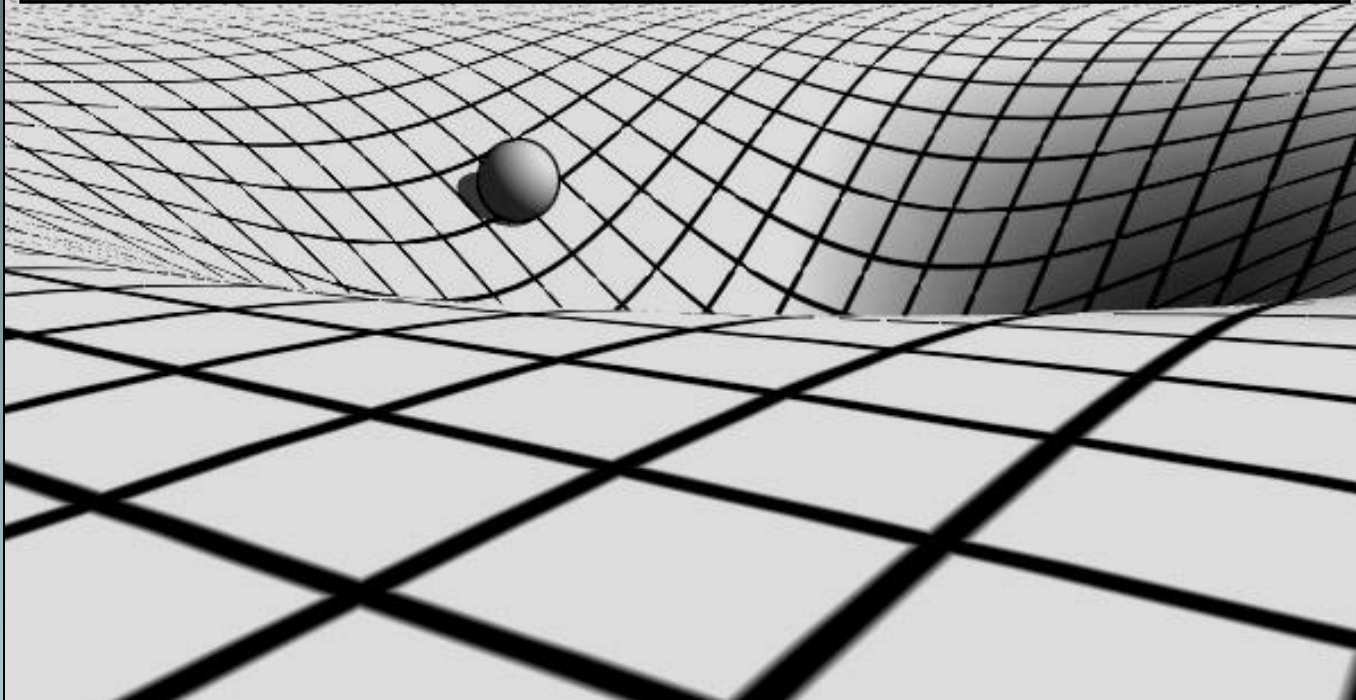


- Low Earth Orbit (LEO)
- Polar Orbit
- Medium Earth Orbit (MEO)
- Highly Elliptical Orbit (HEO)
- Geostationary (GEO)

# Introduction to Orbits



# Geodesics: The Science and Art of 4D Curved Space Trajectories.



All objects in motion conserve momentum through a balance of

Gravity Potential  
and  
Velocity Vector

(think rollercoaster)

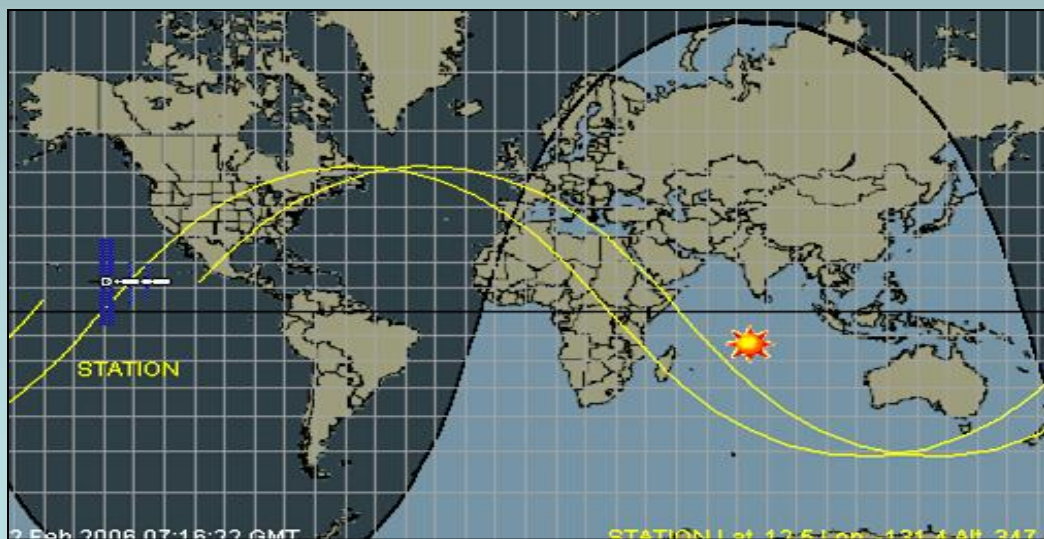
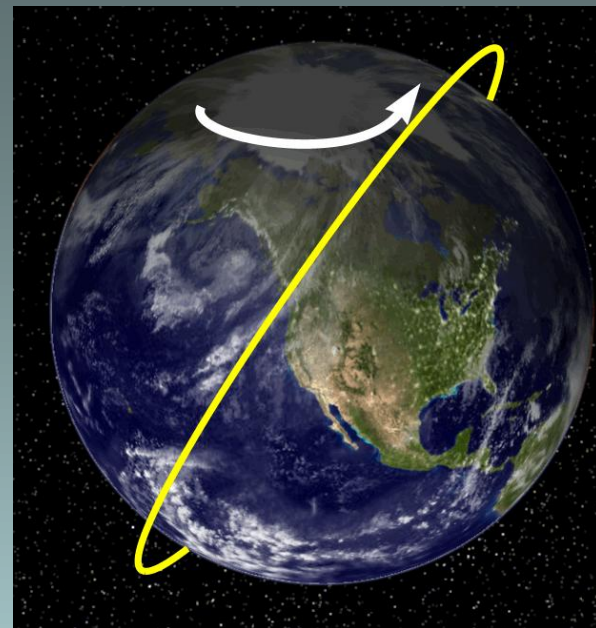
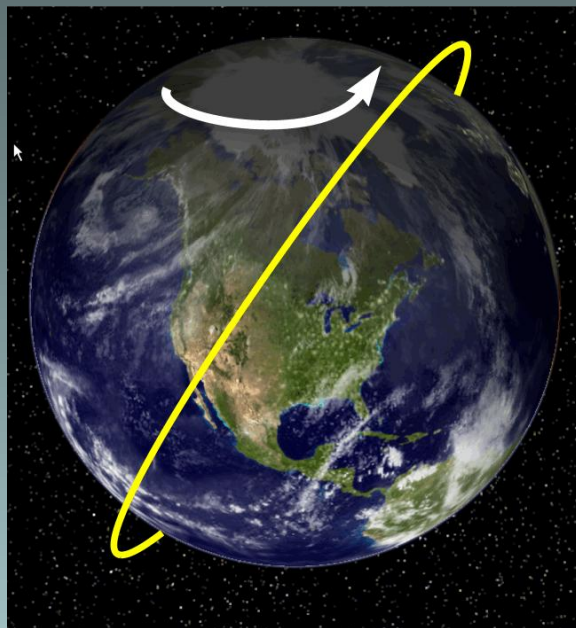
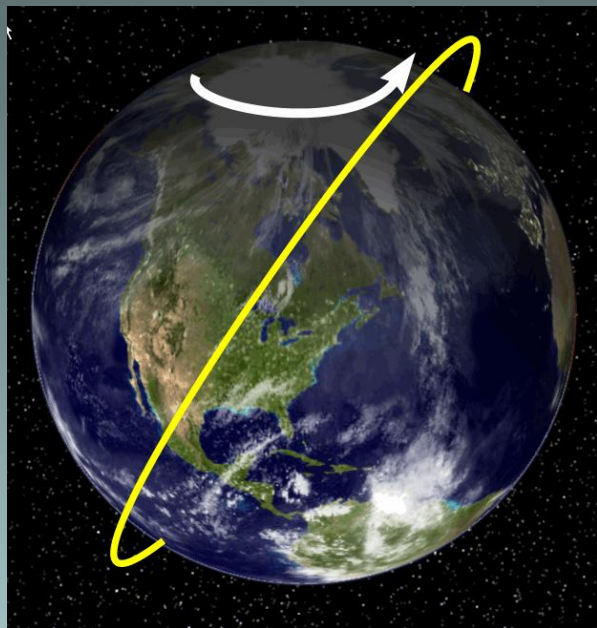
## Kepler's Second Law

A line between an orbiting body and primary body sweeps out equal areas in equal intervals of time.<sup>9</sup>

# Low Earth Orbit (LEO)

- No specified cut-off altitude, but LEOs orbit relatively close to the earth (several hundred km).
- LEO orbits are characterized by short orbital periods (roughly 90 minutes), many revolutions per day and limited swath areas (what the satellite can see) on the Earth's surface.
- All manned space missions except for the lunar missions have been LEO.
- Many Earth-observing satellites are in LEO orbits.

# LEO Ground Tracks

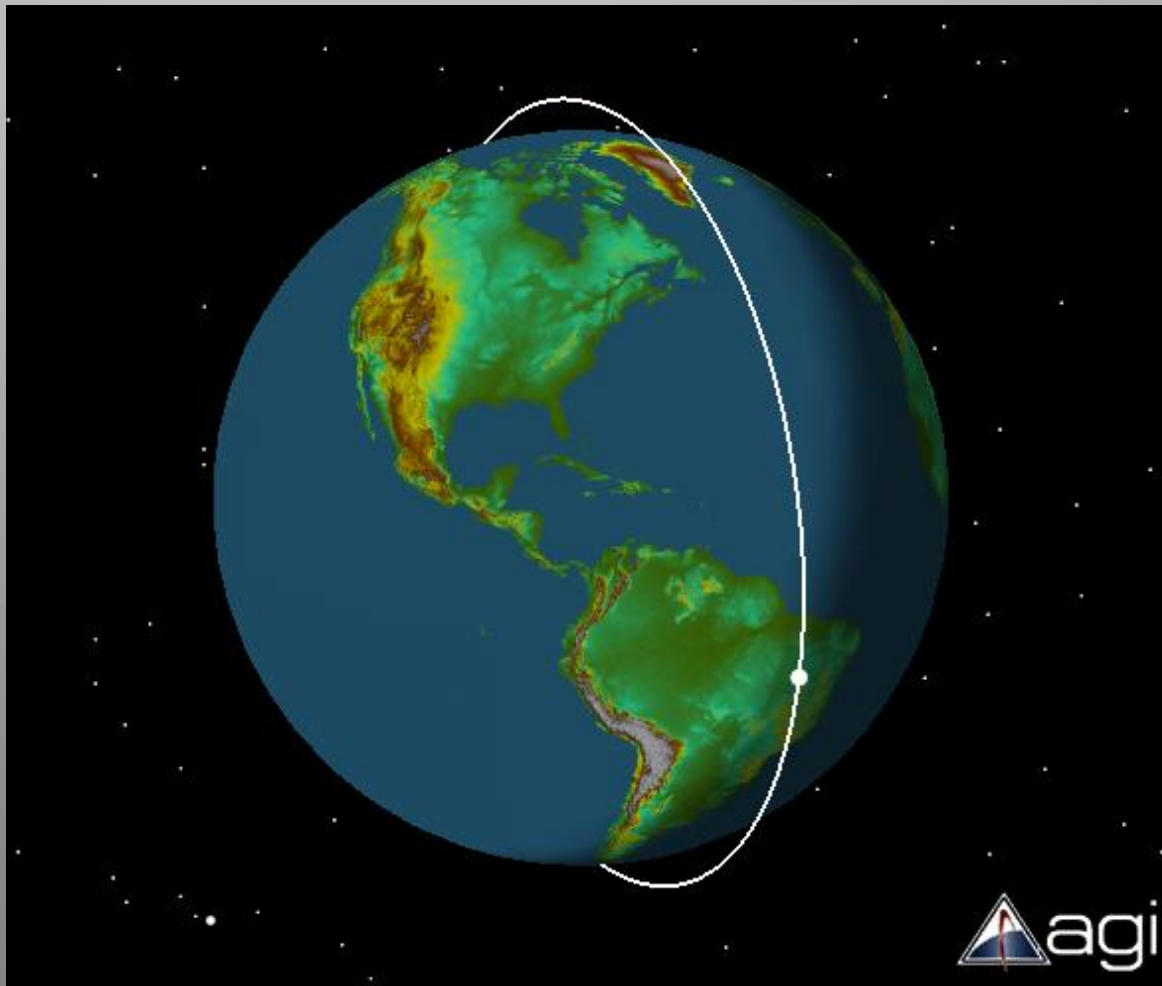


**Ground tracks drift westward as the Earth rotates below an orbit.**

**Each orbit type has a signature ground track.**

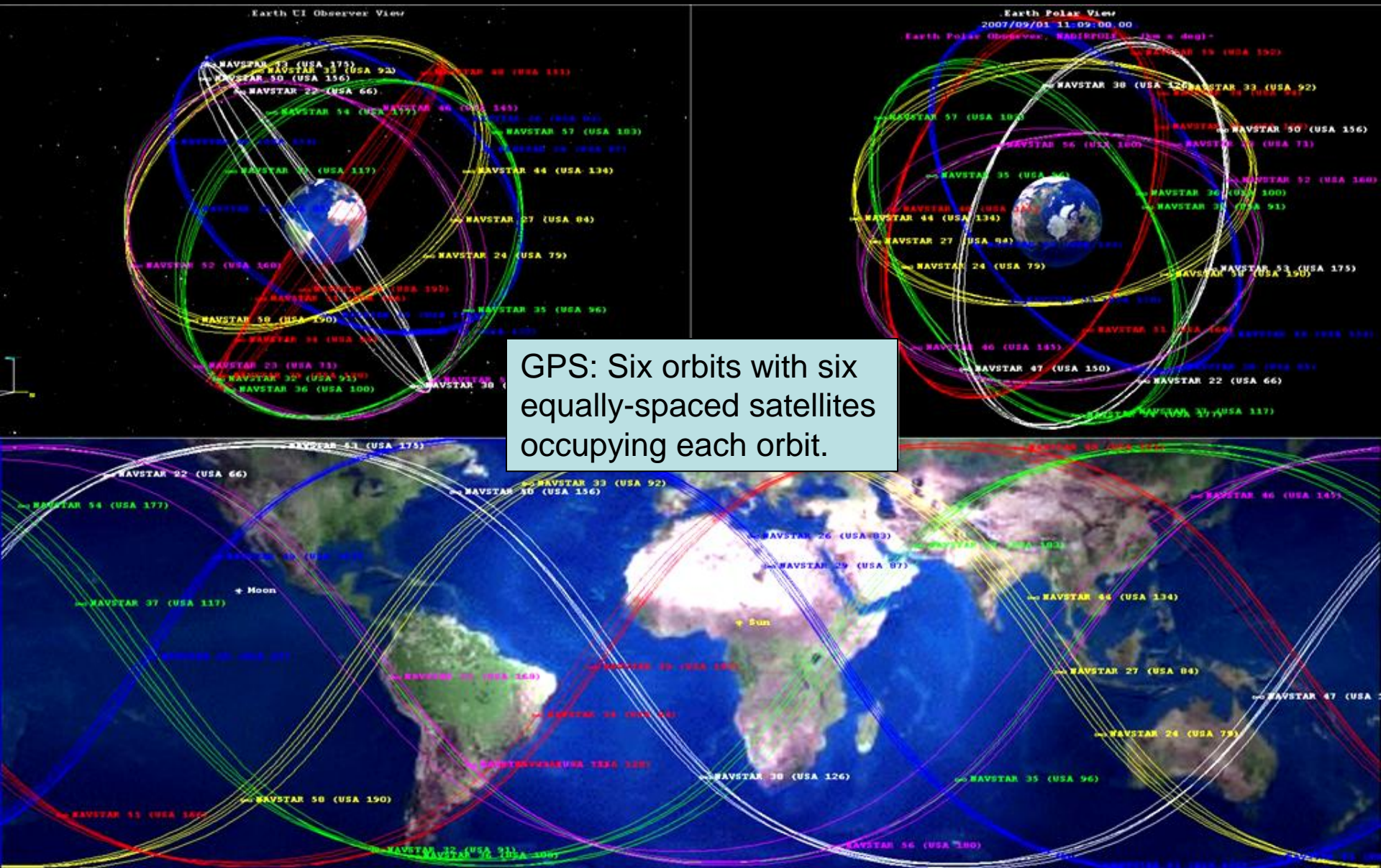


# Polar



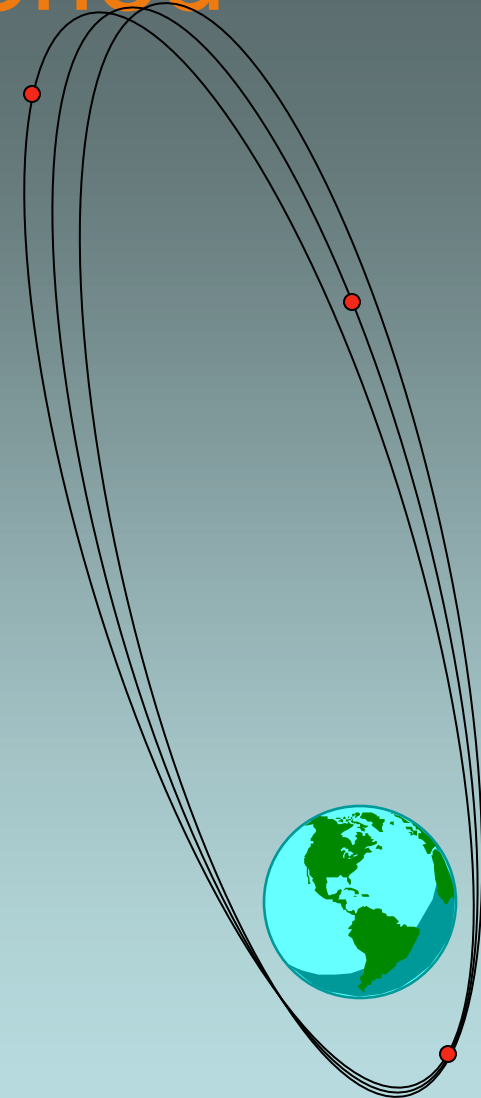
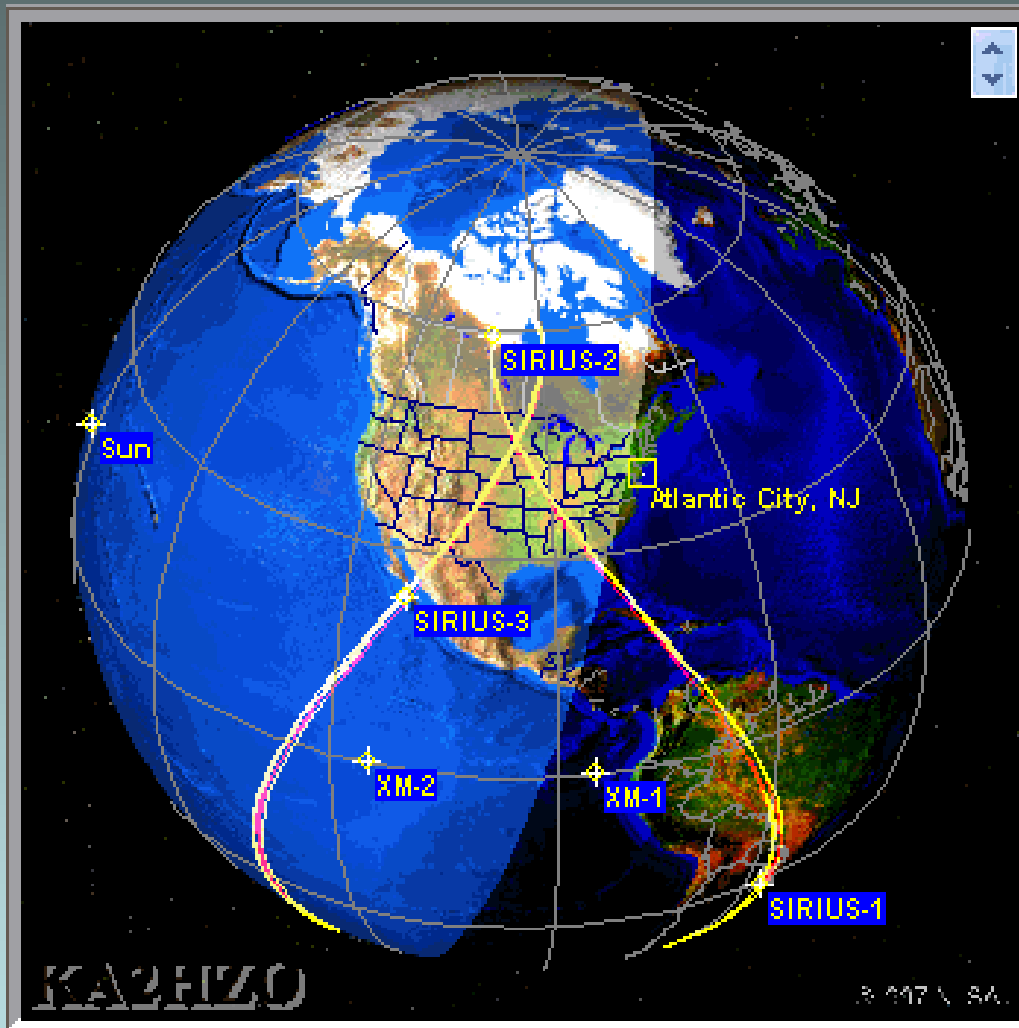
- Because the inclination of a polar orbit is 90 degrees, a satellite in polar orbit will eventually pass over every part of the world.
- This makes polar orbits well suited for satellites gathering information about the Earth, such as weather satellites.

# GPS Constellation ~ 20200km alt.



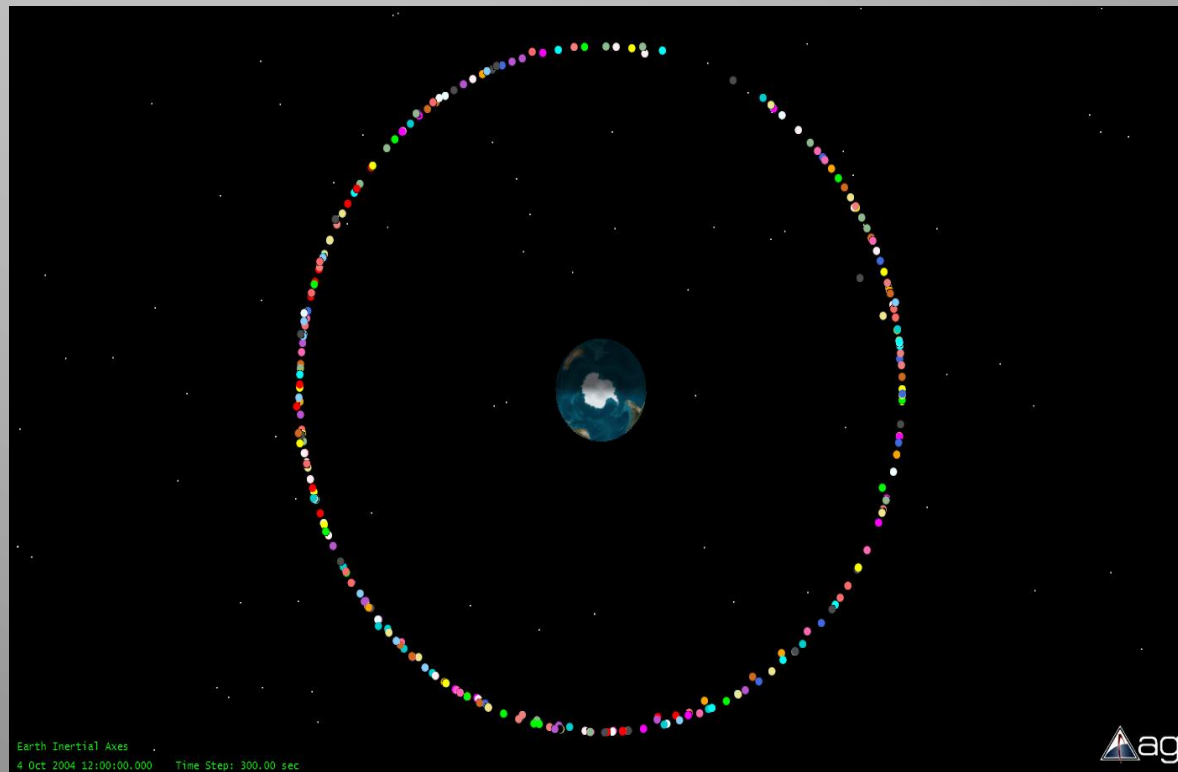


# 'Tundra' Orbit - 24hr Period



Elliptic Orbit to allow the Satellite to dwelling over a specific upper latitude (Used only by Sirius)

# Geostationary (GEO)



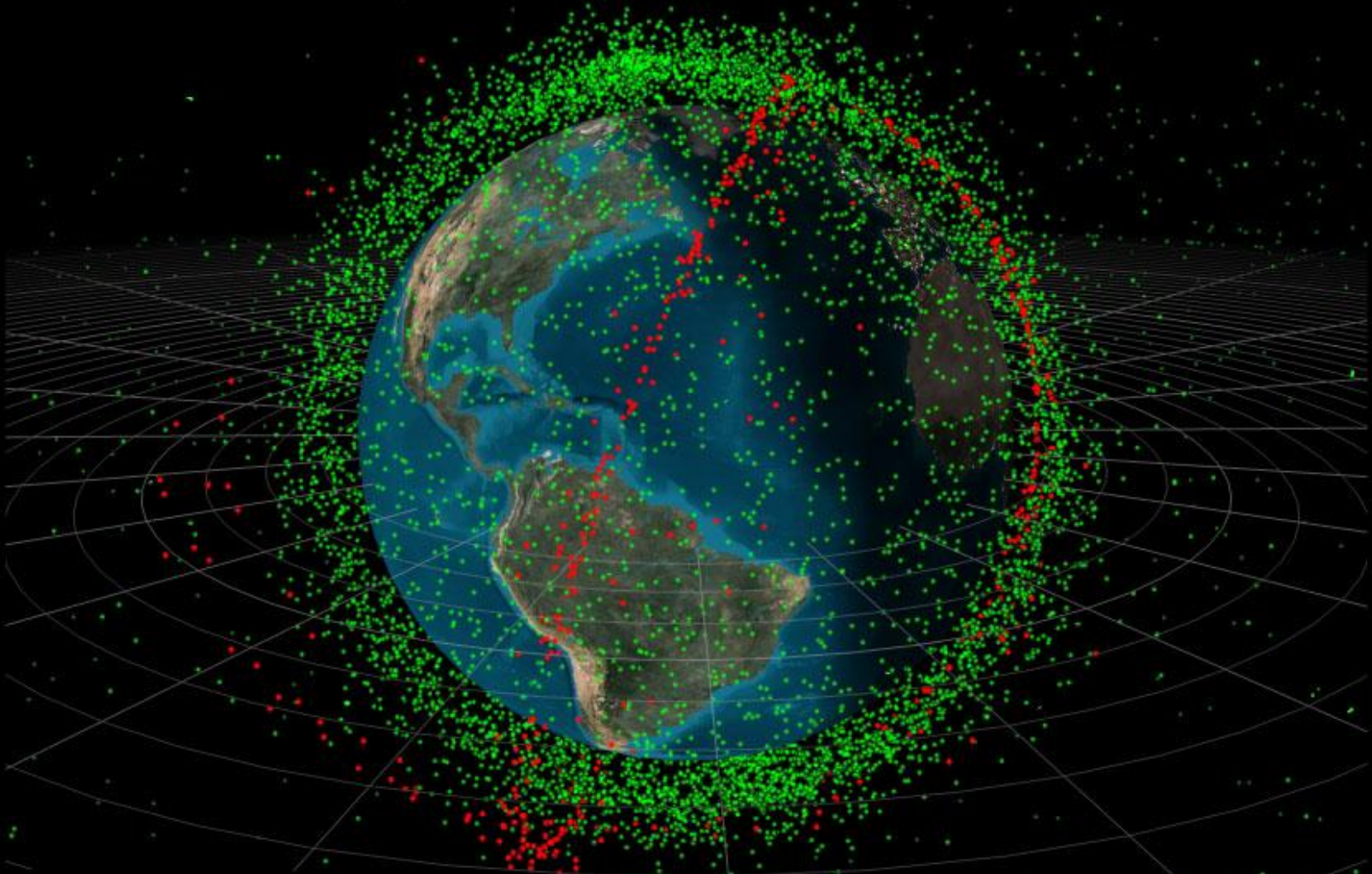
Since there is just one altitude above the earth for which the period of an orbit is 24 hours, all geostationary orbits are in a “ring” around the earth. This “ring” is

What’s in a name?

A **geostationary** satellite **stays in one spot** with respect to the **earth**. This is achieved by placing it at an altitude where its orbital period is exactly equal to one day (about 22,300 miles above the earth!) AND its inclination is <sup>15</sup> exactly zero

# Orbital Debris a.k.a., 'Space Junk'

February 2009 **Iridium / Cosmos** collision created > 1,000 items > 10cm diameter



Currently > 19,000 items 10cm or larger. ~ 700 (4%) functioning S/C.  
In as few as 50 years, upper LEO and lower MEO may be unusable.

# More Astronomy Facts



## The Sun

Drifts east in the sky  $\sim 1^\circ$  per day.  
Rises 0.066 hours later each day.  
(because the earth is orbiting)



## The Earth...

Rotates  $360^\circ$  in 23.934 hours  
(Celestial or “Sidereal” Day)  
Rotates  $\sim 361^\circ$  in 24.000 hours  
(Noon to Noon or “Solar” Day)

**Satellites orbits are aligned to the  
Sidereal day – *not* the solar day**

# Orbital Perturbations

**“All orbits evolve”**

## **Atmospheric Drag** (at LEO altitudes, only)

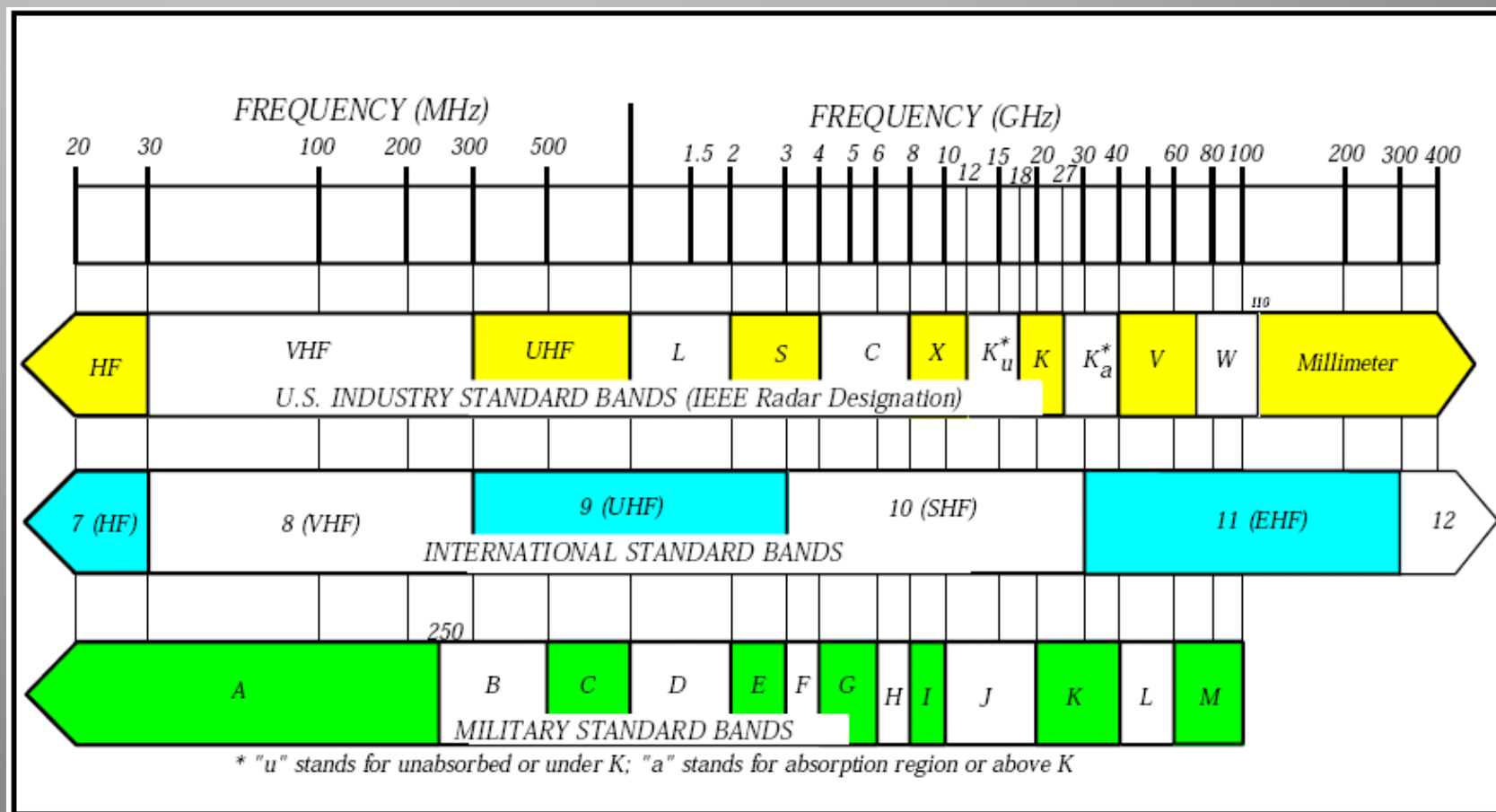
- Worse during increased solar activity.
- Insignificant above ~800km.

**Nodal Regression** – The Earth is an oblate spheroid. This adds extra “pull” when a satellite passes over the equator – rotating the plane of the orbit to the east.

**Other Factors** – Gravitational irregularities – such as Earth-axis wobbles, Moon, Sun, Jupiter gravity (tends to flatten inclination). Solar photon pressure. Insignificant for LEO – primary perturbations elsewhere.

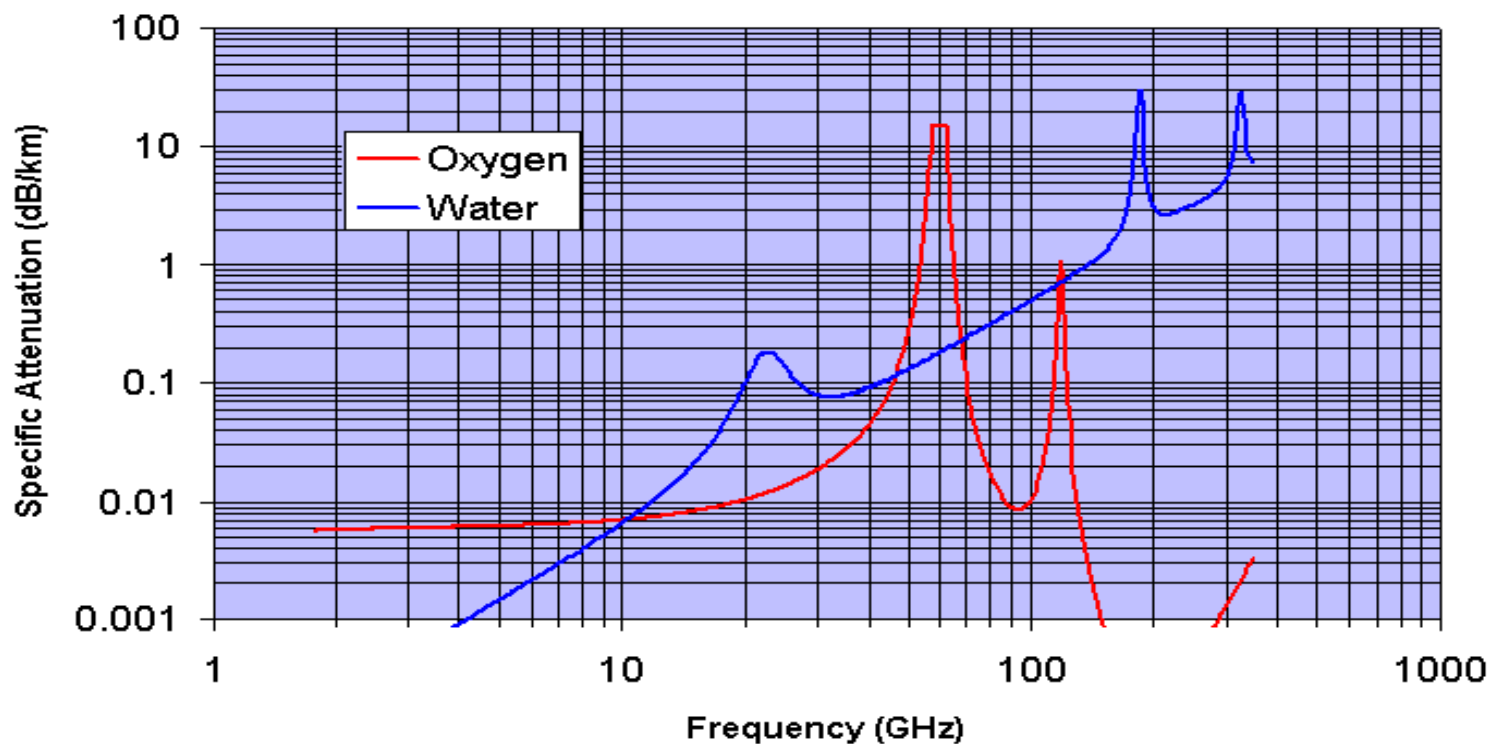


# Frequency Band Designation



# Atmospheric Absorption

**Specific Attenuation for Atmospheric Oxygen and Water Vapour**

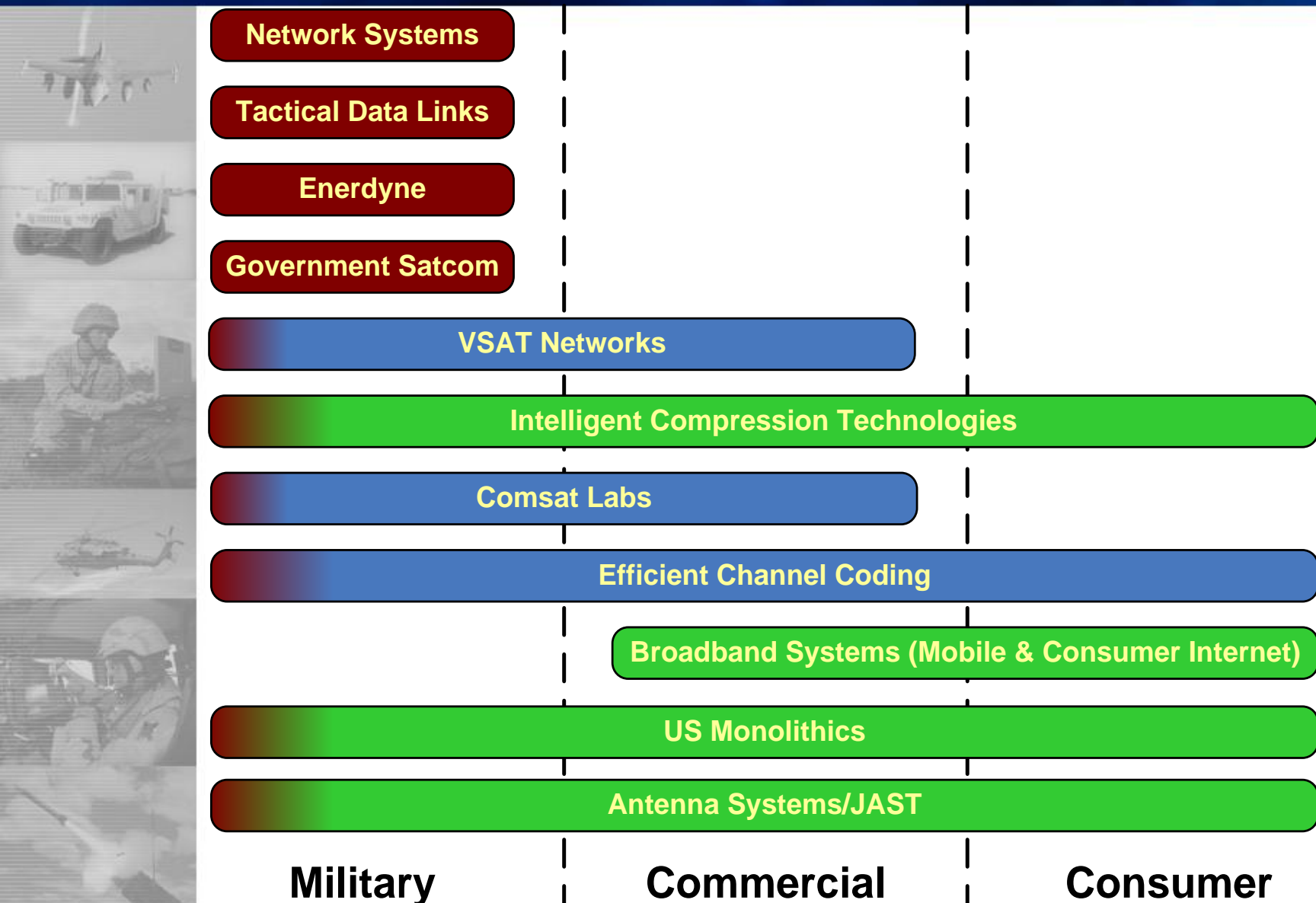


# ViaSat Overview

- **23 year growth & profitability**
  - Publicly Traded Co. as VSAT
  - Employ ~1800 people, 50% degreed engineers
  - 2009 Revenue of \$628+ million
- **Headquarters in Carlsbad, CA (San Diego)**
- **Division facilities near Atlanta, Boston, Baltimore and Washington DC**
- **Wholly Owned Subsidiaries**
  - US Monolithics - MMIC Based RF Products
  - Efficient Channel Coding - ASIC Dev.
  - Enerdyne - Airborne LOS Comms.
  - Intelligent Compression Technologies
  - JAST - Antenna Systems Dev.
- **Majority Owned Subsidiary**
  - Trellisware - San Diego, CA
- **Other offices in:**
  - ◆ Rome                      ◆ Beijing                      ◆ New Delhi
  - ◆ Spain                      ◆ Sydney                      ◆ Canberra
  - ◆ Tampa



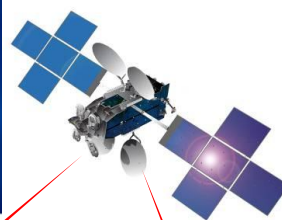
# ViaSat Business Mix



# Where does ViaSat fit in?

UNCLASSIFIED

**ViaSat.**



UHF Satcom  
Ku/Ka Satcom

Secondary  
Dissemination  
Satcom



GBS

LinkStar  
LinkWay  
JIPM  
ArcLight

Enerlinks  
CDL/TCDL

Antenna  
Systems

Link-16

UHF/VHF  
LOS

UHF/VHF LOS  
VDC – Tactical Networking  
Battle Stream Video  
Rover Appliqué

GIG/Network Security  
HAiPE (adapable and scalable)



# ***Selected for Best in Capacity!***

## **The Newest Standards in Satcom Networking**



**Point-to-Point**



**MIL-STD-188-165B  
Modem  
MD-1366 EBEM**



**Mesh – Any-to-Any**



**WIN-T & USMC SWAN  
LINKWAY S2**

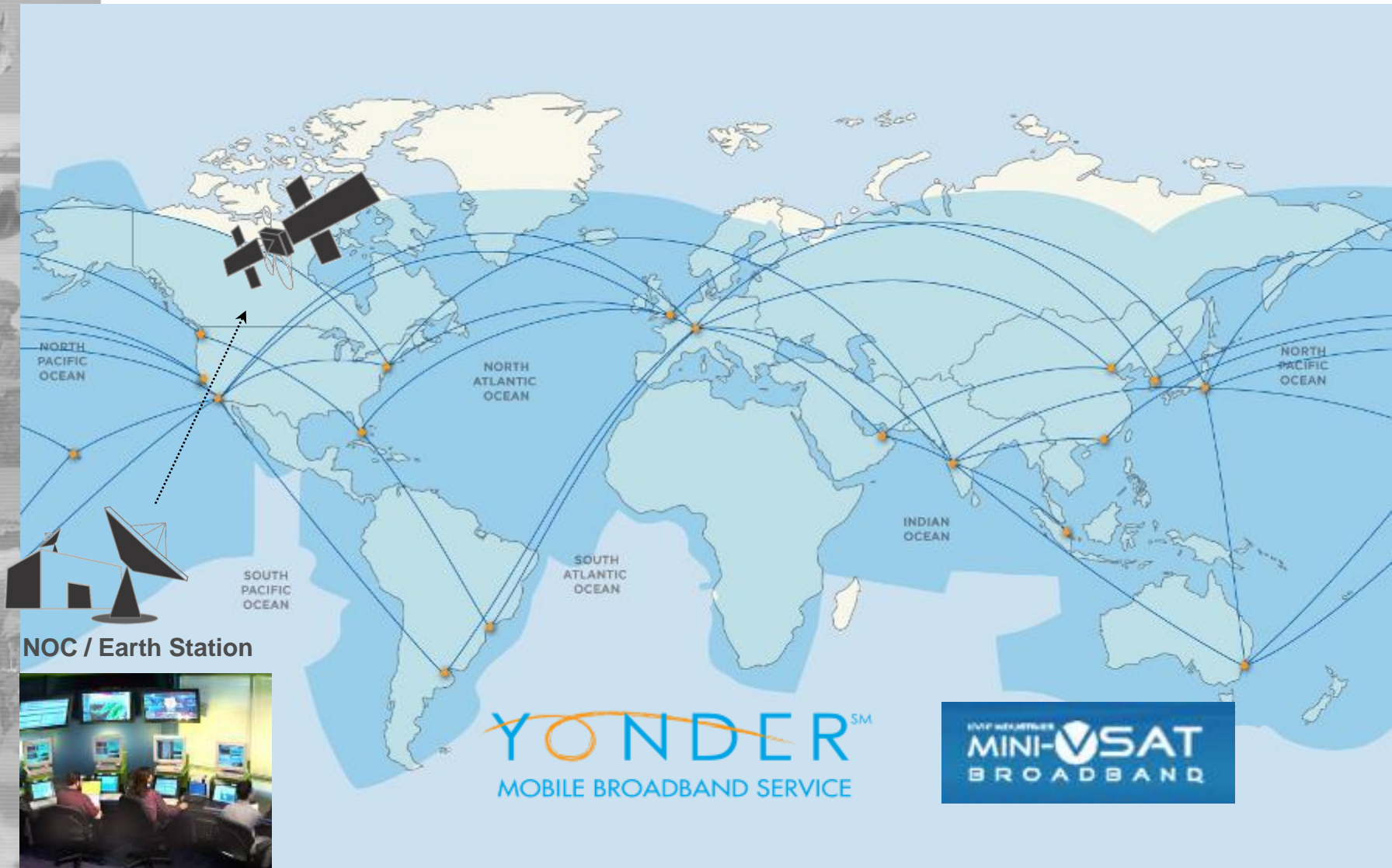


**Hub & Spoke (Client Server)**



**DoD Standard for IP  
Networks  
MD-1377 JOINT IP  
MODEM**

# Planned Service Coverage 2010





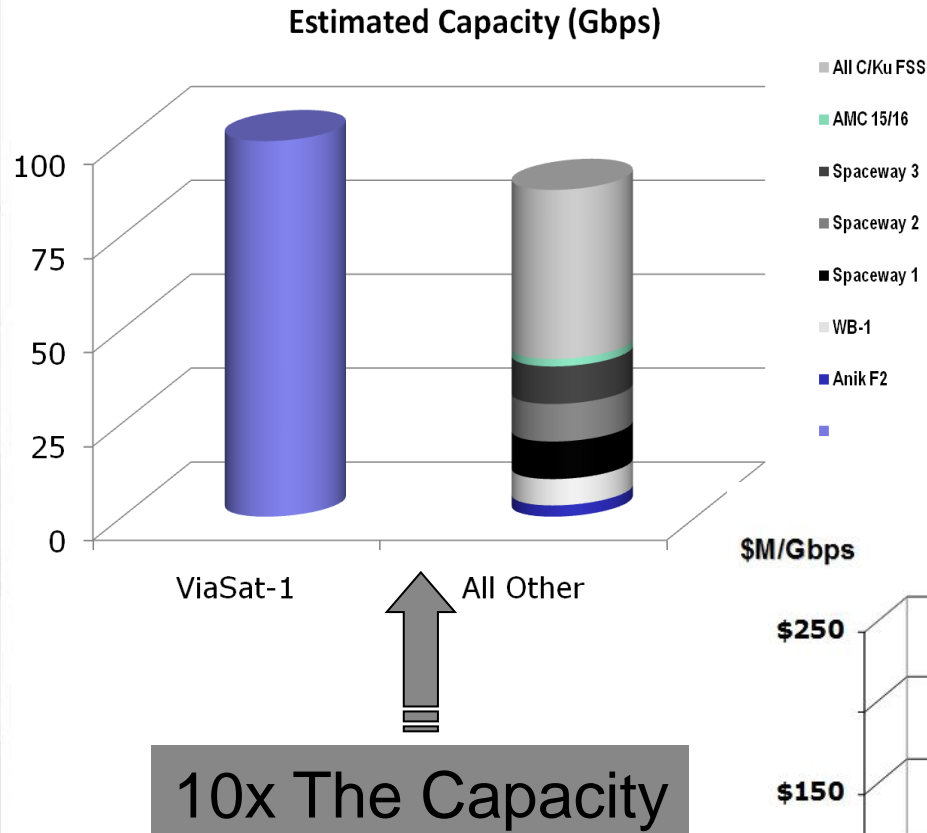
# ***High Capacity Ka-band Satellites***



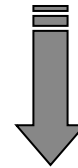
***Benefits from 3rd-G Broadband  
Ka-band Technology!***

# ViaSat-1

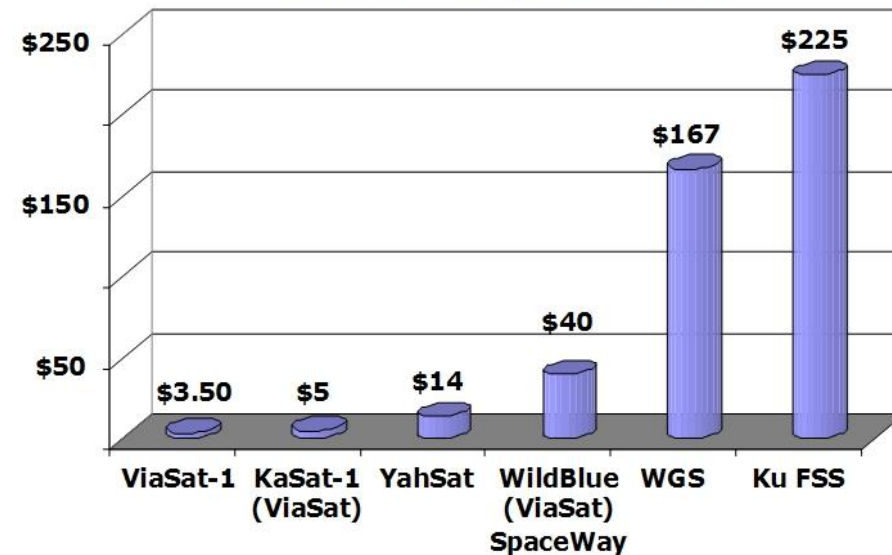
## Extraordinary Capacity: 'Bits in Space'...



**1/10th The Cost**



**Estimated 2-Way Bandwidth  
Capital Cost (Satellite on-orbit)**



# SATCOM-SIG Workshop Links

**SDR Forum:**

**SATCOM-SIG Workshop**

<http://www.sdrforum.org/>

[http://www.sdrforum.org/SDR09/satcom\\_workshop.html](http://www.sdrforum.org/SDR09/satcom_workshop.html)

**ViaSat:**

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[bob.schutz@viasat.com](mailto:bob.schutz@viasat.com)

**Inmarsat:**

<http://www.inmarsat.com/>

**NASA Connect:**

<http://www.nasa.gov/>

**DISA:**

<http://www.disa.mil/>

**CERDEC (GRA):**

<http://www.cerdec.army.mil/>

**CubeSat:**

<http://www.cubesat.org/>

**University of Michigan:**

<http://www.umich.edu/>

**Harris:**

<http://www.harris.com/>

**Gatehouse:**

<http://www.gatehouse.dk/>

**Spectrum Signal Processing:**

<http://www.spectrumsignal.com/>

**Analytic Graphics Inc:**

<http://www.stk.com/>

**Educational Alliance :**

<http://www.stk.com/partners/edu/>