



Embedded Computing *without* Compromise

COTS in Space!

Applications for Embedded Computing Products in Space

Embedded Tech Trends, January 2018



The Use of COTS Products in Space Applications

- ✦ What is Meant by “Space”
- ✦ Platform Applications That Reside Within This Market
- ✦ Earth’s Orbits Defined
- ✦ Known Issues & Misconceptions “Floating Around”
- ✦ Understanding the Needs of the Space Market
- ✦ So, What “Space COTS” Products are Available?

What is Meant by “Space”

Characterized as:

100 km Above
Earth’s Atmosphere



High Vacuum with
Particle Radiation
Solar Wind, Cosmic Rays...

Contains:

- Galaxies
- Stars (All forms)
- Planets/Moons
- Asteroids
- Comets
- Black Holes
- Gas Clouds
- High Energy
Particles, Heavy Ions
- Etc...

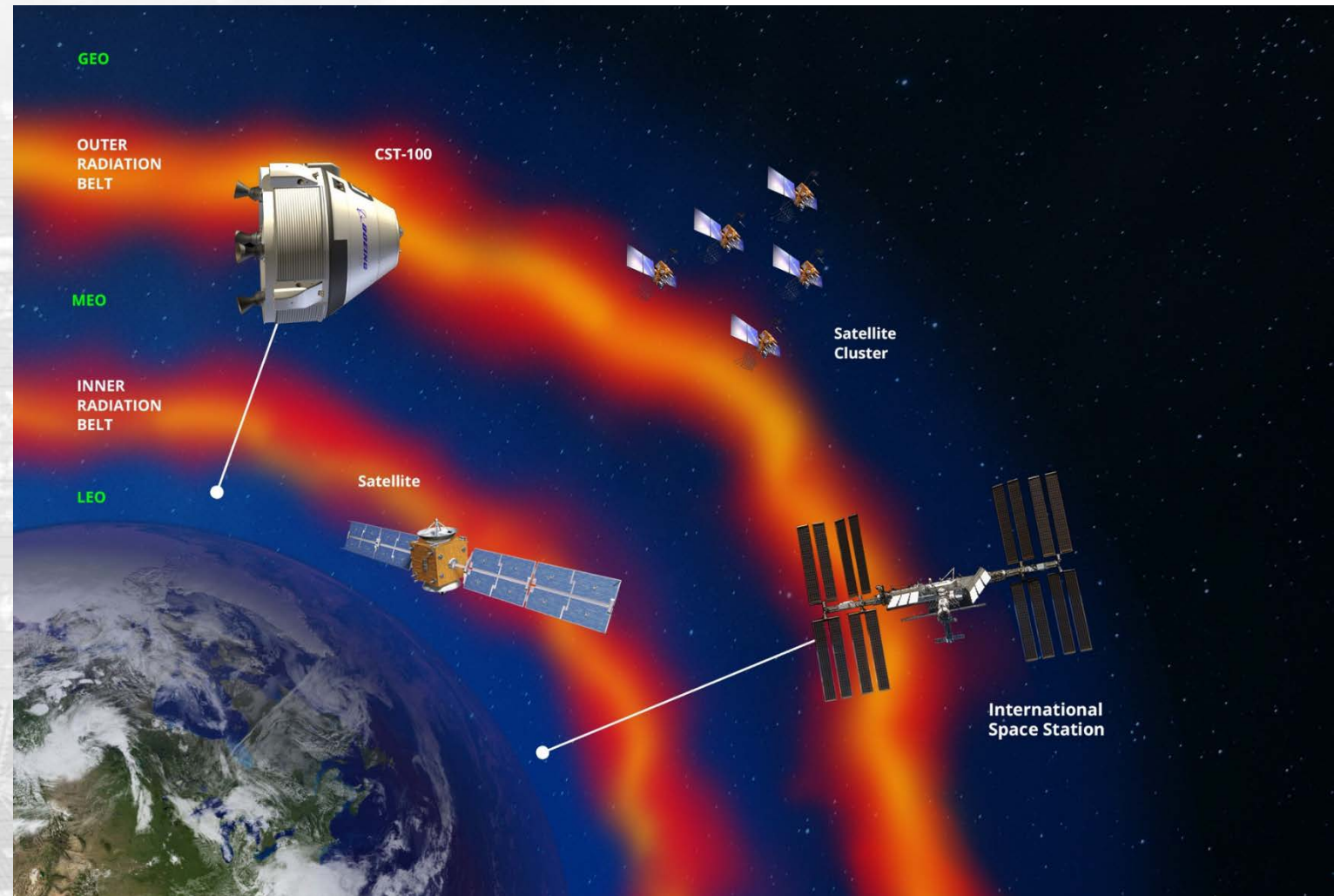
Platform Applications That Reside Within This Market

Manned and Unmanned Space Craft

Space Shuttle, Soyuz, ISS, Skylab, MIR, etc.

Satellites & Satellite Constellation Clusters

Experimental Spacecraft & Space Weapons Platforms, etc.



Earth's Orbits Defined

Low Earth Orbit (LEO)

160 km to 2,000 km
100 mi to 1,250 mi

Medium Earth Orbit (MEO)

2,000 km to 35,786 km
1,250 mi to 22,236 mi

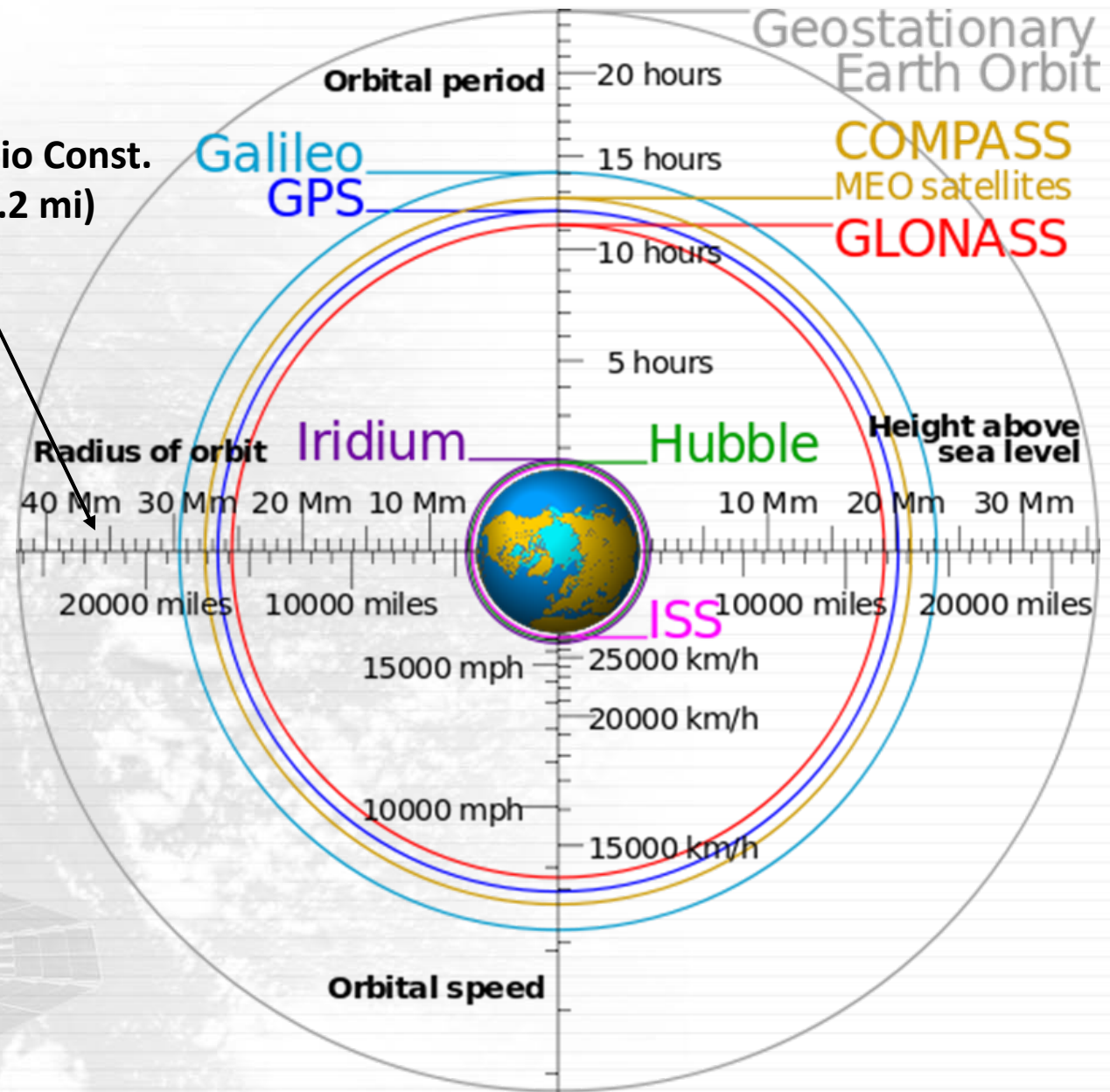
Geostationary Earth Orbit (GEO)

35,786 km or 22,366 mi

High Earth Orbit (HEO)

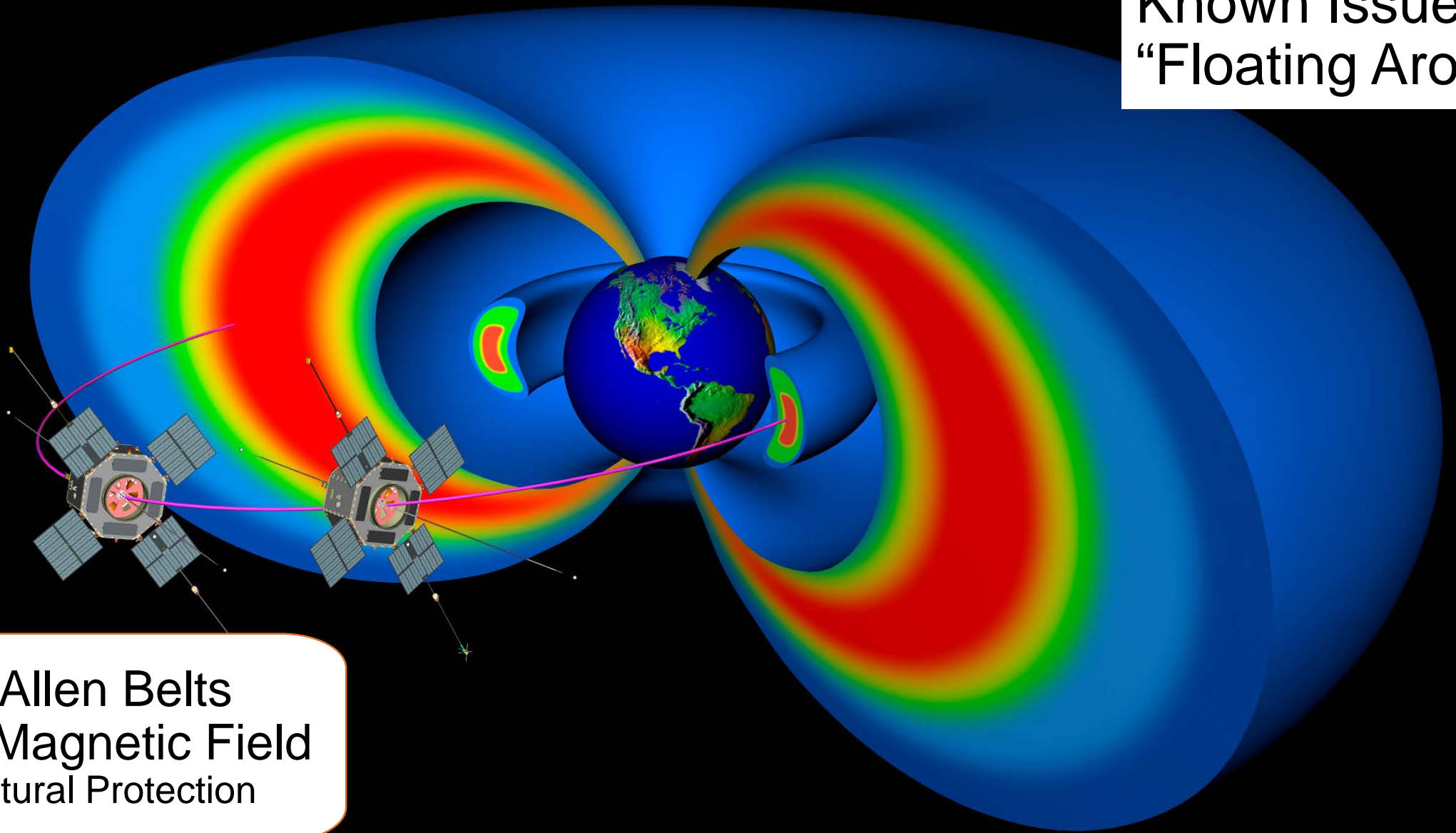
Above GEO = Deep Space

Sirius-XM Radio Const.
3.8 km (22.2 mi)



Elliptical Orbits: Apogee = Orbit Farthest from Earth's Center; Perigee = Orbit Closest to Earth's Center

Known Issues
“Floating Around”



Van Allen Belts
Earth's Magnetic Field
Our Natural Protection

Known Issues “Floating Around”

Our Sun's Solar Wind
Charged Particles &
Heavy Ions

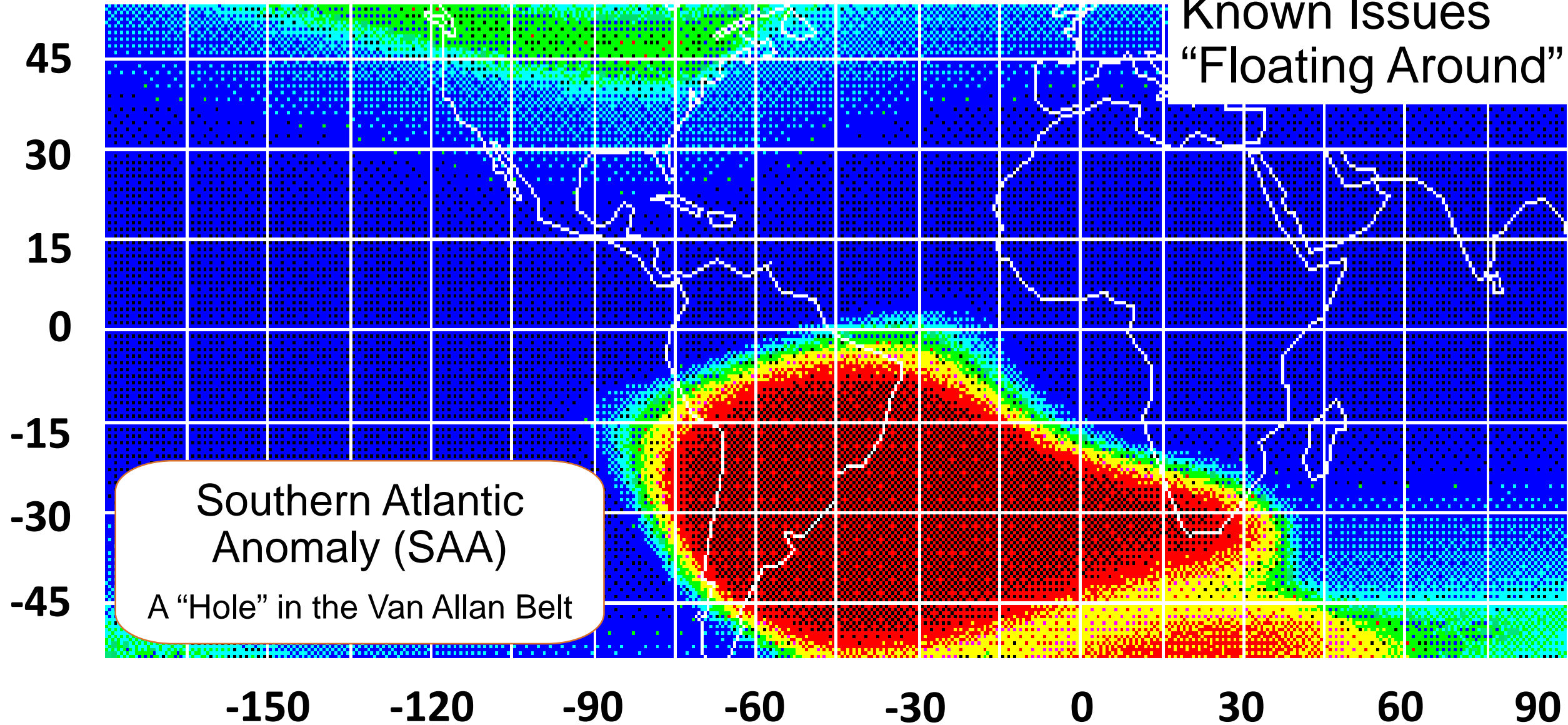


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Known Issues “Floating Around”



Every orbit the ISS makes through the SAA would reset all the onboard Ethernet switches and routers

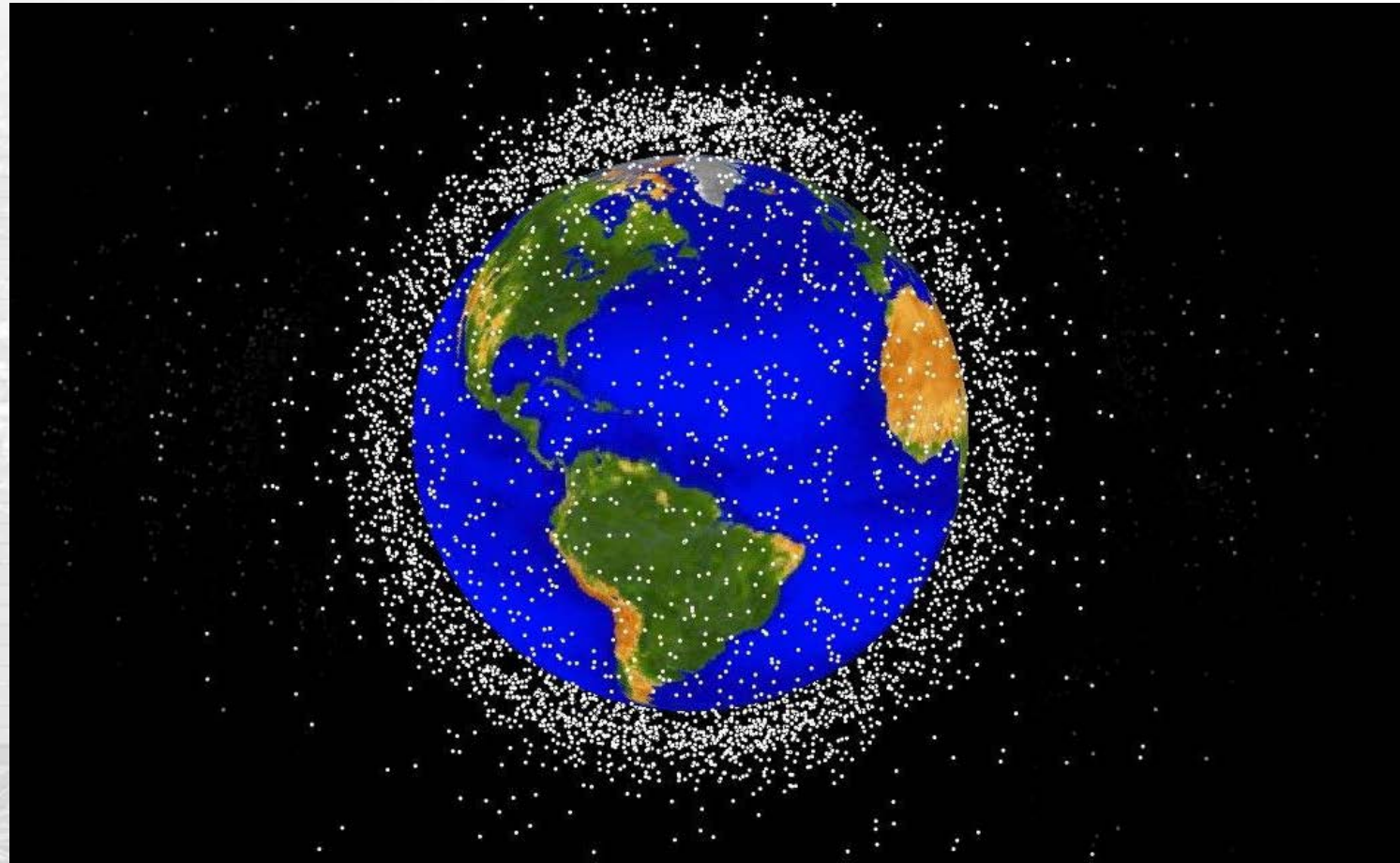
Other Known Issues in Earth's Orbit

Space Debris (Junk!)

- Screws
- Nuts
- Washers
- Wrenches
- Hand Tools
- Paint Flakes
- Dead Satellites & Parts
- Micrometeoroids
- Weapons Platforms

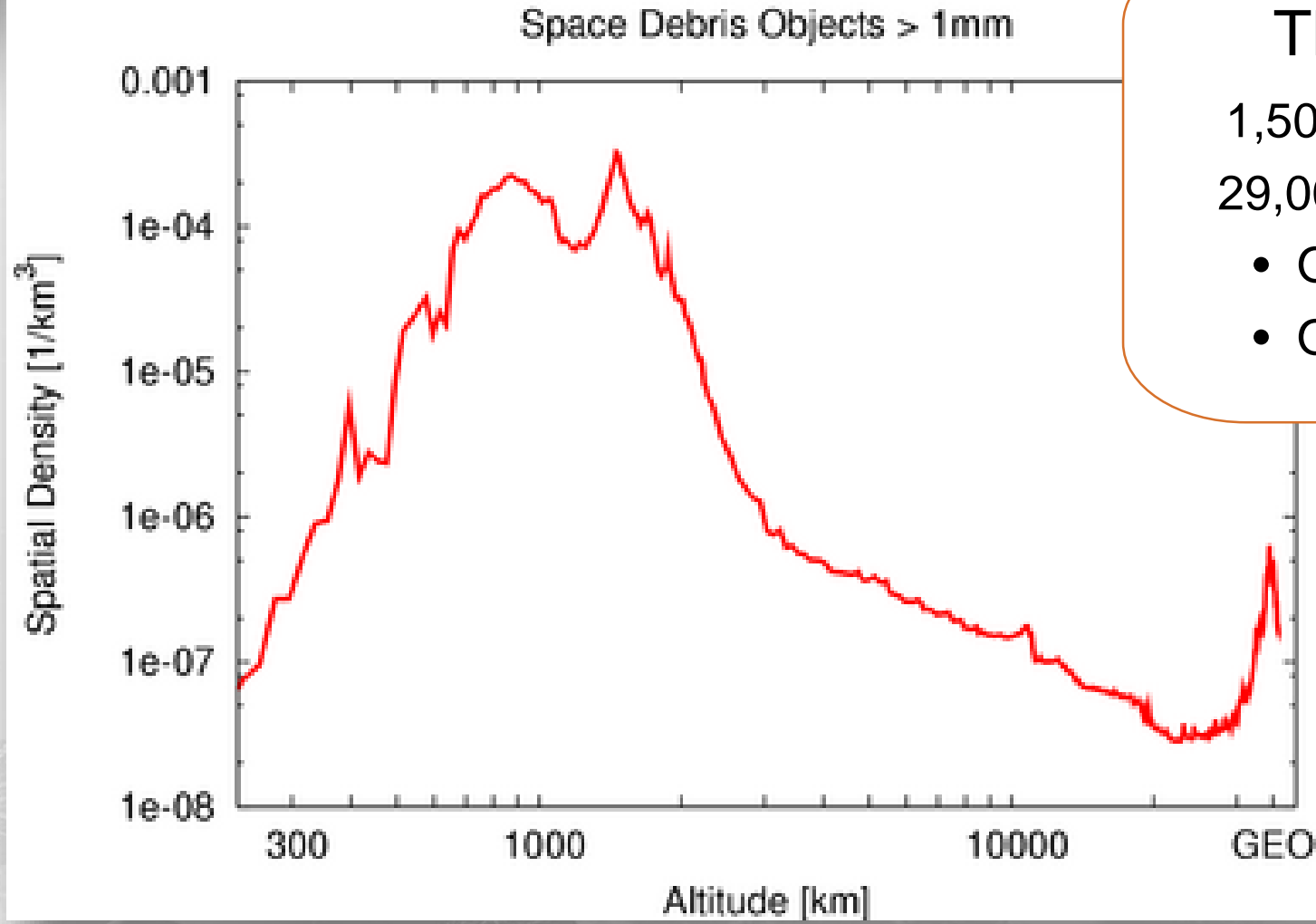
...and *Hundreds* of Spent Rocket Bodies and Booster Stages

Kessler Syndrome = Large object collisions & break-ups could/will exponentially increase the amount of debris



Download the app: "Skyview[®], Explore the Universe"

Other Known Issues in Earth's Orbit

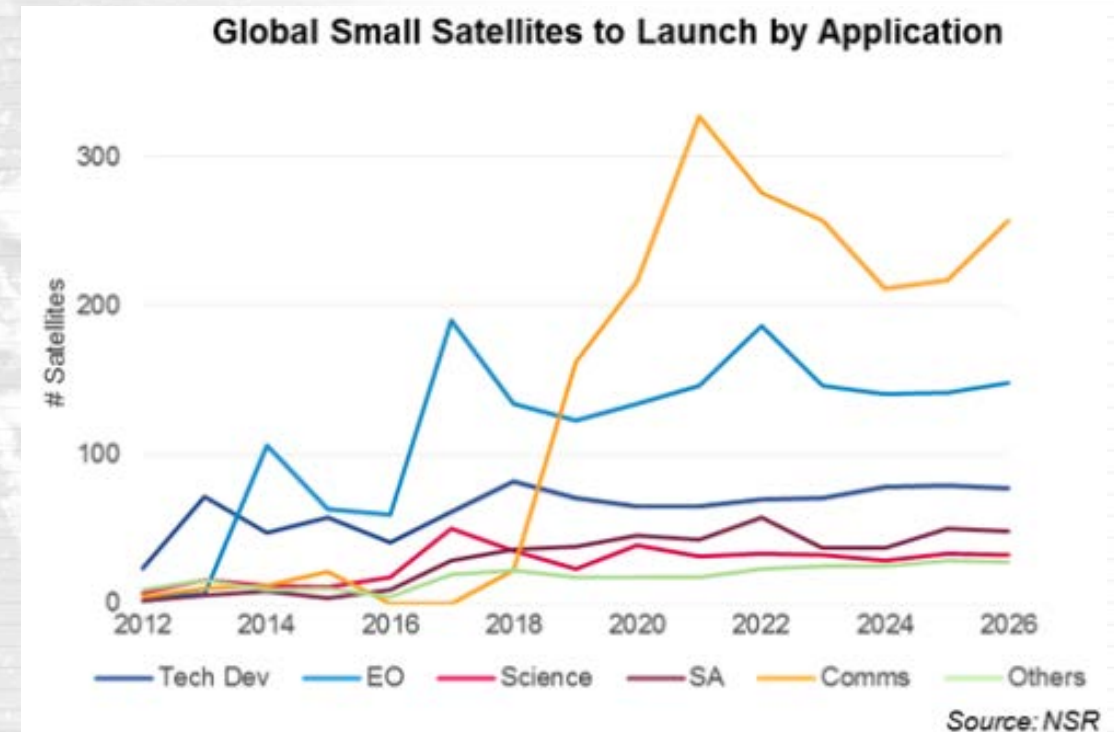
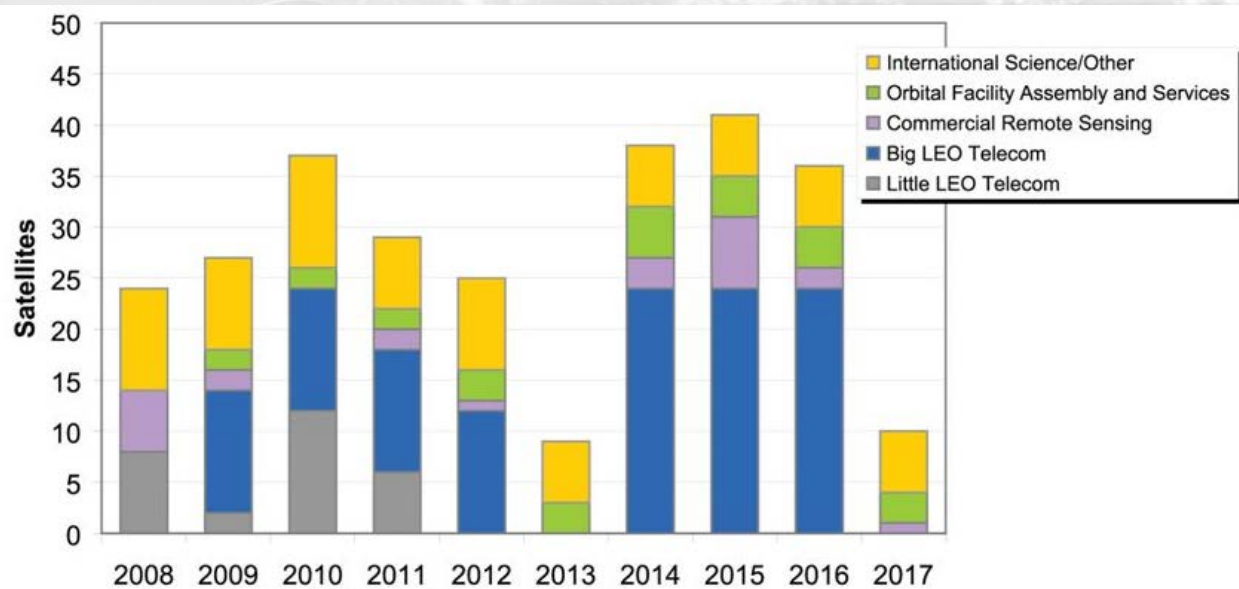


- The USAF is tracking over:
- 1,500 Active Satellites >100 kg (220 lbs)
 - 29,000 Large Manmade Objects >10 cm
 - Over 670,000 range from 1 – 10 cm
 - Over 170 million are 1 cm – 3 mm!

The ISS has been forced to change its orbit height on several occasions to avoid collisions with space debris.

Space Electronics Market Overview

- ✦ Private sector drives most satellites for earth imagery & communications today
- ✦ Need for global Internet access now driving development of new satellite constellations
 - As of 2017, only ~52% of the world's population had Internet access
 - 10 new unique-host Web sites are added approx. every 2.5 seconds
- ✦ Despite export controls, the US commercial space industry is the clear leader, followed by Europe, then Asia



Broadband Satellite Service Market is growing ~20%/yr, estim. at \$7.0 B in 2018, Includes Enterprise VSAT, Broadband Access & Backhaul/Trunking segments

EEE Parts for Space Component Characterization

Orbit altitude,
inclination, mission
length & reliability
will dictate rad-hard
or radiation tolerant
components choices

	TID	SEL	SEU
Commercial ICs	3 – 30 krad (Si)	1 – 65 MeV	1 – 20 MeV
Radiation-Enhanced ICs	Customized to Orbit (100 krad (Si) target)	Customized to Orbit (1 - 65 MeV)	Customized to Orbit (1 – 40 MeV)
Radiation-Hardened ICs	100 krad (Si) minimum	Up to 120 MeV	Up to 120 MeV

EEE Parts

Component Characterization & Issues

- “Space-qualified” and “Space Grade” used too frequently, confusing
- A NASA standard EEE-INST-002/003 exists, available online
 - Clearly defines NEPP parts used for space
 - Used by all NASA & ESA flight and R&D centers worldwide

Level 1 | For missions 5 years or longer,

Level 2 | For missions 1 to 5 years,

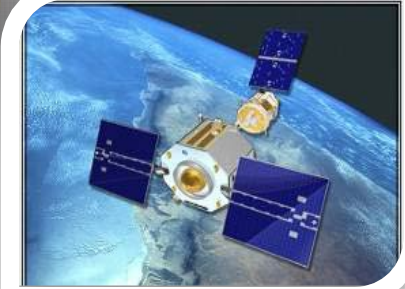
Level 3 | (High risk parts) for programs less than 1 year to 2 years.

Any known pitfalls with Counterfeit Components for Space?

You betcha!...check this out



Applications for Embedded Computing in Space



Flight Computers

- C&DH (Command & Data Handling)
- Propulsion and Flight Control

Payload Management and Data Processing

Robotics and Manipulation

- Hubble Service (Dexter pgm) Manipulator Control
- OSIRIS-Rex Robotics, Orbital Express, Astro

Attitude Control, Navigation and Autonomy

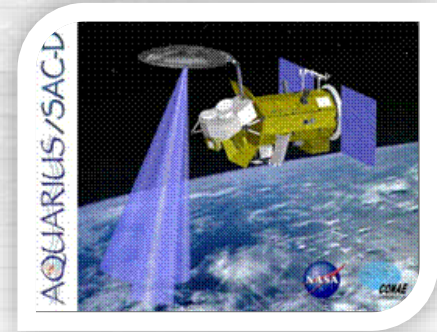
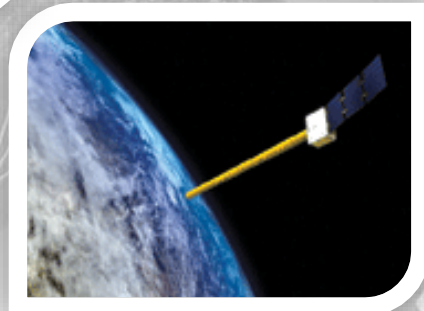
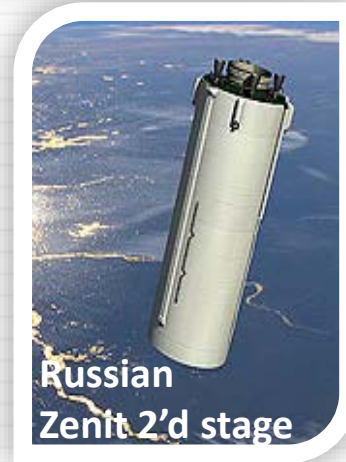
- Orbital Express Rendezvous/Docking
- CST-100 Rendezvous/Docking
- Orion Deep Space Craft, Mars Habitat

Communications

- Orbcomm Gen II RF Payload Processor

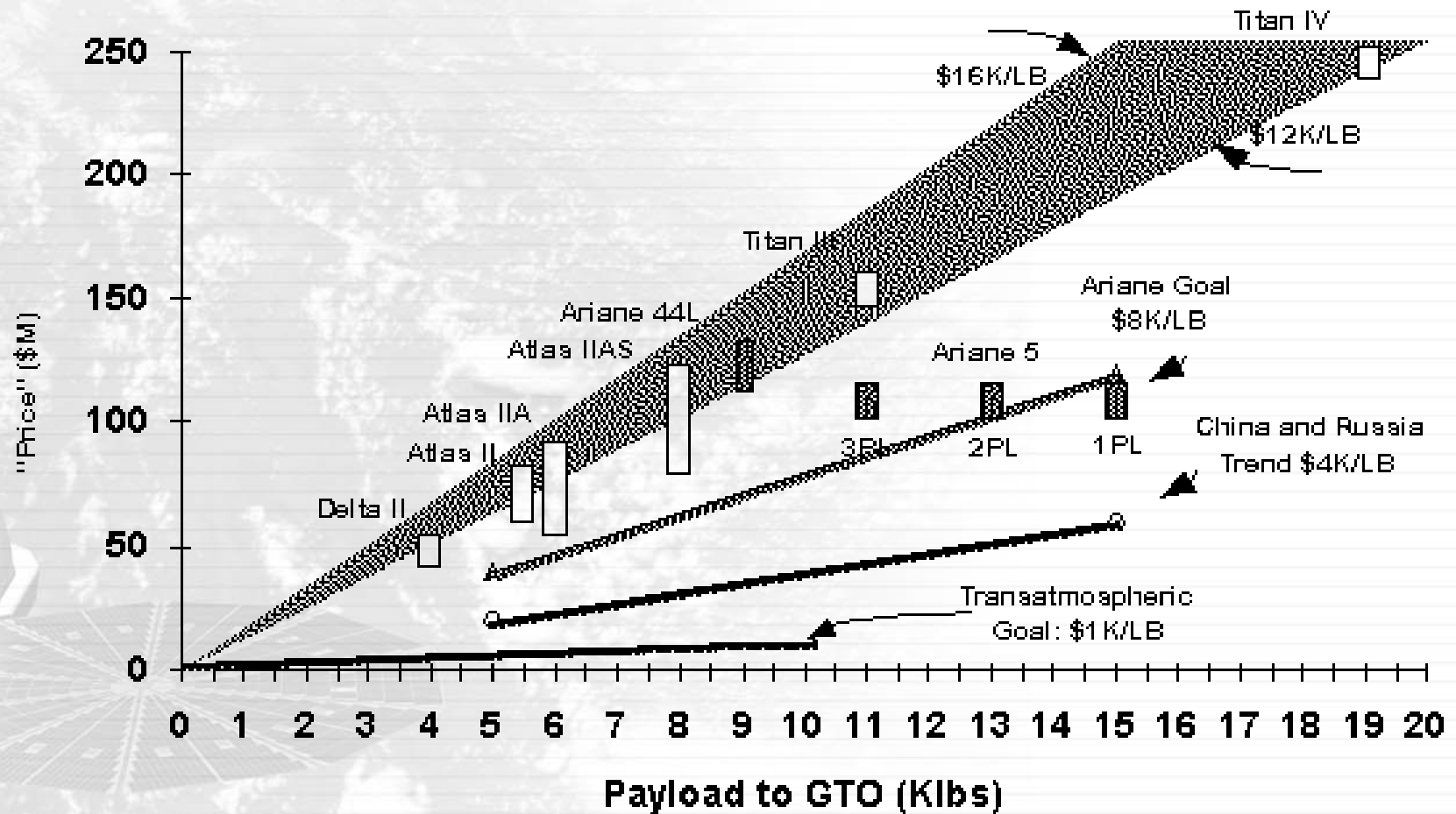
Video and Data Recording & Image Processing

Precision Motor Control



Customer Demands and Trends

- Today's launch costs: ~\$10,000/lb
- Customers and end-users want an Order of Magnitude less (\$1,000/lb)
- Just like today's D&A COTS market, SWAP-C rules!



Source: Space Launch Modernization Study
(except TAV goal)

What are “Space COTS” Products anyway?

Probably
NOT this...



Available Space COTS Boards & Systems

- ✦ I/O boards
 - Analog, digital, discrete and switched motor drivers
- ✦ Communications boards
 - Gigabit Ethernet, MIL-STD-1553B and ESA SpaceWire
- ✦ Turn-key mission data recorder systems
- ✦ Space-qualified chassis and power supplies
- ✦ 100% flight-equivalent, lab development systems



NASA's mandate – "Test What You Fly, Fly What You Test."



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*Thank
You!*



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