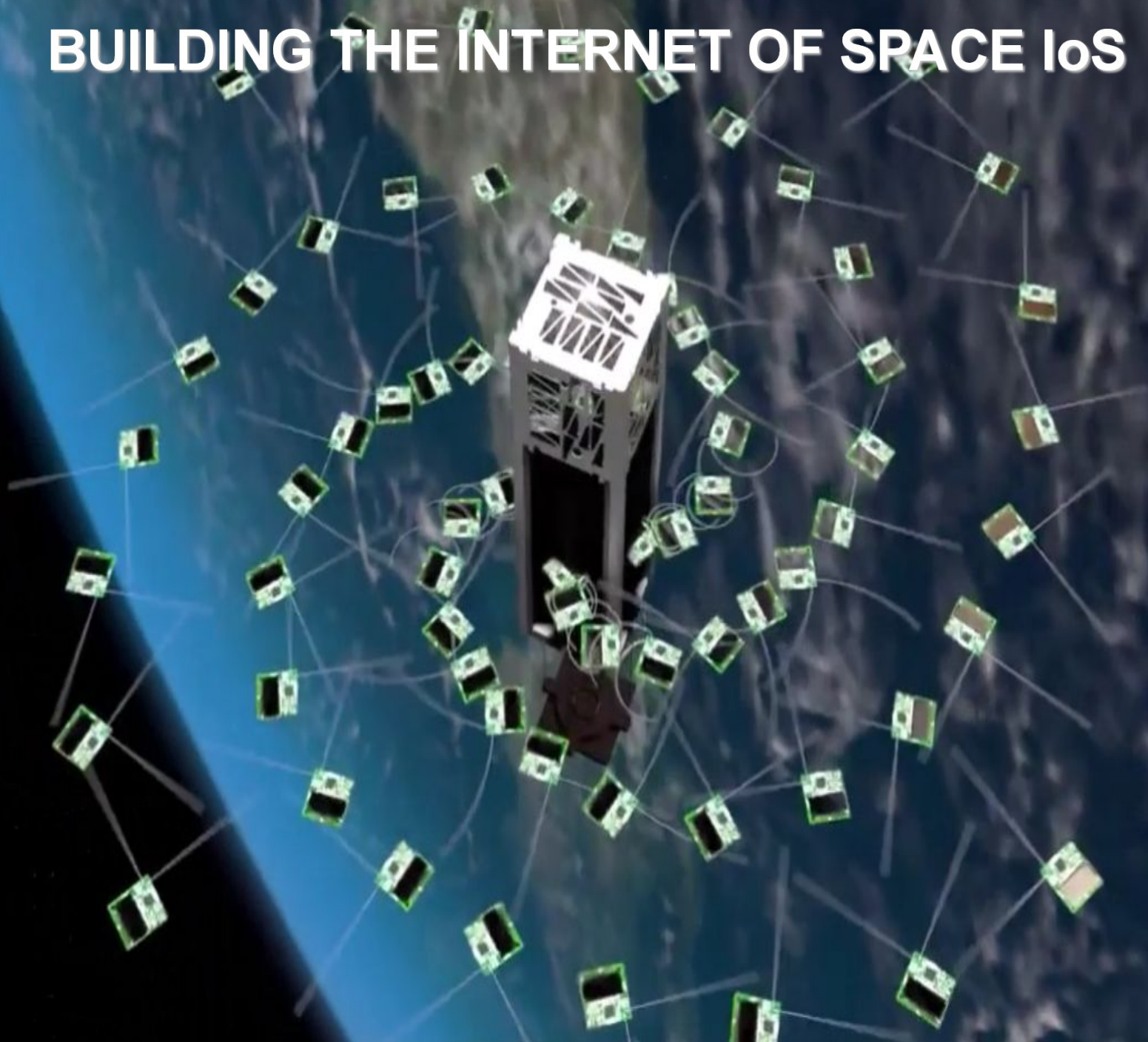


# BUILDING THE INTERNET OF SPACE IoS





# What is IoT ?

*"The Internet of Things is the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment."* **Gartner**



# INTERNET OF THINGS LANDSCAPE

## Platforms & Enablement (Horizontal)

<b>Connectivity</b> FITBIT, Symplic, ioBridge, ARRAYENT, hystack, electric leap, sensinode, ThingWorx, NNODE, bugsworm	<b>Open Source Platforms</b> sense, spark, Nimbits, ThingSpeak	<b>Software Platforms</b> sense, SmartThings, Withings, NINJABLOCKS, xively, TWINE, OSITO, zonoff	<b>Sensor Networks</b> MESHSYSTEMS, SAFECAST	<b>Enabling Networks</b> FreedomPop, SocialSign.in, SIGFOX	<b>Corporates</b> IBM, LG, CISCO, Honeywell
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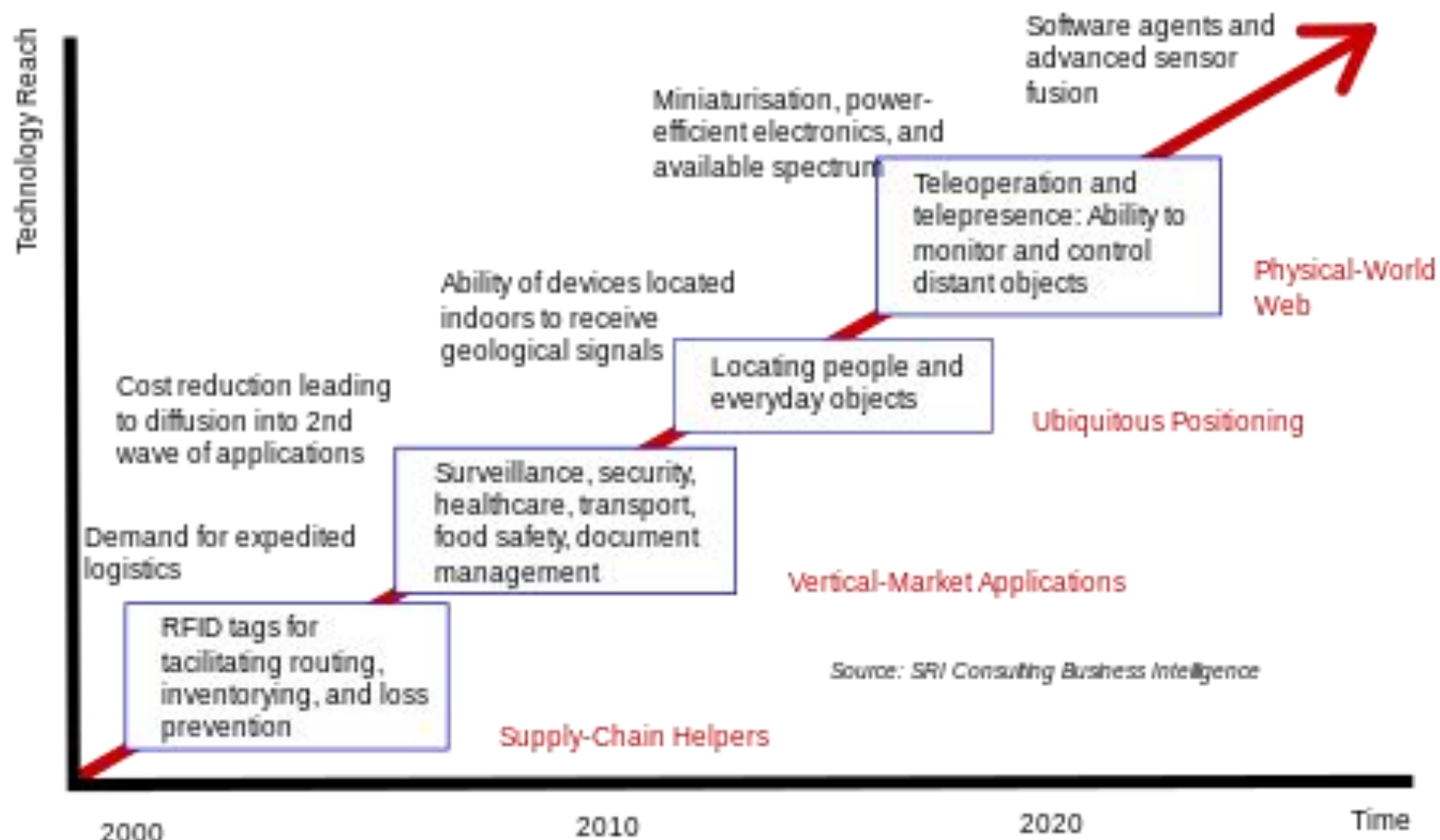
## Applications (Verticals)

<b>Quantified Self</b> Wearable Computing: GLASS, Pebble Fitness: Withings, fitbit, JAWBONE Health: BASIS, LUMO, HAPIfork, wahoo, NuMetrix Family: Lively, Good Night Lamp, Withings, EVADO FILIP	<b>Lifestyle</b> Leisure: blossom, ICA, Thimble, iGrill, HEWBRIGHT, sobi Pets: gibi, FITBARK Toys: sifteo, MakieLab, KAROTZ, greenoostly Music: gitar Gardening: BITPONICS, plantlink, Koubachi Home Improv.: Radiator Labs, netatmo	<b>Connected Home</b> Home Automation: SmartThings, NINJABLOCKS, revolv, Ubi, lapka, Wovyn, electric leap, NNODE Energy Efficiency: knut, nest, tado, LIFX, ecobee, belkin, we mo, microsaverde Security: Kwikset, ALARM.COM, Lockitron, CANARY, HomeMonitor, iSmartAlarm New Interfaces: Nisaco, sphero, gestigon, PrimeSense, EQUISO, emotivo, interaxon, LEAP	<b>Industries</b> Retail: Nomi, euclid, placemeter Healthcare: VISI MOBILE, AdhereTech, AliveCor, TELCARE, intelligent Automotive: Dashlabs, SYNC, OpenXC, ienture Smart Buildings: APOOR, Johnson Controls, Schneider Electric	<b>Industrial Internet</b> KIVA Systems, Double Robotics, Airware, RobotX, Robotics, ROBOTICS, HOKUJIMA, BigBelly, Axeda, SOLAR, enlightened, GRIDMOBILITY, Stratasys, formlabs, shapeways, MakerBot INDUSTRIES, RepRap
---	--	--	---	--

## Building Blocks

<b>Connection Protocols</b> MQTT, ZigBee, NFC, WIF, Bluetooth, M2M, 2G, 3G, 4G	<b>Telecom</b> at&t, verizon, boost	<b>M2M</b> Jasper, gamalto, Telit				
<b>Software</b> amazon web services, Parse	<b>Hardware</b> spark, Arduino, raspberrypi	<b>Parts / Kits</b> MAKE:MAKE, TinkerForge, Imbibo, MOSORO	<b>Services</b> CIRCUIT, CIRCUI	<b>Incubators</b> BOLT, LEMNOS Labs, springboard	<b>Funding</b> KICKSTARTER, indiegogo	<b>Distribution</b> Arxel

## Technology roadmap: The Internet of Things



# Internet of Space Follows the Road Map

## Technology roadmap: The Internet of Things



# What is IoS?

The Internet of Space is the Orbital Network of Objects that contain technology for infrastructure less communications, sensing and interaction with internal states and the external environment

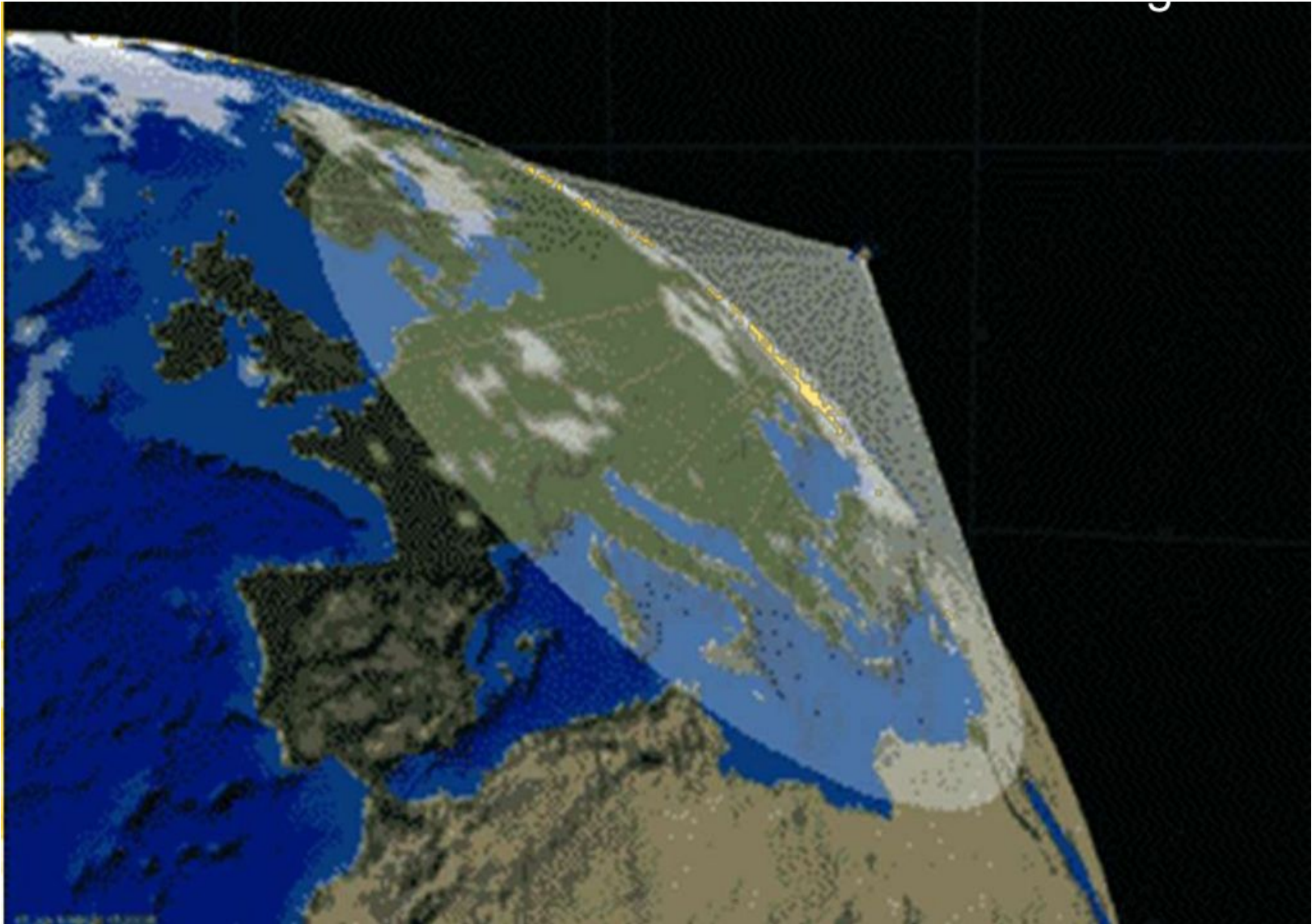


# IoS Femto Satellites for Communications





## IoT Femto Satellites Provide Broad Coverage



# IoS can Detect and Monitor Objects in Space



# Why Detect or Monitor Objects in Space

## Meteorite fragments hit boy in the head



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### Russia Meteor Blast Is Biggest in 100 Years

By Leonard David, Space.com's Space Insider Columnist | February 15, 2013 02:28pm ET

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What appears to be a meteor trail over eastern Russia is seen in this image released Feb. 15, 2013, by the Russian Emergency Ministry. The meteor fall included a massive blast, according to Russian reports.  
Credit: Russian Emergency Ministry

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**Russian Meteor Explodes**  
Credit: Attribution by Reuters  
This video still image shows impact caused by the meteor that exploded over the Chelyabinsk region of Russia on Feb. 15, 2013.

**Russian Meteor Explodes**  
Credit: Attribution by Reuters  
This video still image shows impact caused by the meteor that exploded over the Chelyabinsk region of Russia on Feb. 15, 2013.

The dramatic fireball that exploded over Russia today (Feb. 15) was apparently the biggest such blast in more than a century, scientists say.

**NEWSFIX** NEWSFIX FEATURES WEB WATCH EYEPENER 61° TRAFFIC CONTESTS EVENTS WEATHER 61°

## One dead, three injured when meteorite hits India

POSTED 5:30 PM, FEBRUARY 8, 2016, BY TAMMYFELDSTEIN

f FACEBOOK t TWITTER g+ GOOGLE p PINTEREST in LINKEDIN e EMAIL

## How to Detect Asteroids

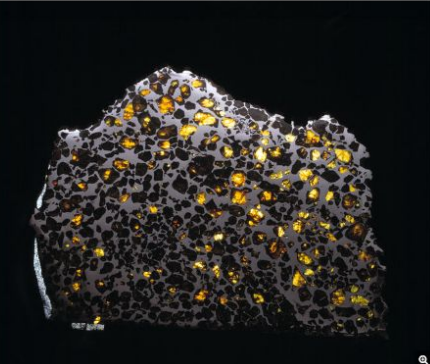
The magnetometer in operation aboard the NEAR-Shoemaker spacecraft has obtained extensive magnetic field observations throughout the 433 Eros environment, from distances in excess of 100,000 km to those conducted after landing on 12 February 2001. We report the apparent absence of global scale magnetization

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### Magnetic Fields of Asteroids Lasted Hundreds of Millions of Years

By Mike Wall, Space.com Senior Writer | January 21, 2015 01:01pm ET


46 f 29 t 4 g+ 6 j 1485 MORE ▾



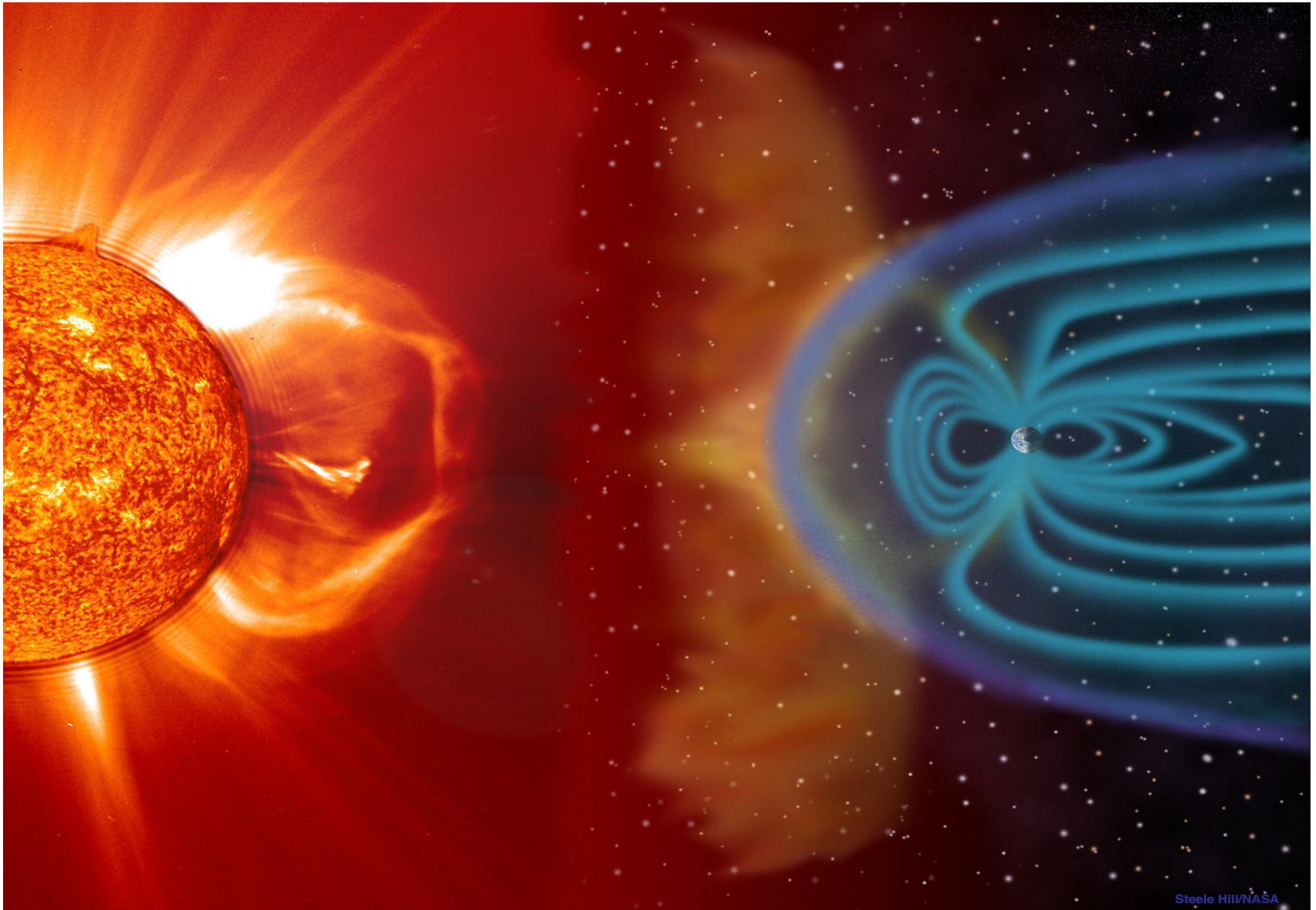
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 Best Telescopes for the Money

## IoS can Monitor Localized Space Weather Conditions



# Why Monitor Localized Space Weather Conditions?

## The Auroral Display in Boston.

Boston, Friday, Sept. 2.

There was another display of the Aurora last night, so brilliant that at about one o'clock ordinary print could be read by the light. The effect continued through this forenoon, considerably affecting the working of the telegraph lines. The auroral currents from east to west were so regular that the operators on the Eastern lines were able to hold communication and transmit messages over the line between this city and Portland, the usual batteries being discontinued from the wire. The same effects were exhibited upon the Cape Cod and other lines.

The New York Times

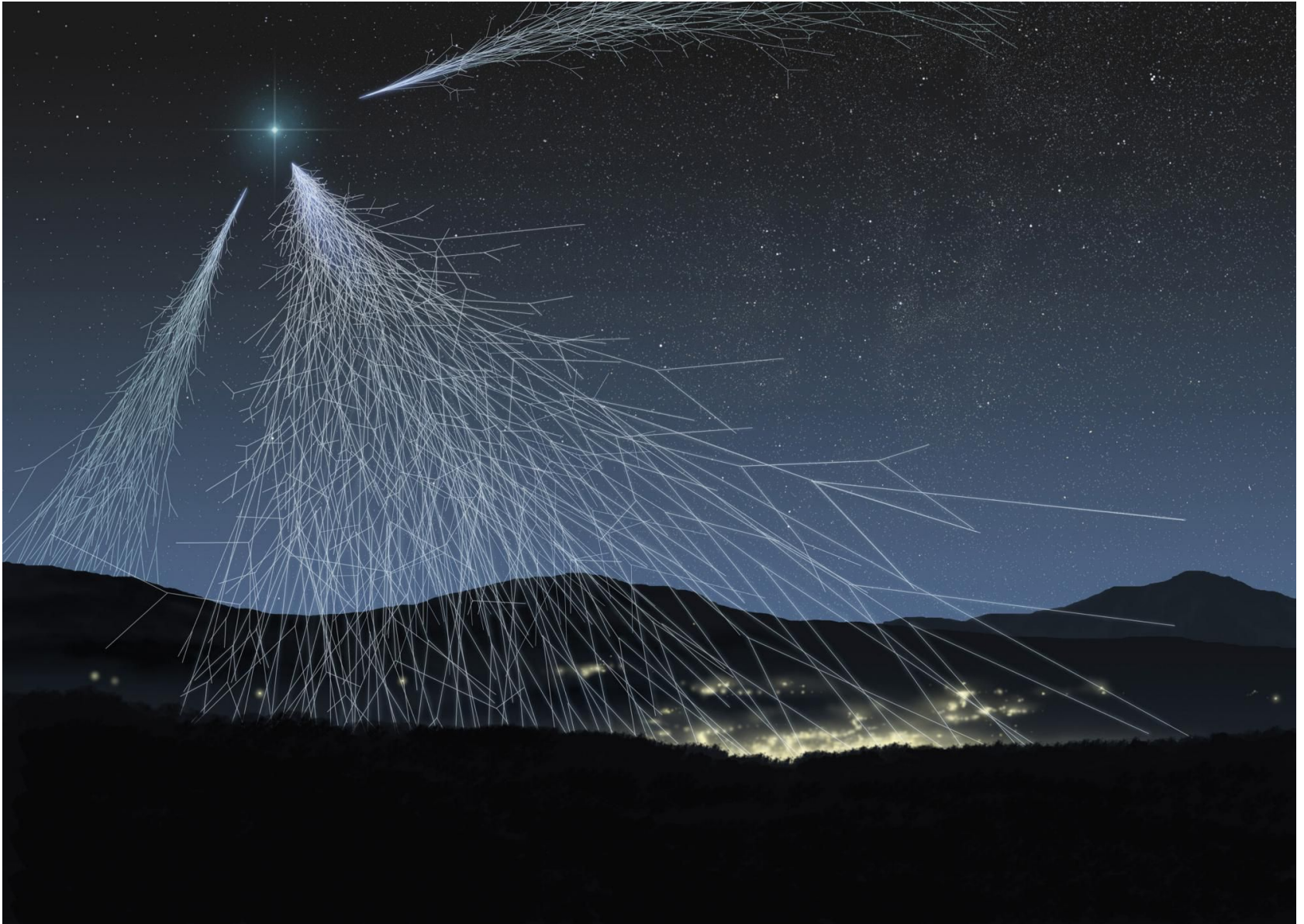
Published: September 3, 1859  
Copyright © The New York Times



What would happen today?



# IoS can Monitor Localized Cosmic Radiation



# Why Monitor Localized Cosmic Radiation?

IEEE SPECTRUM

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## How To Kill A Supercomputer: Dirty Power, Cosmic Rays, and Bad Solder

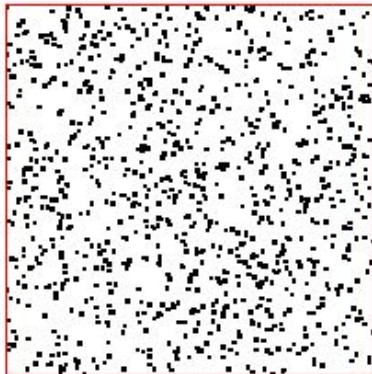
Will future exascale supercomputers be able to withstand the steady onslaught of routine faults?

By Al Geist

Posted 23 Feb 2016 | 16:00 GMT

### COSMIC RAY SECONDARY MUONS HITS OVER 5 MINUTES

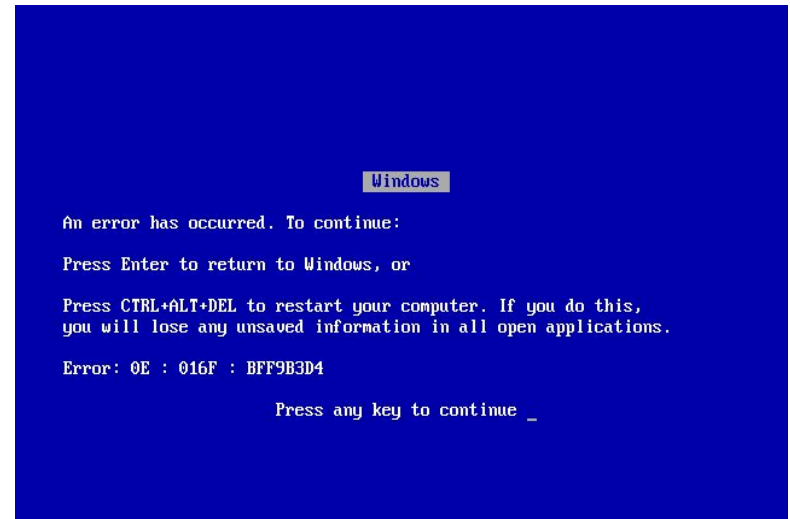
P1 = 16807, P2 = 0, N = 2147483647



1000 dots drawn, seed = 1

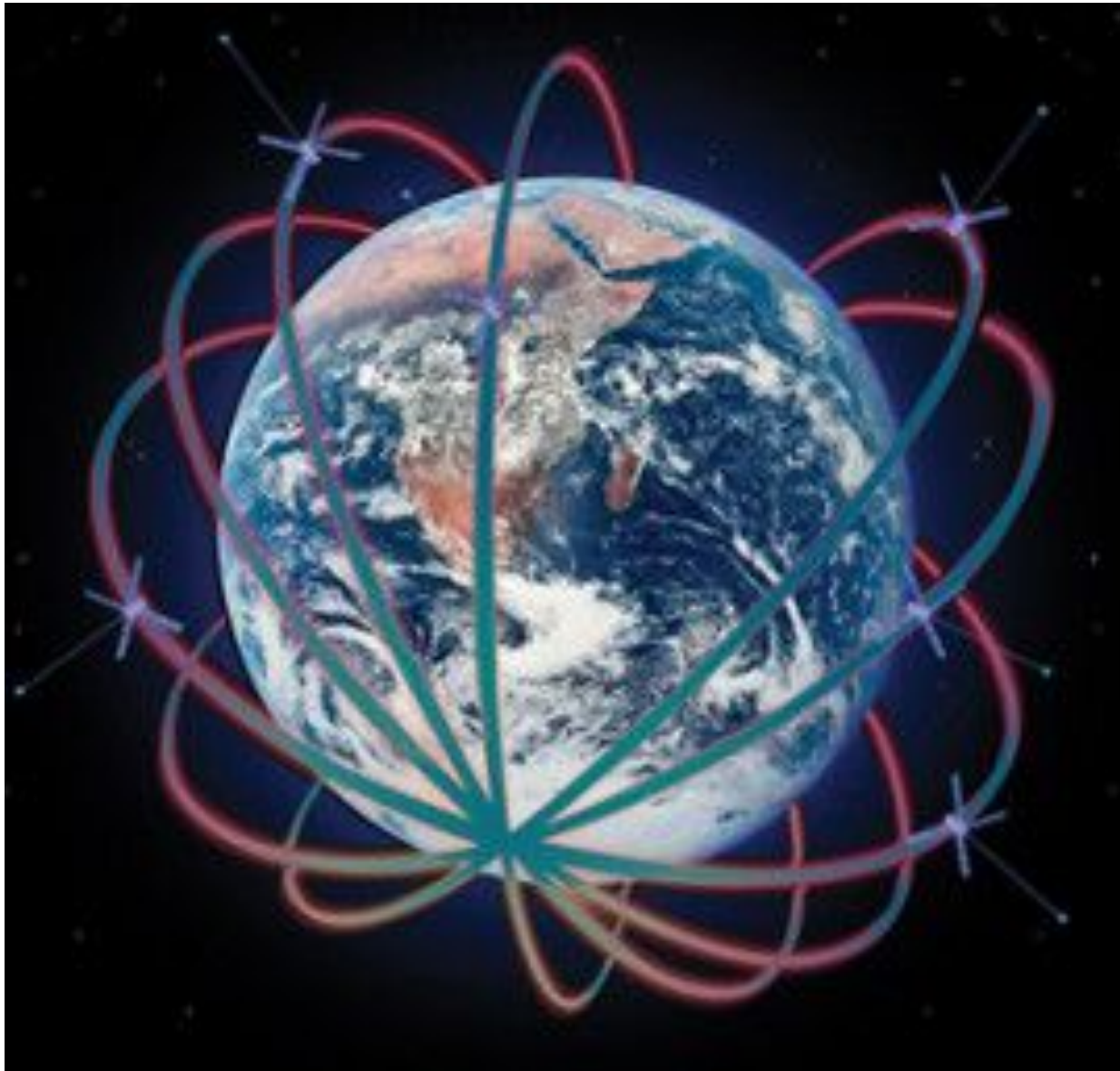


BIG MAC SCRAPPED



PERSONAL EXPERIENCES

## IoS can Provide Navigational Reference





# Why Provide Navigational Reference



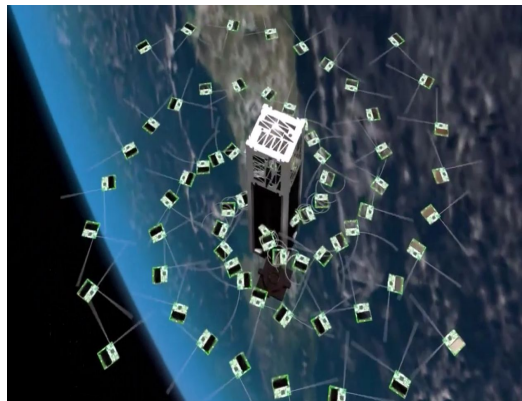
The image shows the header of the GPS World website. On the left, the text 'GPS WORLD' is written in large, bold, white letters, with 'GNSS POSITION NAVIGATION TIMING' in smaller text above 'WORLD'. To the right, there is a 'Follow Us' section with icons for Facebook, Twitter, LinkedIn, RSS, and YouTube. Below this is a search bar with the text 'Search the Site...' and a magnifying glass icon, and a 'subscribe' button. The background of the header features a satellite in space. At the bottom of the header, there are several colored tabs: 'OEM' (blue), 'UAV' (green), 'Survey' (orange), and 'Mapping' (red). To the right of these tabs, the text 'GNSS | Defense | Mobile | Machine Control/Ag | Transportation | More' is displayed.

## U.S. Army Is Seeking GPS-Denied Technology for UAS

By *GPS World staff* - Posted on 26 Oct 2015 in *Defense & Latest News & UAV/UGV*.

The U.S. Army's Armament Research, Development and Engineering Center (ARDEC), located at Picatinny Arsenal in north-central New Jersey, has issued a sources sought notice for technology it can use for a... [Read more»](#)

IoS can Provide a Rapid Deployed Constellation of Navigational References



## IoS can Generate Secure Communications Protocols



# Why Generate Secure Communications Protocols

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SPACE

## Space Thief Or Hero? One Man's Quest To Reawaken An Old Friend

March 18, 2014 · 5:00 AM ET

Heard on Morning Edition



NELL GREENFIELDBOYCE

Science

## Space geeks' resurrected NASA Sun probe ISEE-3 now on collision course with THE MOON

Reboot project down ... but not out



Space hacking team has the right stuff

The Mercury News

## SCIENCE & ENVIRONMENT

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Science & Environment

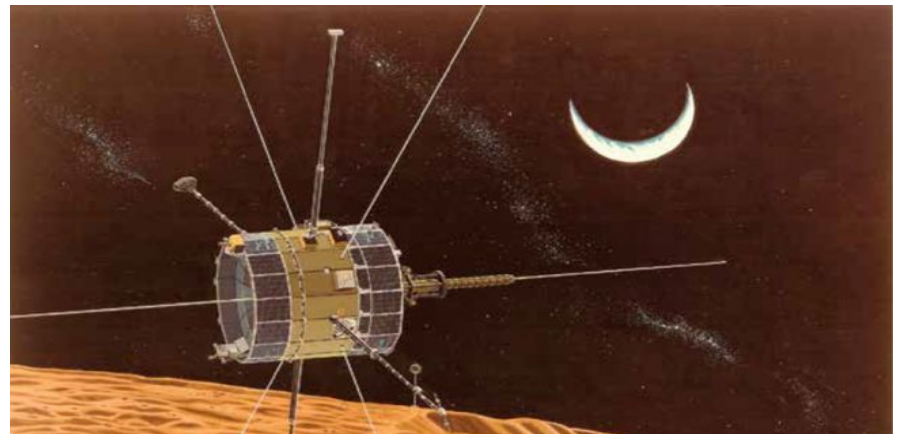
Story

## Moffett Field eyed for NASA cybersecurity facility to protect spaceflights

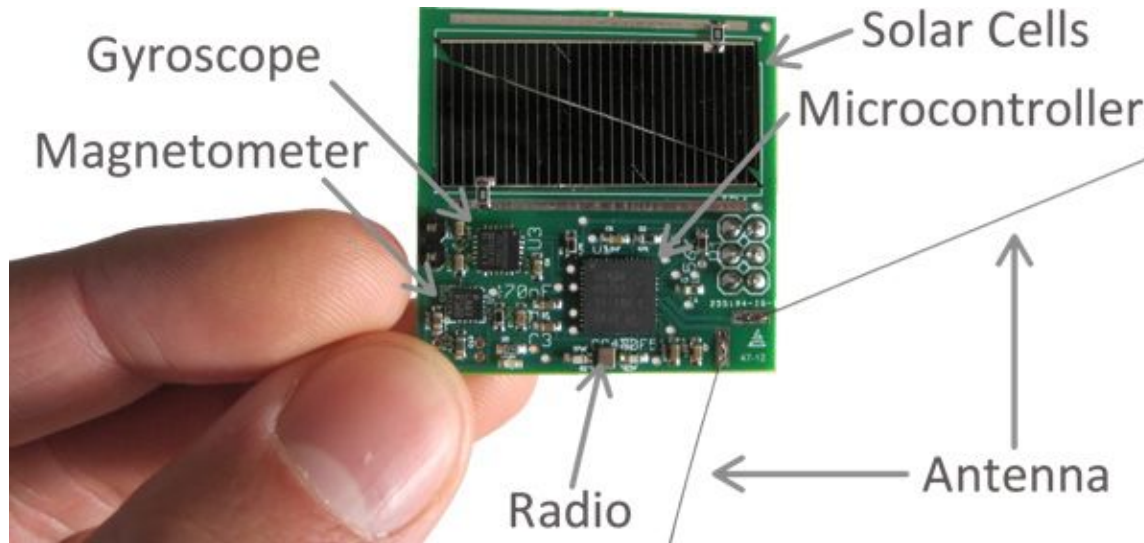
By Ethan Baron, ebaron@mercurynews.com

POSTED: 04/04/2018 12:27:13 PM PDT | UPDATED: A DAY AGO

MOFFETT FIELD -- NASA's Ames Research Center is planning a cutting-edge cybersecurity facility at Moffett Field to protect space missions from potentially catastrophic hacking and to increase collaboration with Silicon Valley.



# IoS Node-The Femto Satellite

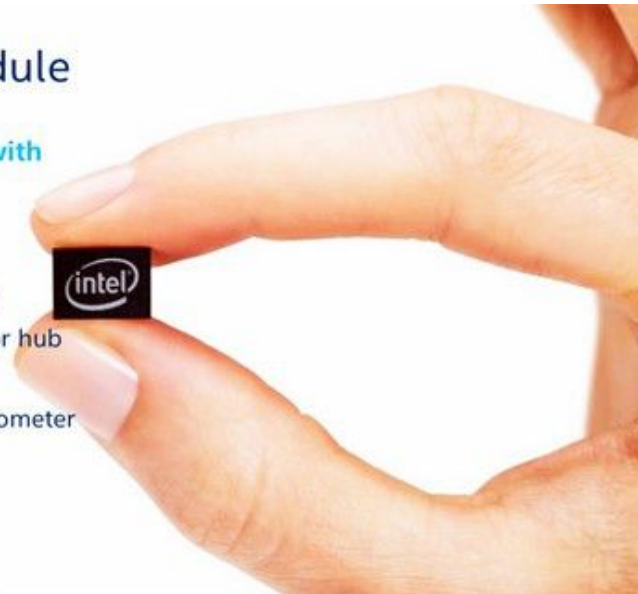


Port to Intel for the Following Benefits:

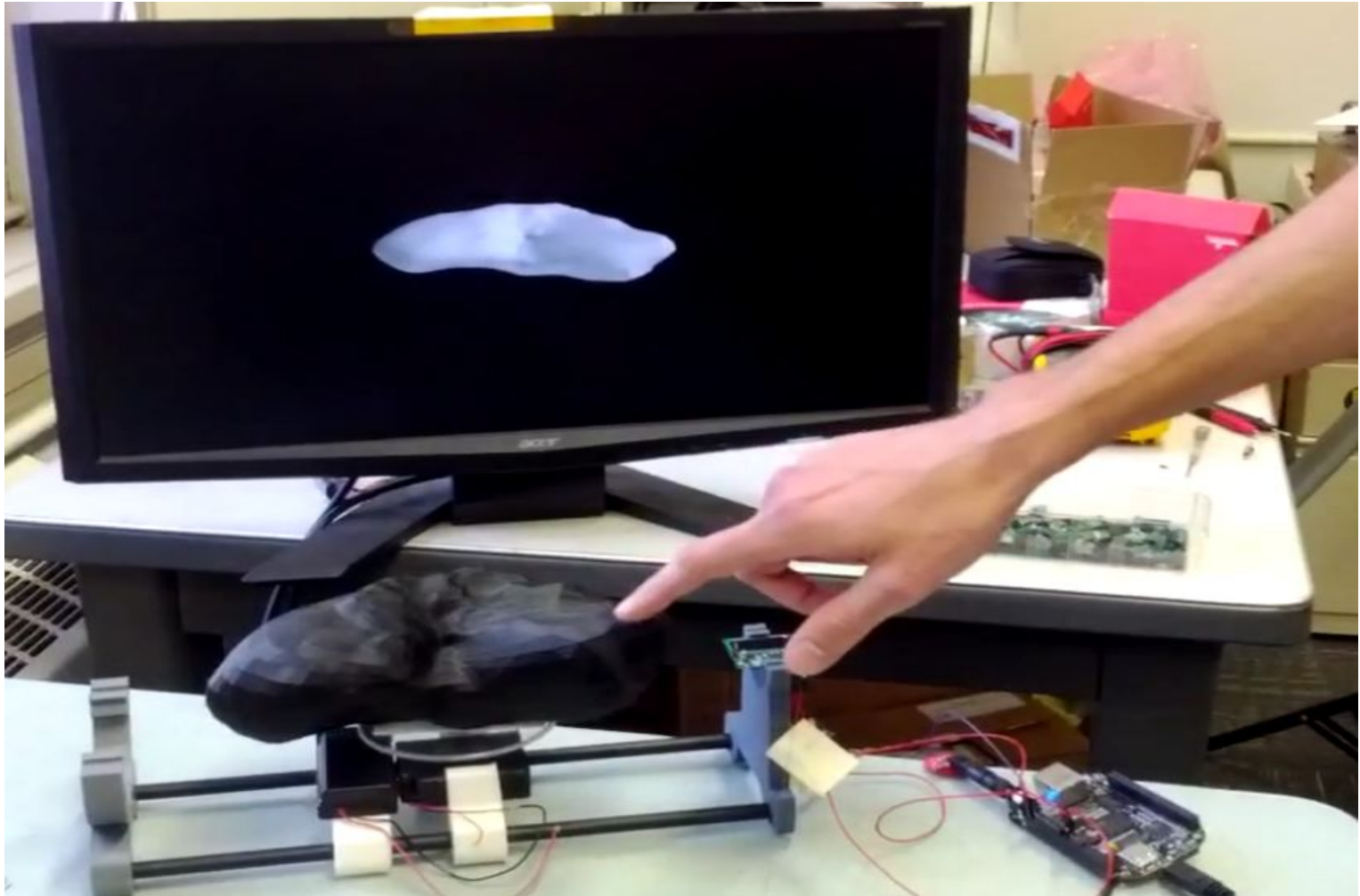
## The Intel® Curie™ Module

### Small as a Button, Jam Packed with Power

- Low-power, 32-bit Intel® Quark™ microcontroller
- 384kB flash memory, 80kB SRAM
- Low-power, integrated DSP sensor hub
- Bluetooth Low Energy
- 6-axis combo sensor with accelerometer and gyroscope

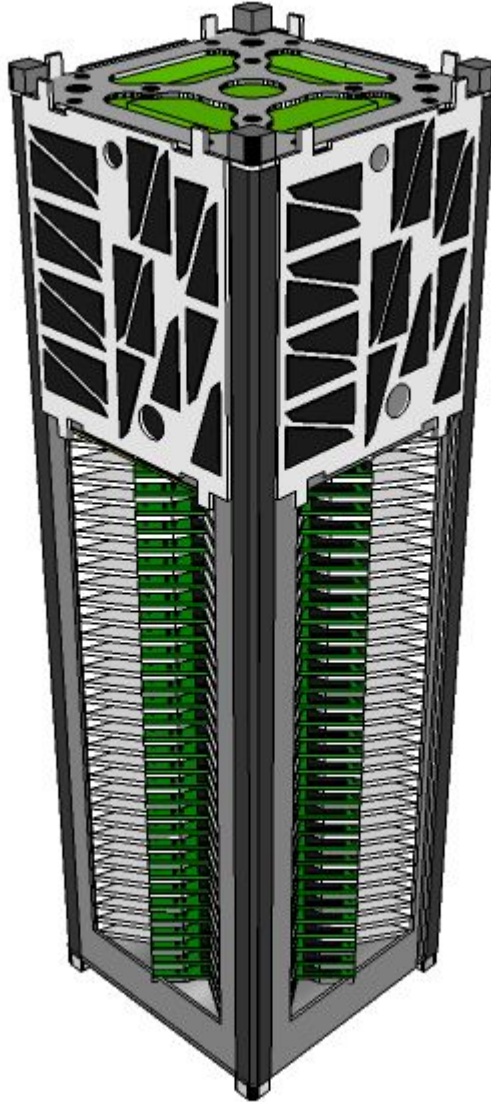


# IoS Node-The Femto Satellite Asteroid Tracker



Graphic Display Shows how a Femto Satellite Tracks an Asteroid

# IoS Node-The Femto Satellite Depolyer



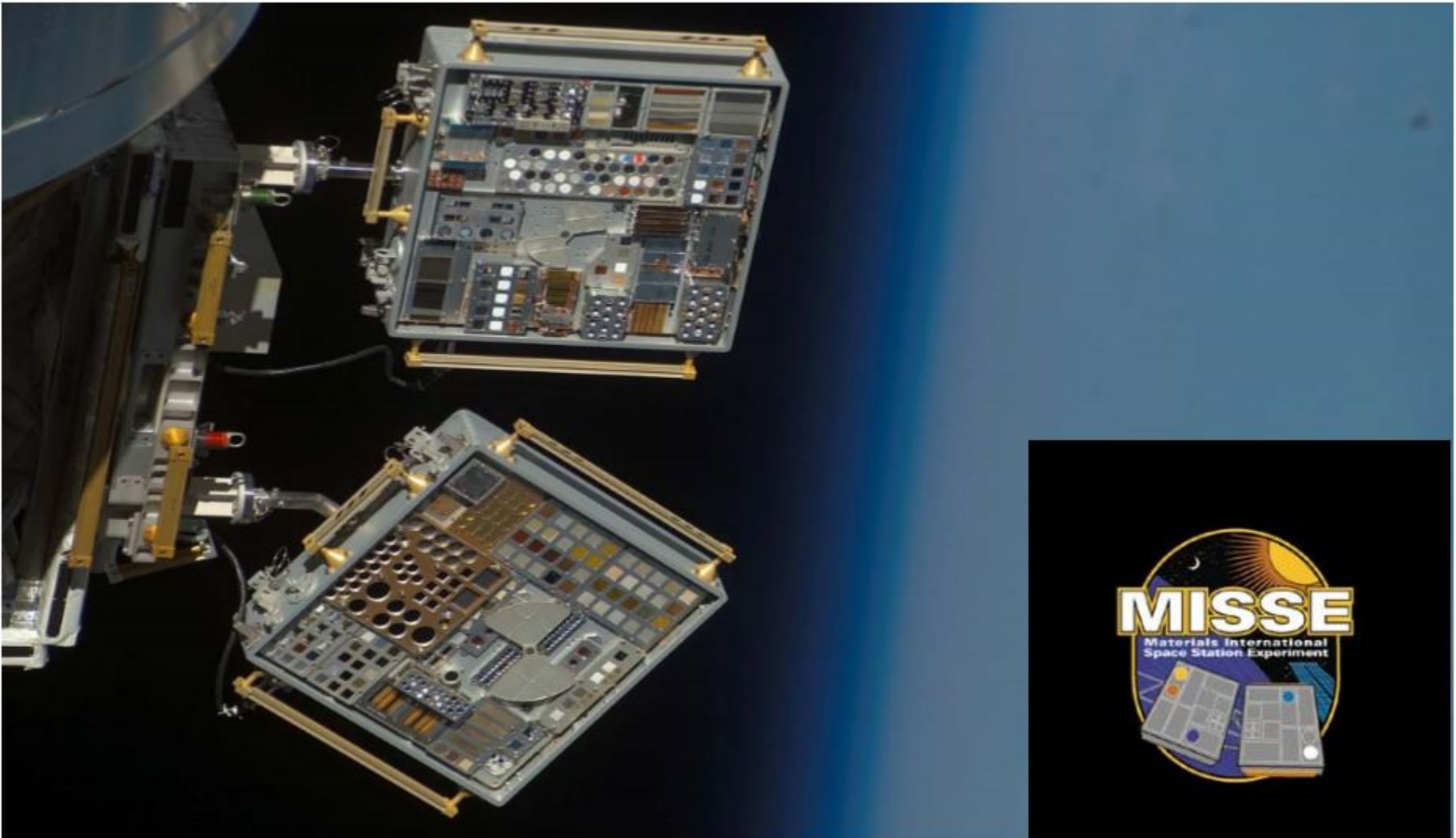
Intel Development Board Controls Deployment  
of Femtosats

IoS Hardware Proof of Concept Missions

# LAUNCHED IN 2011 TO ISS



# 2011-2014 PART OF MISSE 8





# KickSat



**LAUNCH**



**STAGE**



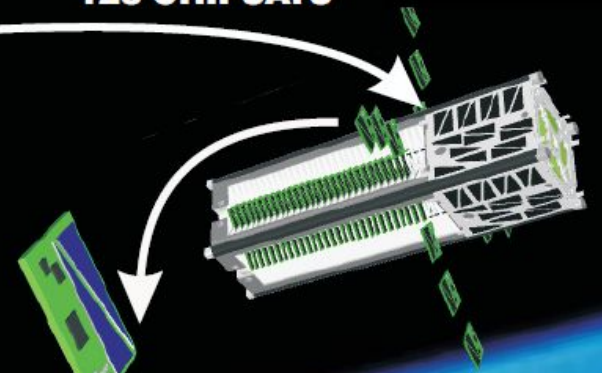
**SEPARATE**



**DEPLOY KICKSAT**



**KICKSAT DEPLOY  
128 CHIPSATS**



**CHIPSAT ORBITS FOR  
2-6 WEEKS BEFORE  
BURNING UP**

# KICKSAT LAUNCHED APRIL 2014



# KICKSAT II TO BE DEPLOYED 2016



ORIGINATED AT CORNELL



Cornell University  
Space Systems Design Studio

[www.spacecraftresearch.com](http://www.spacecraftresearch.com)