HELPING YOU COMMUNICATE BETTER

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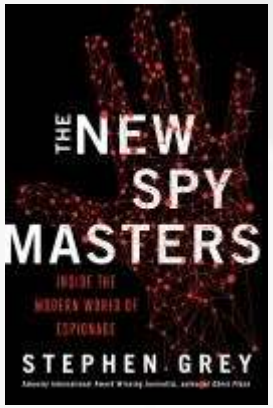
Beyond Navigation – Established and Emerging Satellite Applications

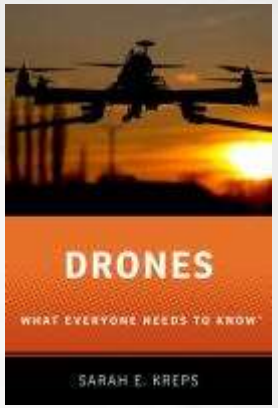
OVERVIEW

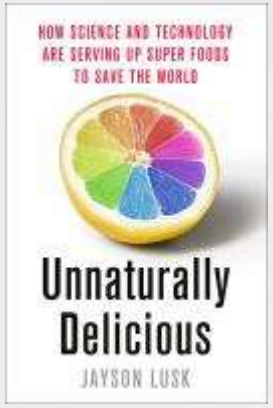
- Basics
- Deployed and planned satellite systems
- Legal framework, treaties, and standards
- Accuracy
- Applications overview: communication, earth observation, economic monitoring, environmental monitoring, transit, disaster response
- Translation resources:
  * general monolingual and multilingual glossaries
  * application-specific resources (precision farming, equipment telematics)
- Q&A

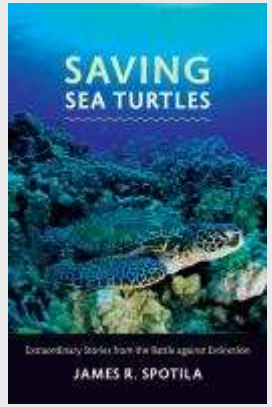
Download this presentation at:
www.argosmultilingual.com/karl-pfeiffer-ata2016/

Exploring the topic ...









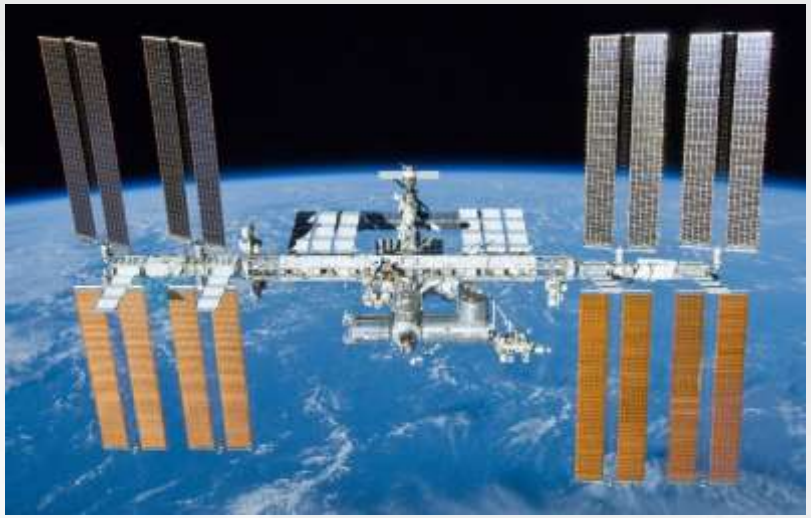
BASICS

- Nomenclature: artificial objects (intentionally placed into orbit) vs. natural satellites (e.g. moon)
- Etymology - Latin: attendant, companion, accomplice
- First use in reference to the moons of Jupiter by German astronomer Johannes Kepler (~1610s)
- First artificial satellite, Sputnik 1, launched by the Soviet Union in 1957
- In orbit less than 3 months, but caused “Sputnik Shock” and triggered space race

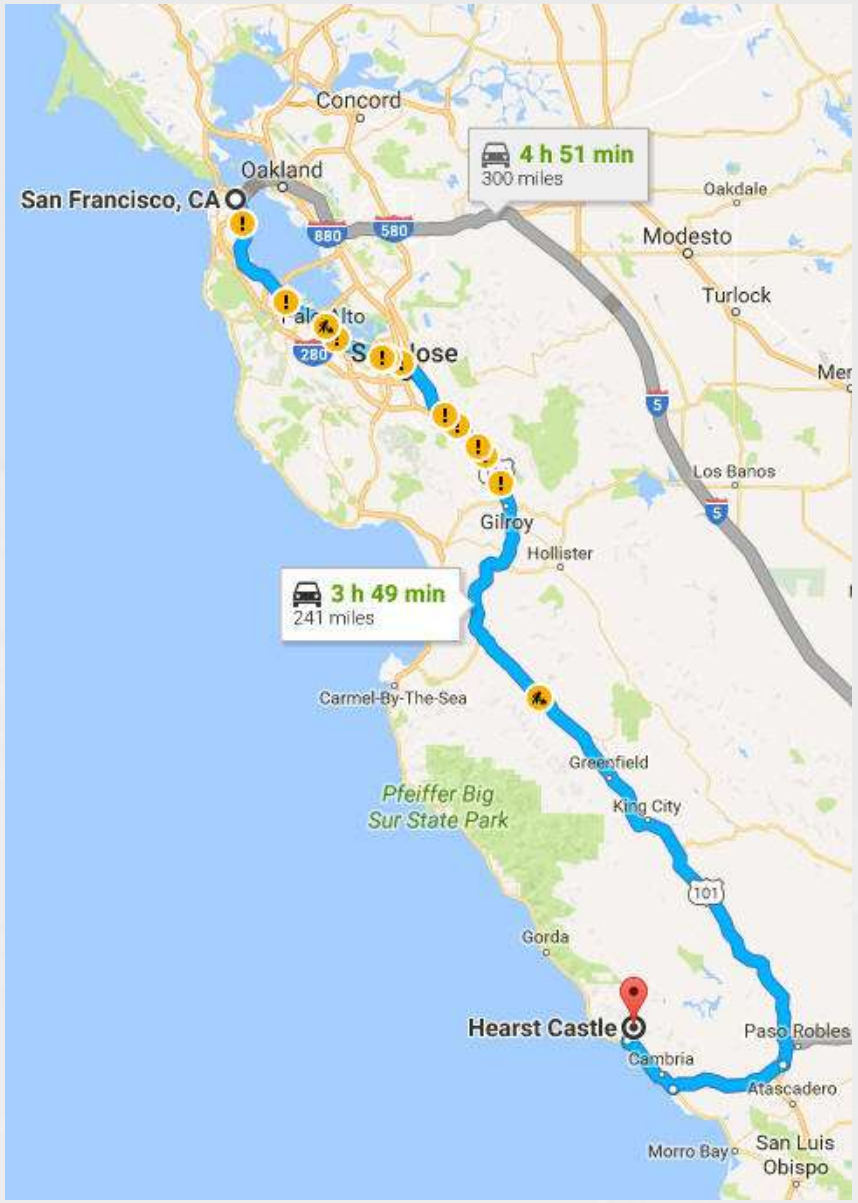
BASICS

- 10 nations have launching capabilities
- More than 40 countries have satellites in orbit
- Common purposes:
  * military and civilian Earth observation
  * communications
  * navigation
  * weather
  * research
- Statistics:
  * ~ 6,600 launched
  * ~ 3,600 remain in orbit
  * ~ 1,000 operational

- **Orbit classes:**
- Low-earth orbit (LEO)
  *~ 500 operational
  * altitude: 160 km – 2,000 km, usually >300 km
  * characteristics: atmospheric drag, > 7.8 km/s orbital velocity, simple and cheap placement, high bandwidth, low communication time lag (latency)
  * Examples: earth observation/spy satellites → better view
  * Example: International Space Station
- [ ] 400 km?
- [ ] 800 km?
- [ ] 1,200 km?



400 km (comparable with: SF – Hearst Castle)



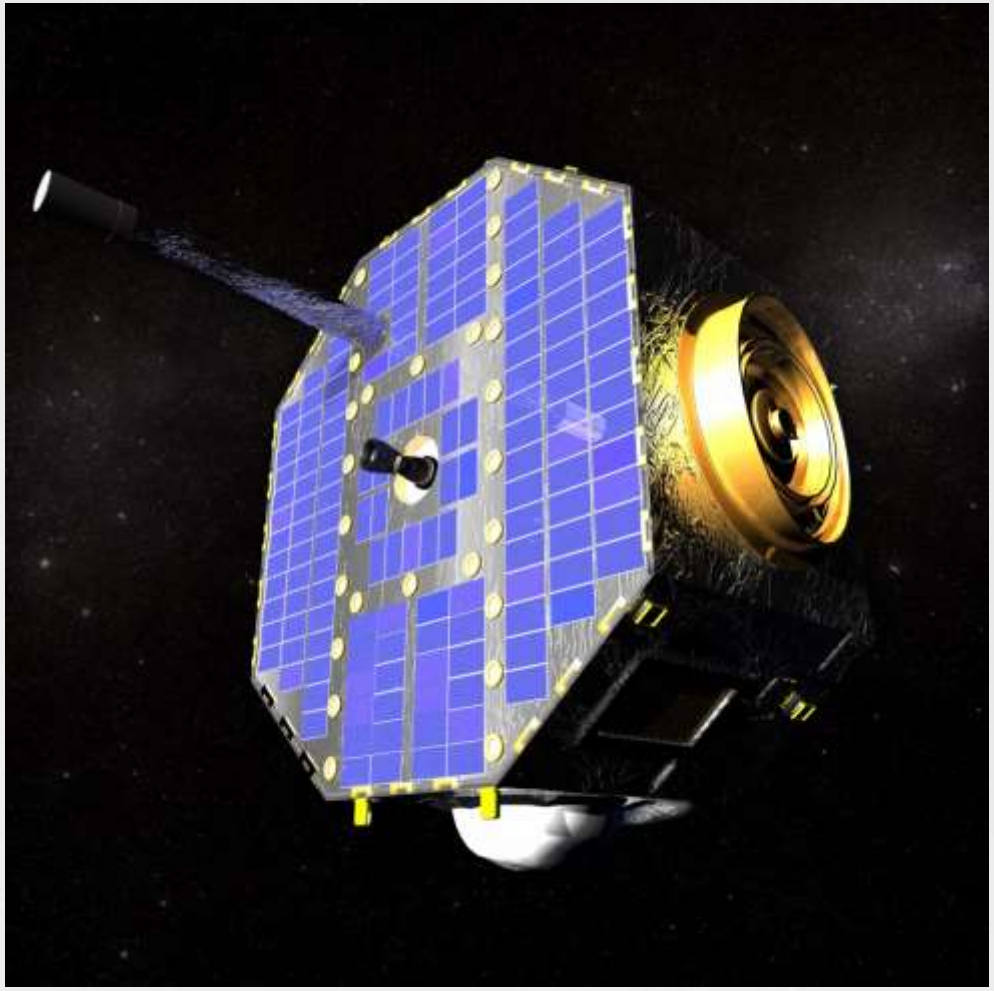
- **Orbit classes (continued):**
- Medium-earth orbit (MEO) / intermediate circular orbit (ICO)
  * 2,000 km < altitude < 35,786 km
  * most common: ~20,200 km – orbital period: 12 hours
  * navigation
  * communication
  * geodetic/space environment science
- Examples:
  * GPS (20,350 km)
  * Glonass (19,100 km)
  * Galileo (23,222 km)

- **Orbit classes (continued):**
- Geosynchronous orbit (GSO)
  * altitude = 35,786 km
  * orbital period matches Earth's sidereal rotation period (~23 h 56 min 4 sec)

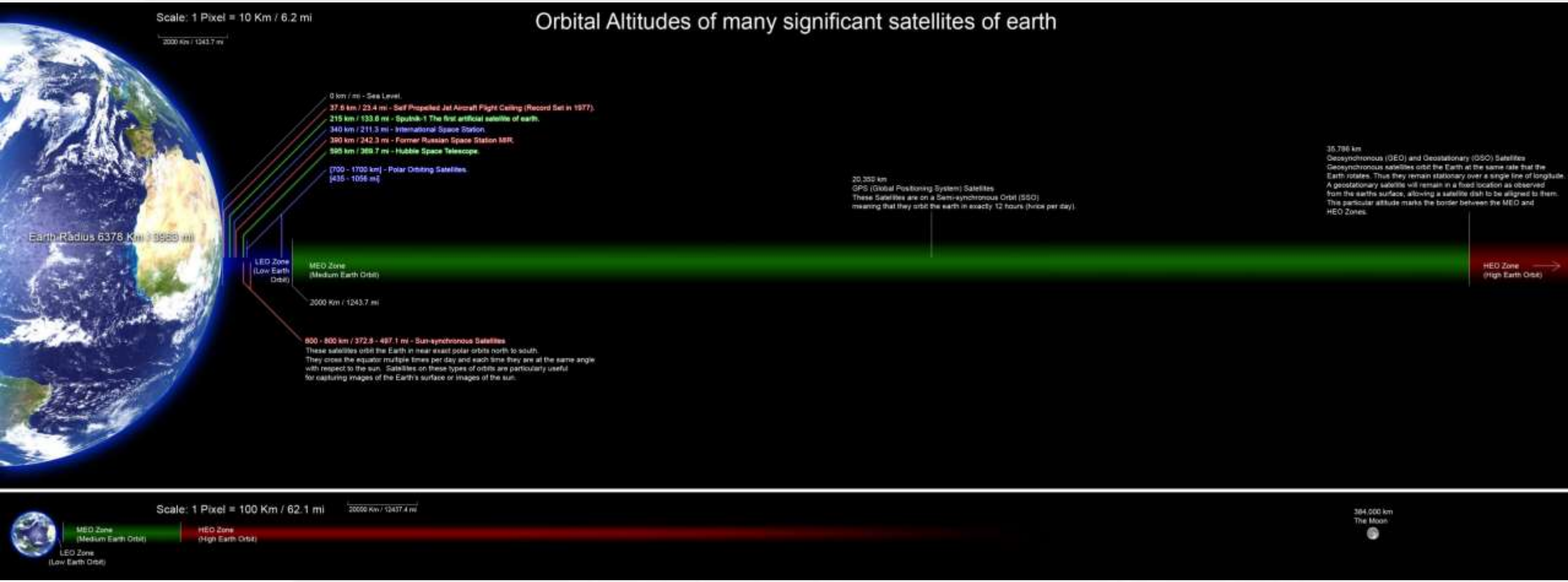
- Special case: geostationary Earth orbit (GEO)
  * zero inclination, i.e. directly above the equator

- Examples: communications satellites
  * antennas point permanently at a fixed location in the sky

- **Orbit classes (continued):**
- High earth orbit (HEO)
  * altitude < 35,786 km
  * orbital period: >24 hours
  * orbital velocity < Earth's rotational speed
- Example: Interstellar Boundary Explorer



source: NASA/Goddard Conceptual Image Lab - www.nasa.gov/mission_pages/ibex/multimedia/013112-briefing-materials.html



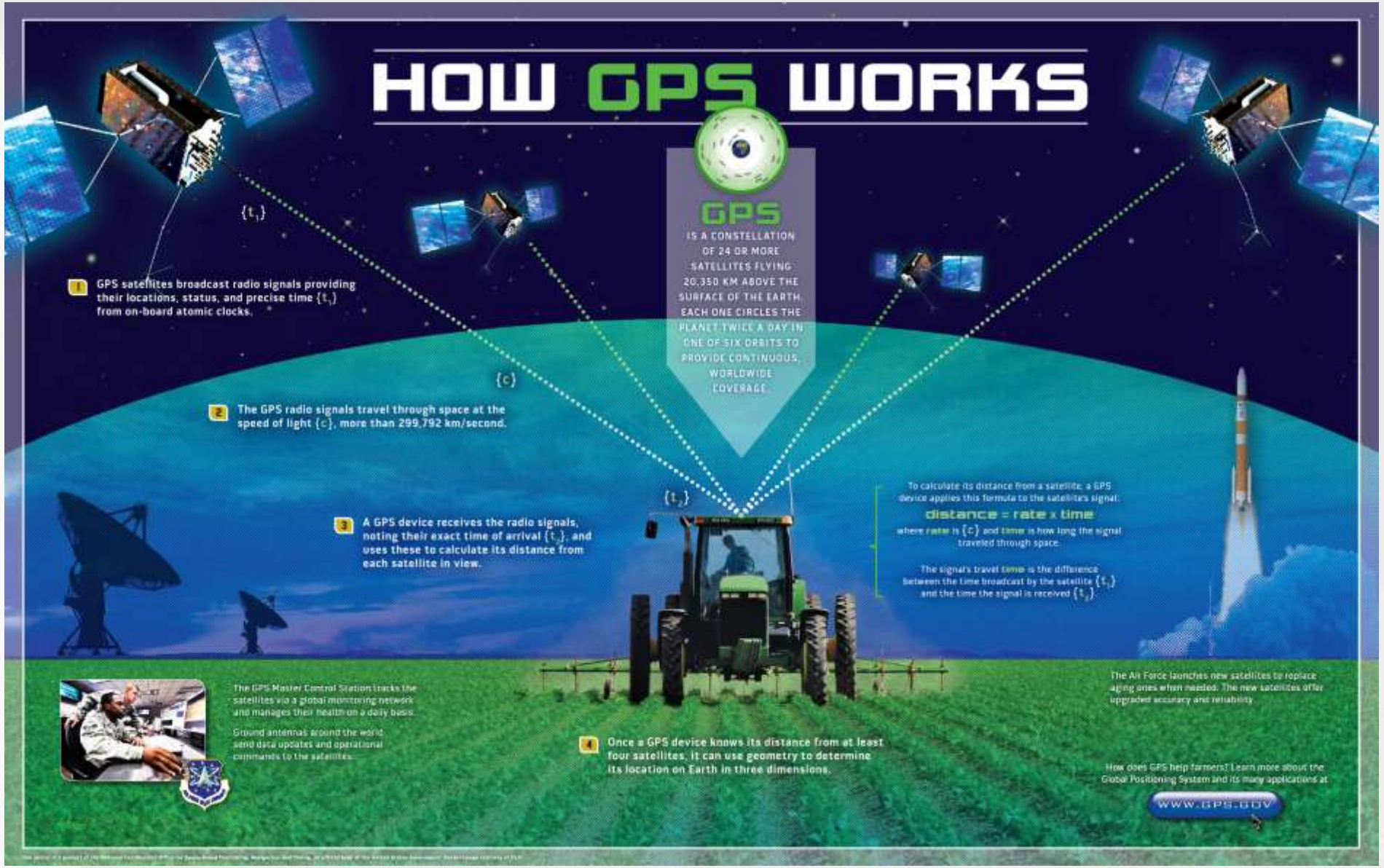
Source: By Rrakanishu - Own work, GFDL, commons.wikimedia.org/w/index.php?curid=4189737

DEPLOYED AND PLANNED SATELLITE SYSTEMS

USA: Global Positioning System (GPS)

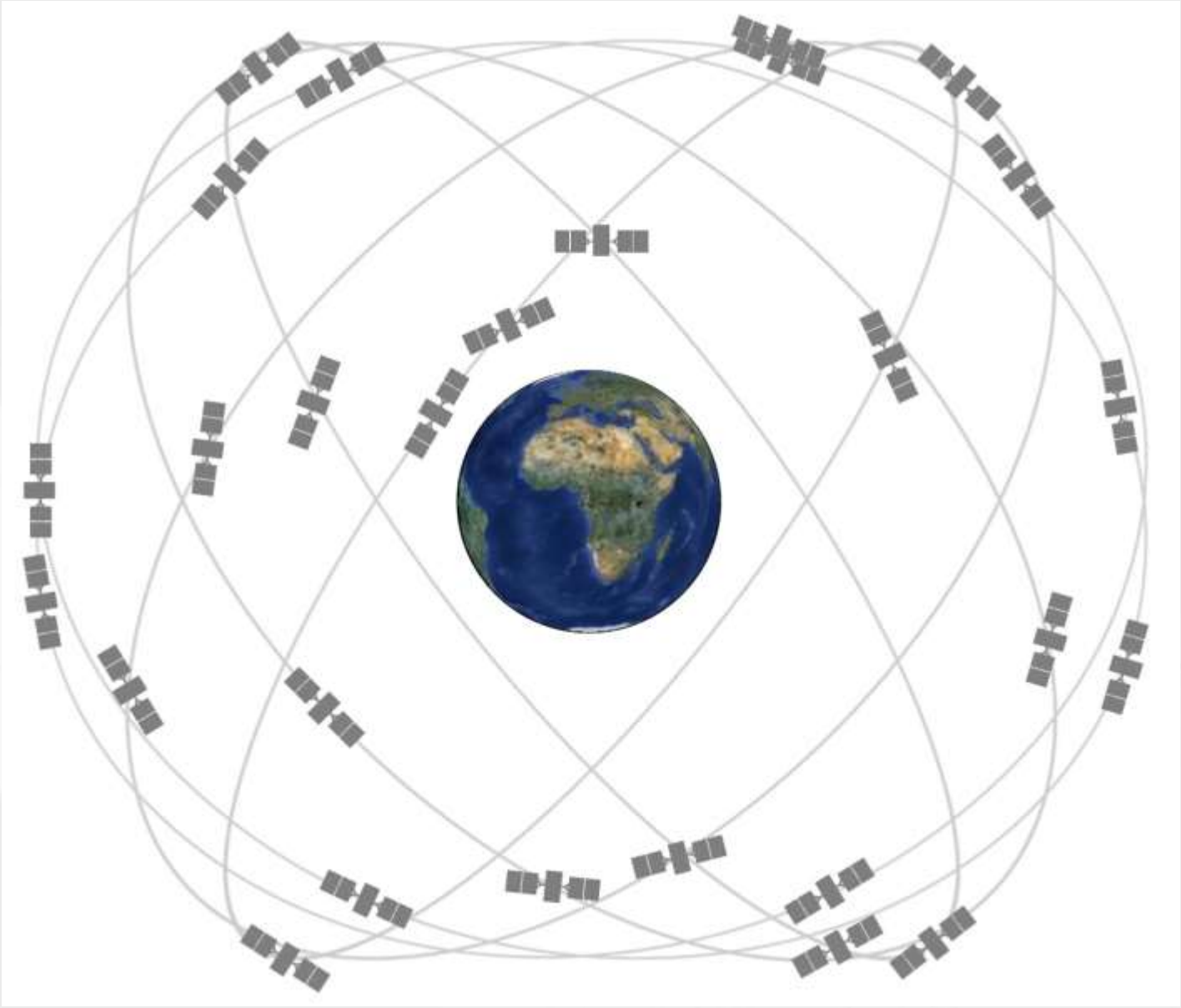
- 24+ satellites
- Each circles earth twice a day
- six equally-spaced orbital planes surrounding the Earth
- four "slots“ per plane occupied by baseline satellites
- users can view at least four satellites from virtually any point
- Altitude: 20,350 km

DEPLOYED AND PLANNED SATELLITE SYSTEMS



Source: www.gps.gov/multimedia/poster/poster-web.pdf

DEPLOYED AND PLANNED SATELLITE SYSTEMS



Source: www.gps.gov/multimedia/images

DEPLOYED AND PLANNED SATELLITE SYSTEMS

GPS Generations:

- mix of old and new satellites, aka “blocks”
- Currently 31operational satellites, plus decommissioned “residuals”
- Planned: GPS III
  * 4th civil signal on L1 frequency
  * better signal reliability, accuracy, and integrity
  * No Selective Availability (www.gps.gov/systems/gps/modernization/sa/)
  * 15-year lifespan

DEPLOYED AND PLANNED SATELLITE SYSTEMS

GPS Generations:

IIA
(1990-97)

IIR(M)
(2005-09)

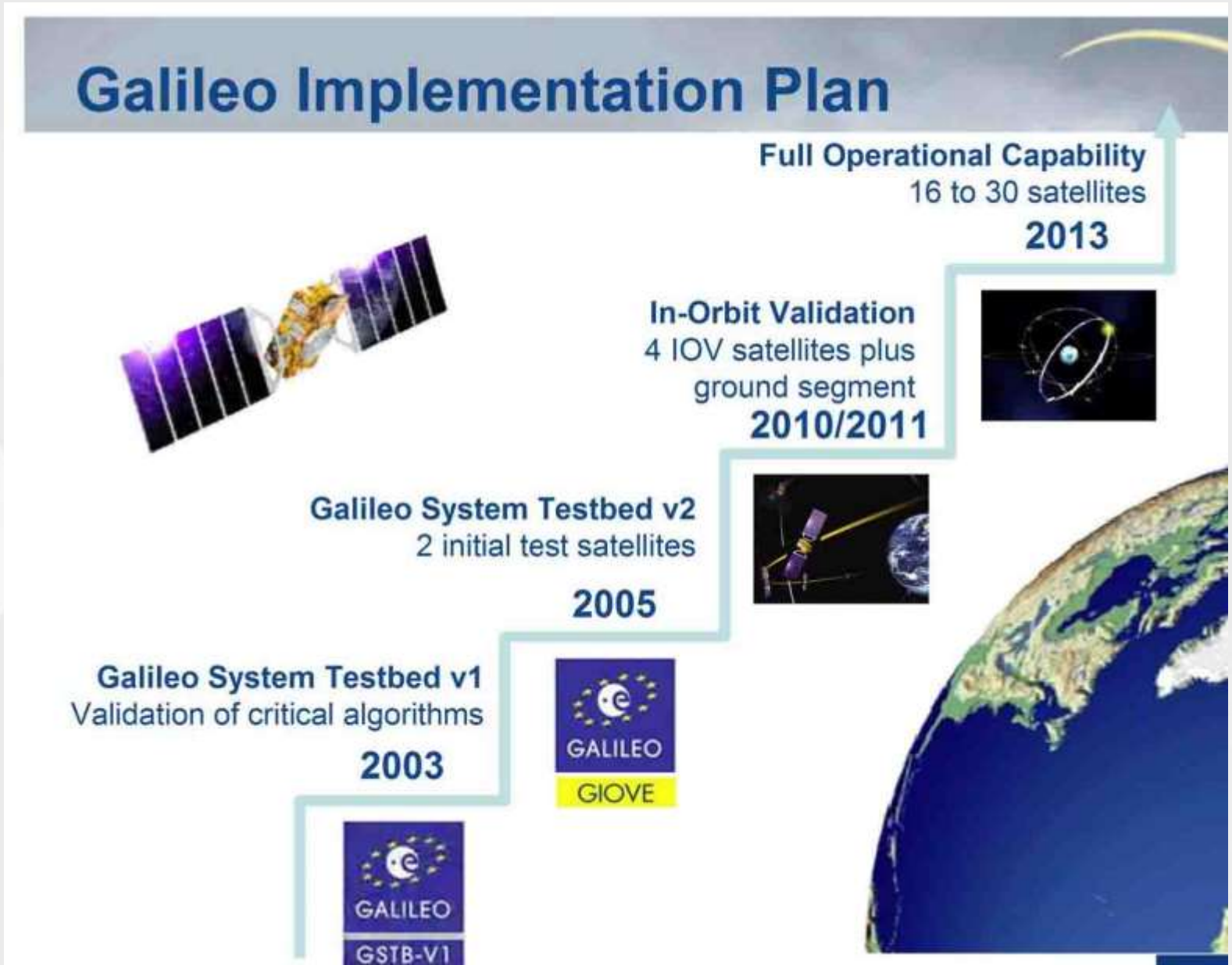
IIF
(2010-16)

DEPLOYED AND PLANNED SATELLITE SYSTEMS

Europe: Galileo

- Currently: 12 full-operational capability satellites (FOC)
- Planned: 30 satellites in Medium-Earth Orbit (MEO) on three orbital planes
- Political and organizational challenges
- New global search and rescue (SAR) function
- Tension and cooperation with USA re. jamming capability

DEPLOYED AND PLANNED SATELLITE SYSTEMS



DEPLOYED AND PLANNED SATELLITE SYSTEMS

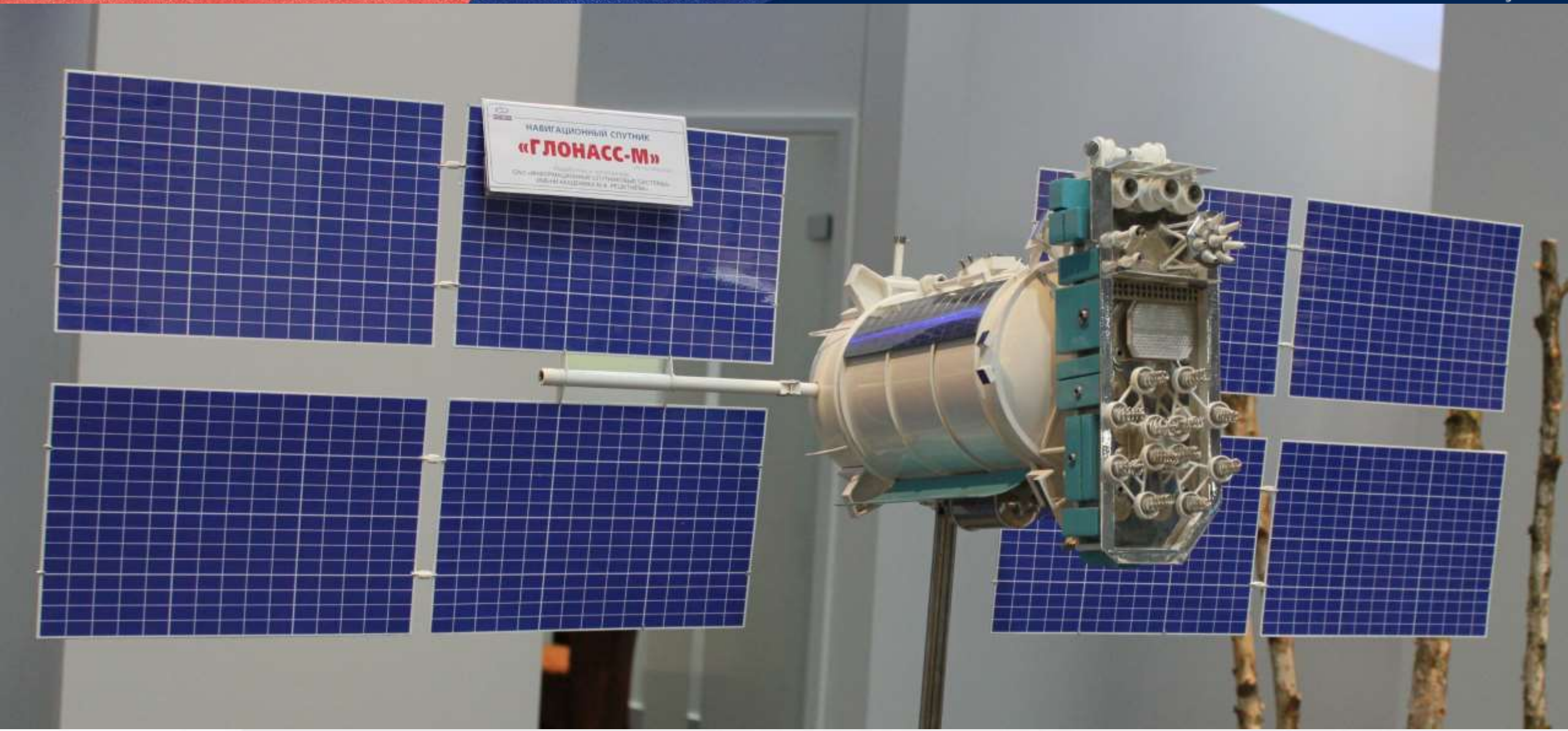
Inspection of main Antenna of 2nd Full Operational Capability (FOC) Galileo Satellite

DEPLOYED AND PLANNED SATELLITE SYSTEMS

Russian Federation: GLONASS

- Russian acronym: **GLO**bal'naya **NA**vigatsionnaya **S**putnikovaya **S**istema (Global Navigation Satellite System)
- 1982: First launch
- 1995: Full constellation
- 2001: only 7 operational
- 2016: 23 operational, mostly GLONASS-M
- 2016: first next-generation GLONASS-K satellite operational

DEPLOYED AND PLANNED SATELLITE SYSTEMS



DEPLOYED AND PLANNED SATELLITE SYSTEMS

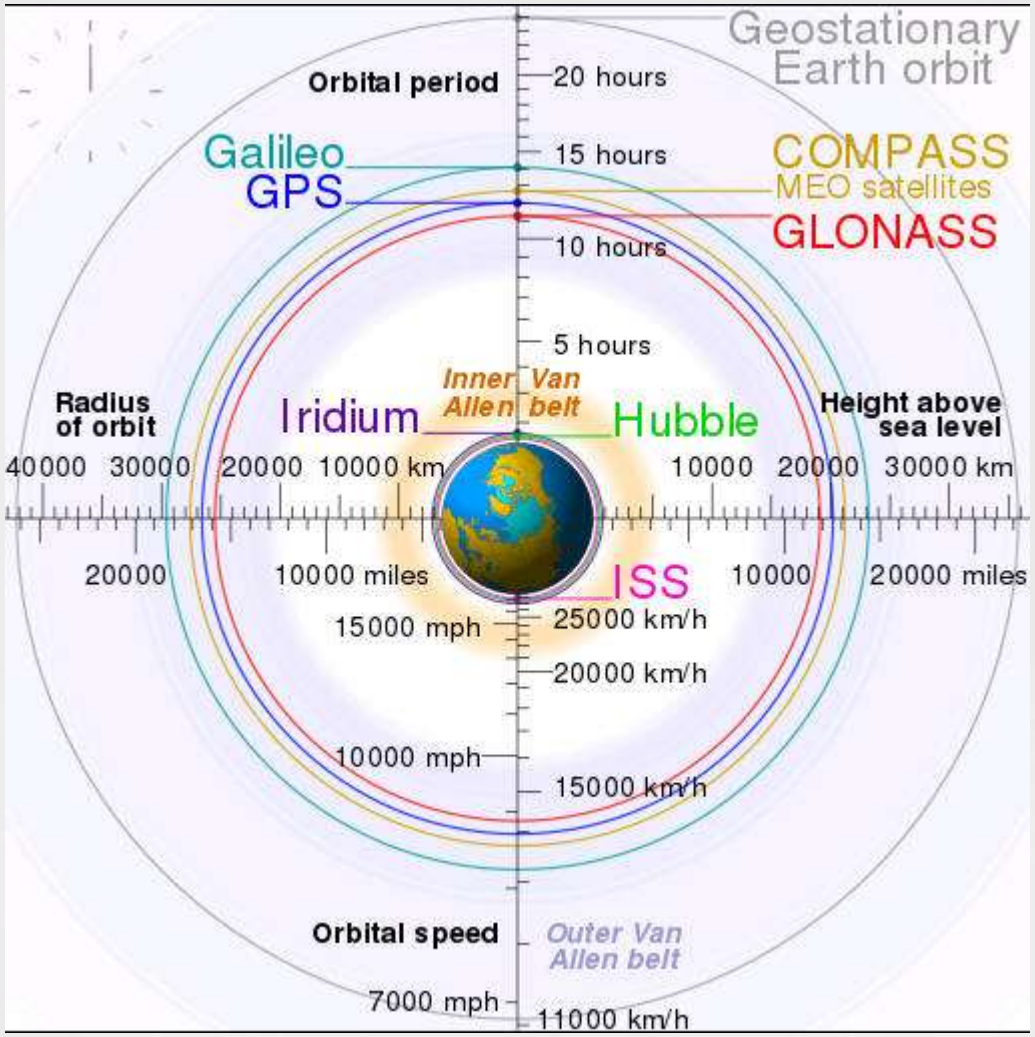
China: BeiDou

- 1st generation: limited test system since 2000
- 2nd generation: full-scale global navigation system with 35 satellites, operational in China since 2011; global completion planned for 2020
- 3rd generation: first launch in 2015 (currently 4)

DEPLOYED AND PLANNED SATELLITE SYSTEMS

DEPLOYED AND PLANNED SATELLITE SYSTEMS

Animated comparison of orbits



Source: en.wikipedia.org/wiki/Medium_Earth_orbit#/media/File:Comparison_satellite_navigation_orbits.svg

Space Agencies around the World

- Brazilian Space Agency (INPE)
- Canadian Space Agency (CSA)
- European Space Agency Earth Observation Portal (ESA)
- French Space Agency (CNES)
- German Space Agency (DLR)
- Indian Space Agency (ISRO)
- Japanese Space Agency (JAXA)
- Korean Space Agency (KARI)
- NASA earth observation portal (NASA)
- Nigeria Space Research and Development Agency (NASRDA)
- Russian Space Agency (RosCosmos)
- Taiwanese Space Agency (NSPO)

DEPLOYED AND PLANNED SATELLITE SYSTEMS

More details at:

- www.gps.gov
- www.gps.gov/systems/gps/space/
- en.beidou.gov.cn/index.html
- galileognss.eu/
- www.esa.int/Our_Activities/Navigation/Galileo/What_is_Galileo
- www.vermessung-und-ortung-mit-satelliten.de
- www.glonass-iac.ru/en/GLONASS/
- www.insidegnss.com/
- www.nasa.gov/content/goes
- www.space.com/19794-navstar.html

LEGAL / TREATIES / STANDARDS

- 1959: UN Committee on the Peaceful Uses of Outer Space (COPUOS)
- 2 subcommittees:
  * Scientific and Technical Subcommittee
  * Legal Subcommittee

International Treaties:

* 1967: Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (the "Outer Space Treaty")
* 1968: Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (the "Rescue Agreement")
* 1972: Convention on International Liability for Damage Caused by Space Objects (the "Liability Convention")
* 1975: Convention on Registration of Objects Launched into Outer Space (the "Registration Convention")
* 1979: Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (the "Moon Treaty")

LEGAL / TREATIES / STANDARDS

International Principles and Declarations:

- The Declaration of Legal Principles Governing the Activities of States in the Exploration and Uses of Outer Space (1963)
- The Principles Governing the Use by States of Artificial Earth Satellites for International Direct Television Broadcasting (1982)
- The Principles Relating to Remote Sensing of the Earth from Outer Space (1986)
- The Principles Relevant to the Use of Nuclear Power Sources in Outer Space (1992)
- The Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries (1996)

- Plus: 1998: **ISS Agreement** between Canada, ESA member states, Japan, Russian Federation, USA

- International Telecommunication Union (ITU) allocation mechanism regarding **geostationary orbit allocation** (limited number of orbital “slots”)

LEGAL / TREATIES / STANDARDS

Standards:

- Space Communications Protocol Specifications (SCPS)
- Developed by: Consultative Committee for Space Data Systems (CCSDS)
- FTP extensions
- TCP options
- Security protocol
- Bit-efficient network protocol

More details at:

- www.scps.org
- www.ccsds.org
- www.unoosa.org/oosa/en/ourwork/spacelaw/treaties.html
- www.americanbar.org/groups/young_lawyers/publications/the_101_201_practice_series/space_law_101_an_introduction_to_space_law.html

ACCURACY

- **GPS**: 2 services: civilian Standard Positioning Service (**SPS**) / military Precise Positioning Service (**PPS**)
- SPS: one frequency / PPS: two frequencies
- → PPS: *ionospheric correction,* reduces radio degradation caused by the Earth's atmosphere
- High-quality GPS SPS receivers: <3.5 meter horizontal accuracy
- SPS enhancements with local or regional augmentations (centimeter accuracy)
  * Nationwide Differential GPS System (NDGPS) [maritime users]
- * Wide Area Augmentation System (WAAS) [aviation users, plus others]
  * Continuously Operating Reference Stations (CORS) [tied to the National Spatial Reference System]
  * Global Differential GPS (GDGPS) [developed by the NASA Jet Propulsion Laboratory (JPL)]
  * International GNSS Service (IGS) [Earth science research, multidisciplinary applications, and education]

- **Selective Availability** officially ended in 2000
- Enhanced security and jam resistance for military GPS remain goals

ACCURACY

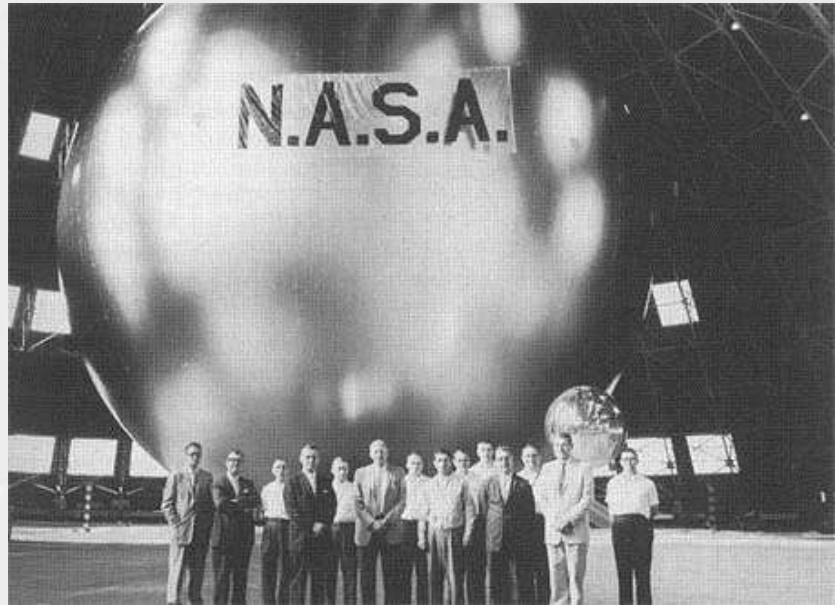
More details at:

- www.gps.gov/systems/gps/performance/accuracy
- www.gps.gov/systems/augmentations

APPLICATIONS OVERVIEW

Communication

- Purpose: relay and amplify radio telecommunications signals via a transponder
- History:
  * Oct. 4, 1957: Sputnik 1; 20.005 and 40.002 MHz
  * Aug. 12, 1960: Echo 1: 30 m aluminized PET film balloon; altitude: 1,600 km ("satelloon")
- Classes:
  * passive: only reflect; signal attenuation
  * active: amplify signal before re-transmission
- Applications:
  * Telephone
  * Television
  * Radio broadcasting
  * Amateur radio
  * Internet access
  * Military



APPLICATIONS OVERVIEW

Earth observation

- *Applications:*
  * Environmental monitoring
  * Meteorology
  * Mapping
- *Characteristics:*
  * Low-Earth Orbit (LEO), e.g. 700-800 km
  * Polar orbit
  * orbital period: ~100 min
  * ground track shifted westward by 25 degrees in longitude
- *Overview:* Earth Observation Portal: directory.eoportal.org/web/eoportal/satellite-missions

APPLICATIONS OVERVIEW

Earth observation

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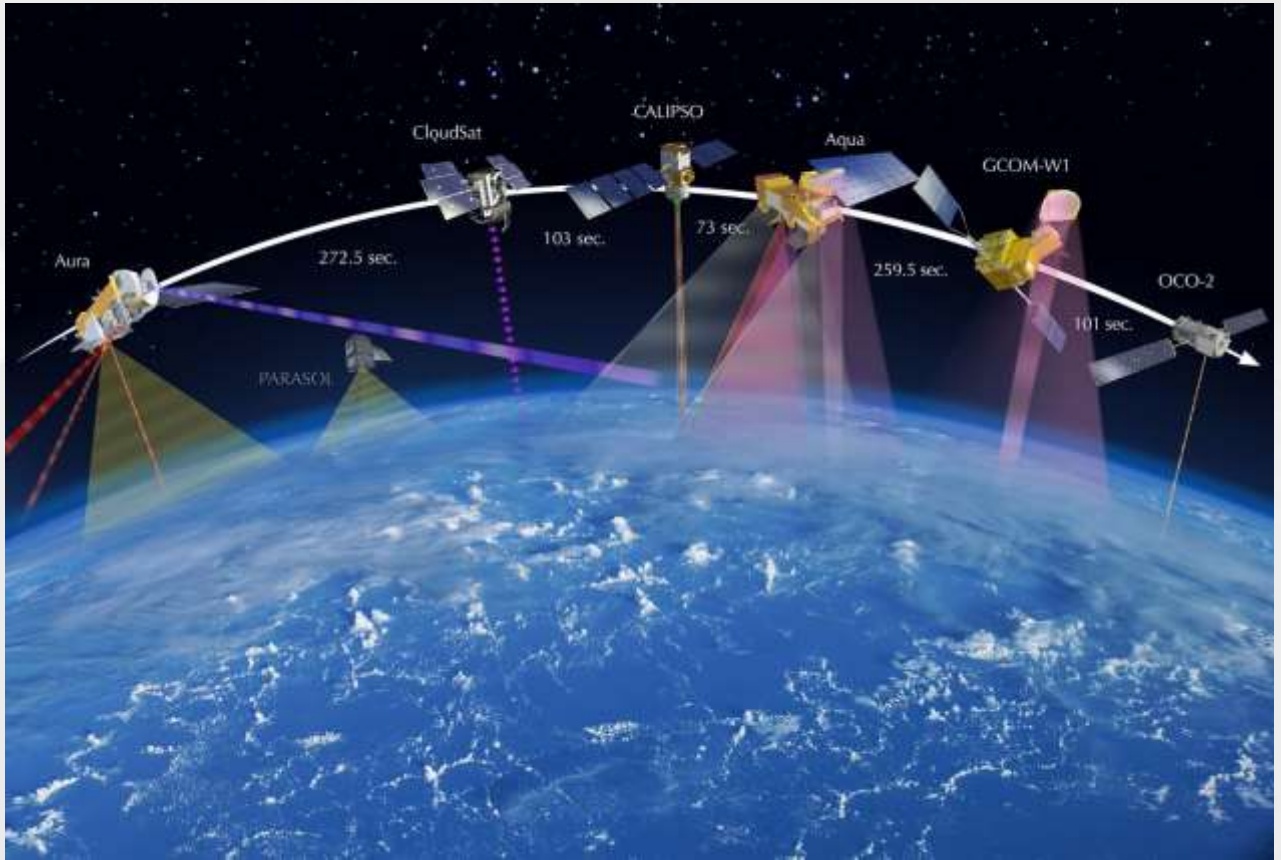
Earth observation

- Example: A-Train Constellation
  * “Afternoon Train” – crosses equator each day around 1:30 p.m. (and again at 1:30 a.m.)
  * 6 satellites, closely spaced for HD 3D images of atmosphere and Earth’s surface



APPLICATIONS OVERVIEW

Top Ten examples for earth observation, economic monitoring, environmental monitoring, disaster response, etc.

- 1: Search and Rescue support after aircraft crashes
  * all newer navigation satellites with SAR payload
- 2: Damage assessment after earthquakes
  * change detection (pre- and post-earthquake)
  * casted shadows from buildings
- 3: Early warning signs for famines
  * vegetation growth and crop yield forecasting
- 4: Snowpack assessment
  * predict drinking water supply
  * flood control
- 5: Detecting undeclared nuclear power plants
  * circular cooling tower
  * thermal emissions
  * near waterways and roads/railways

APPLICATIONS OVERVIEW

Top Ten examples for earth observation, economic monitoring, environmental monitoring, disaster response, etc.

- 6: Counting polar bears
  * image comparison: bears move, big white rocks don't
- 7: Measuring the size of protests
  * area and density of protesters → how big is the crowd?
- 8: Predict retail earnings & market share
  * count cars in parking lots
- 9: Measuring rise of sea levels
  * compare baseline spatial data with changed imagery
- 10: Watching the aurora borealis from above
  * front row seating from International Space Station
  (www.nasa.gov/topics/shuttle_station/features/20110917-aurora.html)





- Source: gisgeography.com/100-earth-remote-sensing-applications-uses

APPLICATIONS OVERVIEW

More details at:

- www.sia.org (Satellite Industry Association)
- www.esoa.net (European Satellite Operators Association)

TRANSLATION RESOURCES

Monolingual

- *System sites:*
  * www.gps.gov
  * www.earthobservatory.nasa.gov
  * galileognss.eu
  * www.esa.int/ESA
  * www.esa.int/ger/ESA_in_your_country/Germany
  * www.esa.int/fre/ESA_in_your_country/France
  * www.esa.int/ita/ESA_in_your_country/Italy
  * en.beidou.gov.cn/index.html
  * www.beidou.gov.cn/

- *Overview sites:*
  * www.kowoma.de/gps/

TRANSLATION RESOURCES

Glossaries

* www.nasa.gov/content/scan-glossary (**S**pace **C**ommunications **A**nd **N**avigation) (EN)
* www.kowoma.de/gps/glossar.htm (EN-DE)
* www.eutelsat.com/en/support/glossary/satellite-terminology.html (EN)
* www.intelsat.com/tools-resources/library/satellite-technology-glossary (EN)
* www.kathrein.com/de/loesungen/satellitenempfangs/support/sat-lexikon (DE)
* www.dwd.de/DE/service/lexikon/Functions/glossar.html (DE)
* www.axio-net.eu/technologien/glossar (DE)

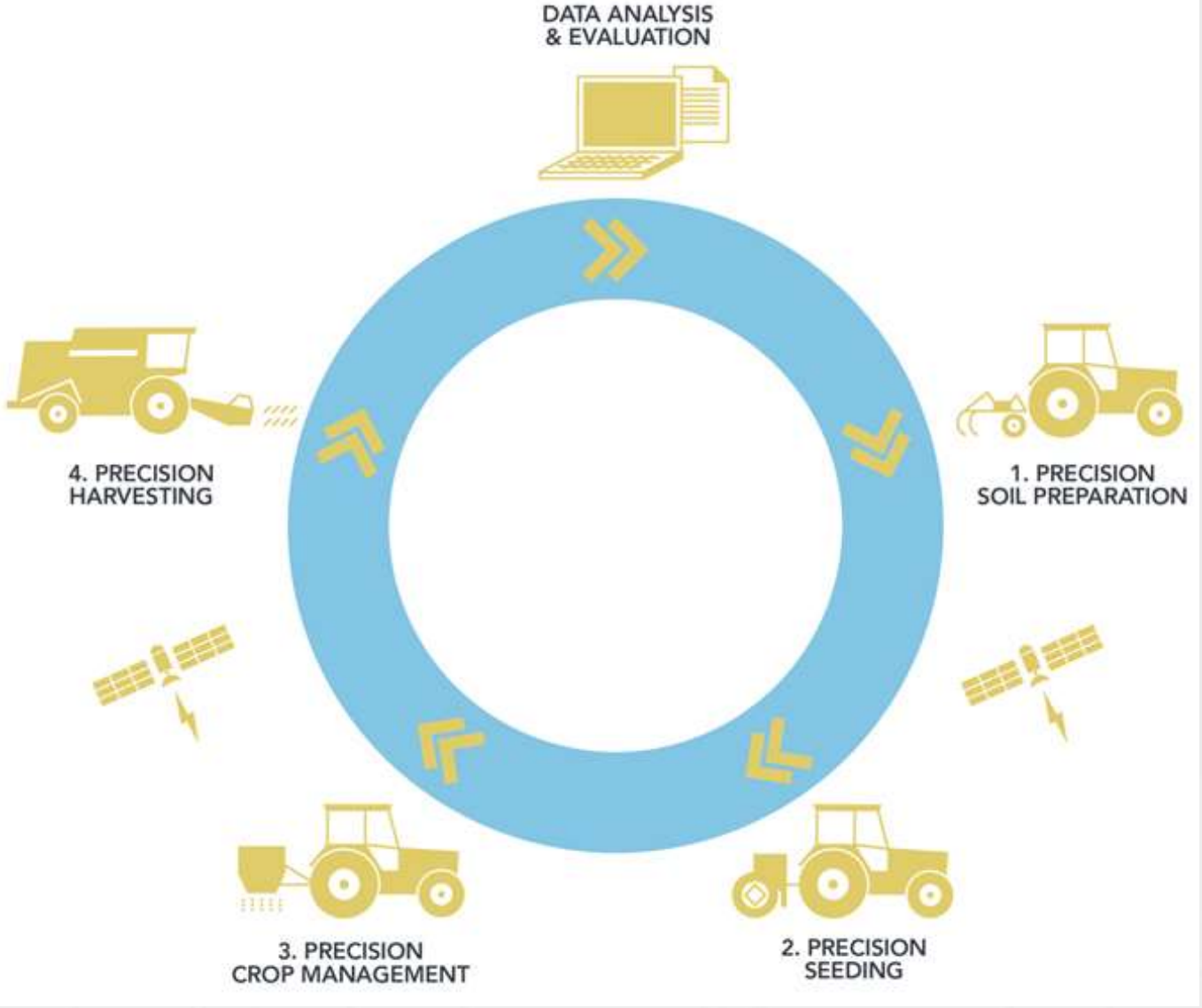
Application-specific: Precision Farming

What is Precision Farming?

Basic objective:
using IT tools during the entire crop growth cycle,
grow more food
with fewer resources and
lower production costs

See terms and definitions at:
www.precisionag.com/business/precision-agriculture-terms-and-definitions

More details at:
earthobservatory.nasa.gov/Features/PrecisionFarming



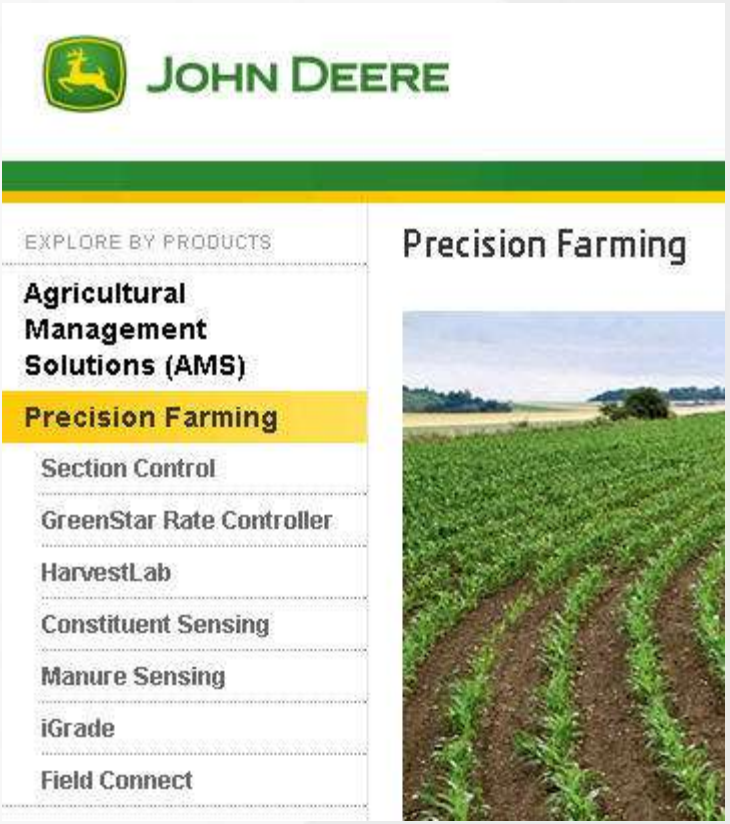
Source: http://cema-agri.org/page/precision-farming-0

TRANSLATION RESOURCES

Application-specific: Precision Farming

* align multi-lingual sites, e.g.

www.deere.com/en_INT/products/equipment/agricultural_management_solutions/precision_farming_solutions/precision_farming_solutions.page
and www.deere.de/de_DE/products/equipment/agricultural_management_solutions/precision_farming_solutions/precision_farming_solutions.page



Application-specific: Precision Farming

GreenStar Rate Controller

This compact unit enables rate and section control of non-ISOBUS implements by serving as the interface for your GreenStar display. You can automatically control fertilizer, chemical, nutrient and seed delivery without the need of a second console in the cab.

GreenStar Rate Controller integrates with many implements, such as John Deere or non-John Deere pull-type sprayers, anhydrous ammonia applicators, liquid manure spreaders, liquid fertilizer systems, and planters.

Übersicht | Technische Daten

GreenStar Ausbringmengen-Steuerung

Mit diesem kompakten System regulieren und steuern Sie über Ihr GreenStar Display die Ausbringmengen und Teilbreiten nicht ISOBUS-fähiger Anbaugeräte. Es erlaubt die punktgenaue automatische Ausbringung von Dünge-, Pflanzenschutzmitteln und Saatgut und erfordert nicht einmal ein zweites Display in Ihrer Kabine.

Die GreenStar Ausbringmengen-Steuerung eignet sich für viele Anbaugeräte unterschiedlicher Hersteller wie Anhängefeldspritzen, Geräte zur Ausbringung von wasserfreiem Ammoniak oder Flüssigdünger, Güllefässern und Sämaschinen.

Application-specific: Precision Farming

- Glossaries:
  * www.agriculture.purdue.edu/ssmc/frames/newglossery.htm
  * www.environmental-studies.de/Precision_Farming/Glossary__Precision_Farming/glossary.html (EN-DE)

English	German
A	A
absorption	Absorption
absorption band	Absorptionsband
absorption factor	Absorptionsgrad
acidification of the soil	Bodenversauerung
active sensing system	Aufnahmeverfahren, aktives
activity-based costing	Prozeßkostenrechnung
add-on costs	Zusatzkosten, Mehrkosten
adjudication	Feststellung von bodenrechtlichen Ansprüchen
aeration of soil	Bodenbelüftung
agrarian reform	Agrarreform
agrarian structure	Agrarstruktur
agrarian structure development planning	agrarstrukturelle Entwicklungsplanung (AEP)

Application-specific: Telematics

- Telecommunication technology to control remote objects
- Specifically: monitor and control vehicles
  * tracking
  * GeoFence
  * fleet management
  * machine health monitoring
  * remote diagnostics and repair

Application-specific: Telematics

How does it work?

- Example: Telematics for heavy equipment management

Source: www.youtube.com/embed/W3c_OJW6H_w

TRANSLATION RESOURCES

Application-specific: Telematics

- Glossaries:
  * www.ctrack.co.uk/terminology-explained.html (EN)
  * www.telogis.com/glossary (EN)
  * telematikwissen.de/glossar (DE)
  * teleorbit.eu/de/service/glossar (DE)

A | B | C | D | E | F | G | H | I | J | K | L | M | O | P | Q | R | S | T | U | V | W | X | Z | Ö

Reset list

Galileo - Galileo ist das erste, unter ziviler Kontrolle stehende, weltweite Satellitennavigations- und Ortungssystem, das der internationalen Zusammenarbeit offen steht und kommerziell betrieben wird. Dieses unabhängige System bietet einen hochpräzisen, garantierten, weltumspannenden Dienst, der auch in Krisenzeiten einsatzfähig bleibt. Galileo gewährleistet damit einerseits die europäische Unabhängigkeit von den beiden militärisch kontrollierten Systemen GPS (USA) und GLONASS (Russland) und unterstreicht andererseits die Souveränität Europas.

Gateway - Schnittstelle eines internen Netzes zu anderen Netzen (Internet), oder zwischen Internet-Netzen wie Vodafone und T-Online, um die unterschiedlichen, teils proprietären Protokolle zu übersetzen.

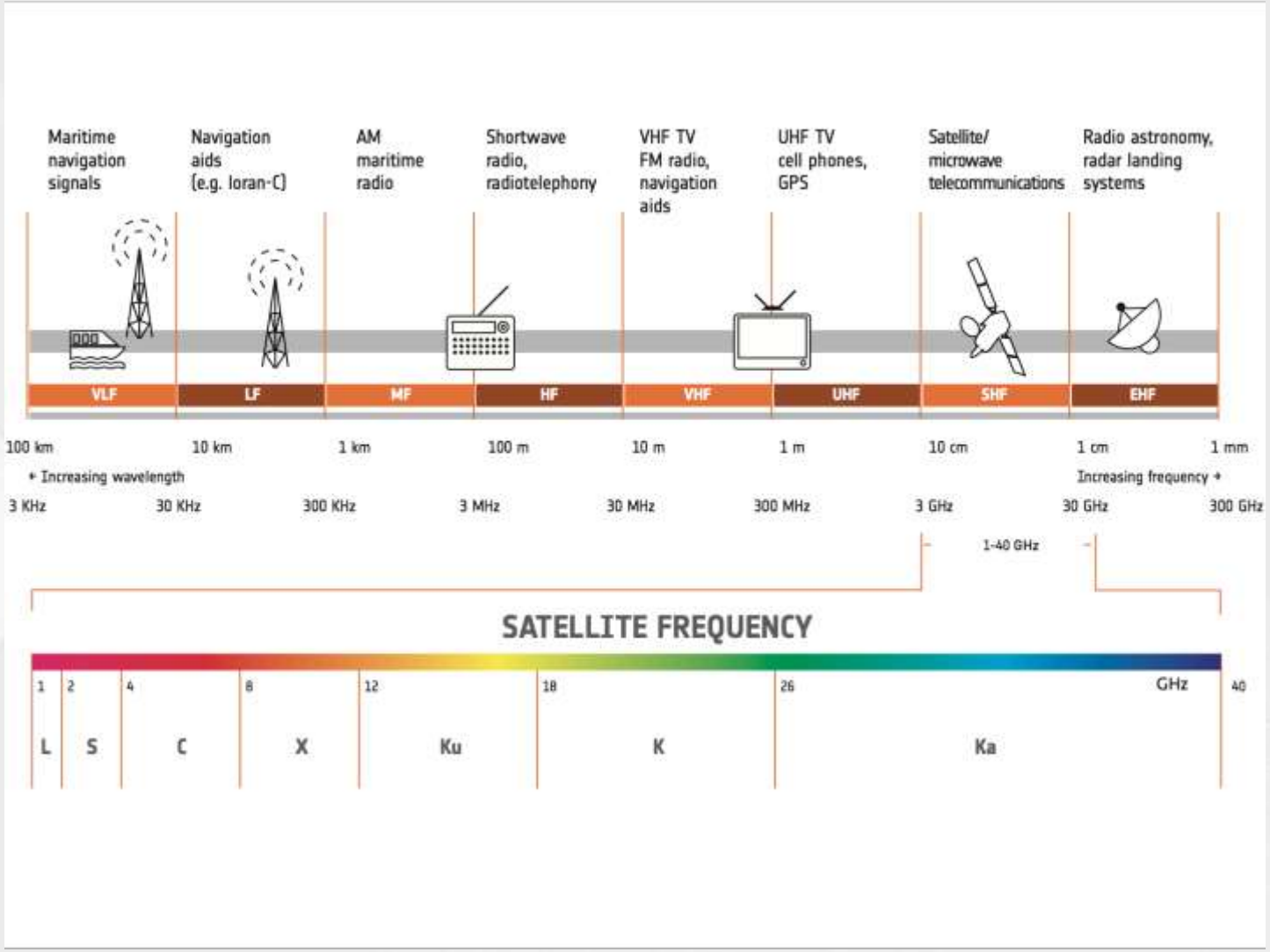
Geofencing - Verbindung zwischen Geoinformationssystem, der Lokalisation der Objekte und aktiven Eingriffen, wenn das lokalisierte Objekt ein vordefiniertes Gebiet verlässt oder betritt.

TRANSLATION RESOURCES

Forum

- www.gpsforum.geospector.de

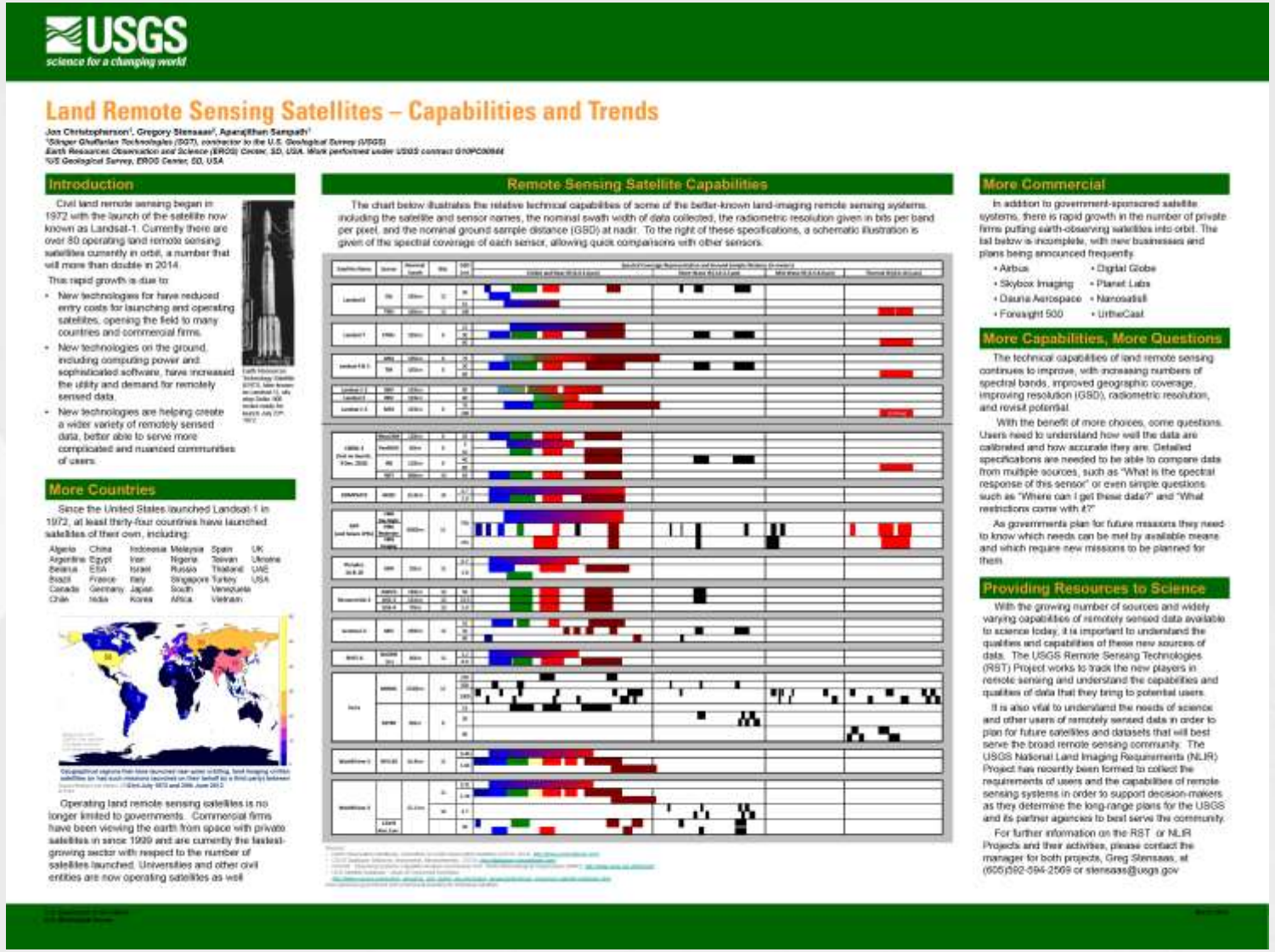
What frequencies do satellites use?



Source: www.esa.int/Our_Activities/Telecommunications_Integrated_Applications/Satellite_frequency_bands

Which remote-sensing capabilities do satellites have?

- Visible spectrum
- Near infrared
- Short-wave IR
- Mid-wave IR
- Thermal IR



USGS
science for a changing world

Land Remote Sensing Satellites – Capabilities and Trends

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Introduction

Civil land remote sensing began in 1972 with the launch of the satellite now known as Landsat-1. Currently there are over 80 operating land remote sensing satellites currently in orbit, a number that will more than double in 2014.

This rapid growth is due to:

- New technologies for have reduced entry costs for launching and operating satellites, opening the field to many countries and commercial firms.
- New technologies on the ground, including computing power and sophisticated software, have increased the utility and demand for remotely sensed data.
- New technologies are helping create a wider variety of remotely sensed data, better able to serve more complicated and nuanced communities of users.

More Countries

Since the United States launched Landsat-1 in 1972, at least thirty-four countries have launched satellites of their own, including:

Algeria	China	Indonesia	Malaysia	Spain	UK
Argentina	Egypt	Iran	Nigeria	Taiwan	Ukraine
Belarus	ESA	Israel	Russia	Thailand	UAE
Brazil	France	Italy	Singapore	Turkey	USA
Canada	Germany	Japan	South	Venezuela	
Chile	India	Korea	Africa	Vietnam	

Operating land remote sensing satellites is no longer limited to governments. Commercial firms have been viewing the earth from space with private satellites in since 1999 and are currently the fastest-growing sector with respect to the number of satellites launched. Universities and other civil entities are now operating satellites as well.

Remote Sensing Satellite Capabilities

The chart below illustrates the relative technical capabilities of some of the better-known land-imaging remote sensing systems, including the satellite and sensor names, the nominal swath width of data collected, the radiometric resolution given in bits per band per pixel, and the nominal ground sample distance (GSD) at nadir. To the right of these specifications, a schematic illustration is given of the spectral coverage of each sensor, allowing quick comparisons with other sensors.

More Commercial

In addition to government-sponsored satellite systems, there is rapid growth in the number of private firms putting earth-observing satellites into orbit. The list below is incomplete, with new businesses and plans being announced frequently.

- Airbus
- Digital Globe
- Skybox Imaging
- Planet Labs
- Dauria Aerospace
- Nanosatisfi
- Foresight 500
- UrtheCast

More Capabilities, More Questions

The technical capabilities of land remote sensing continues to improve, with increasing numbers of spectral bands, improved geographic coverage, improving resolution (GSD), radiometric resolution, and revisit potential.

With the benefit of more choices, come questions. Users need to understand how well the data are calibrated and how accurate they are. Detailed specifications are needed to be able to compare data from multiple sources, such as "What is the spectral response of this sensor" or even simple questions such as "Where can I get these data?" and "What restrictions come with it?"

As governments plan for future missions they need to know which needs can be met by available means and which require new missions to be planned for them.

Providing Resources to Science

With the growing number of sources and widely varying capabilities of remotely sensed data available to science today, it is important to understand the qualities and capabilities of these new sources of data. The USGS Remote Sensing Technologies (RST) Project works to track the new players in remote sensing and understand the capabilities and qualities of data that they bring to potential users.

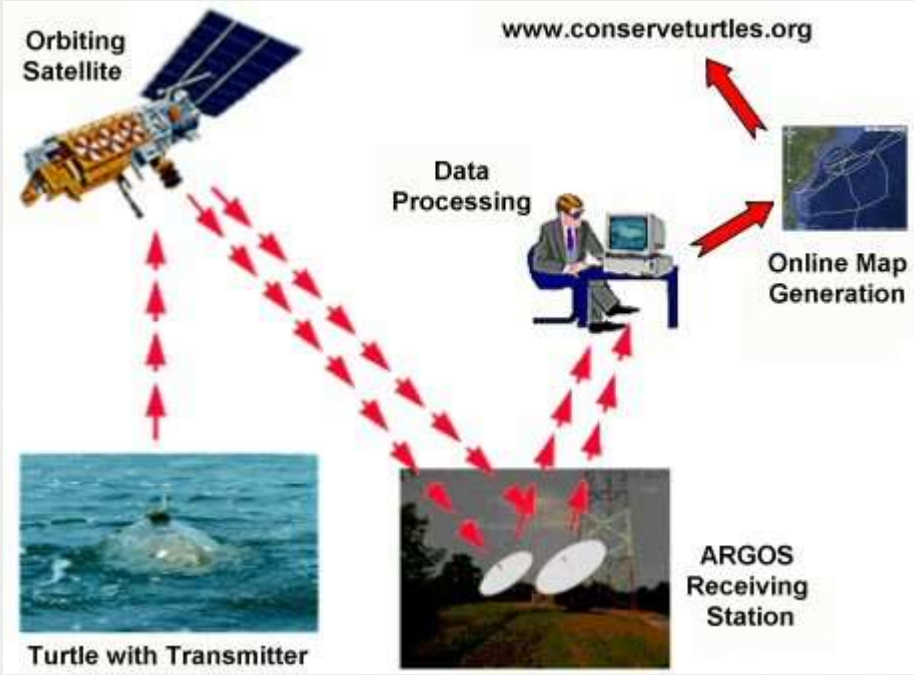
It is also vital to understand the needs of science and other users of remotely sensed data in order to plan for future satellites and datasets that will best serve the broad remote sensing community. The USGS National Land Imaging Requirements (NLIR) Project has recently been formed to collect the requirements of users and the capabilities of remote sensing systems in order to support decision-makers as they determine the long-range plans for the USGS and its partner agencies to best serve the community.

For further information on the RST or NLIR Projects and their activities, please contact the manager for both projects, Greg Stensaas, at (605)592-594-2569 or stensaas@usgs.gov

Source: calval.cr.usgs.gov/wordpress/wp-content/uploads/Satellite-Trends-Poster-ASPRS-JACIE.pdf

THANK YOU!

- Remember the sea turtles?



THANK YOU

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Book and AV recommendations

- Alfred, Randy (ed.): Mad science : Einstein's fridge, Dewar's flask, Mach's speed, and 362 other inventions and discoveries that made our world; New York: Little, Brown and Company, 2012.
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- Segal, Adam: The hacked world order : how nations fight, trade, maneuver, and manipulate in the digital age; New York: PublicAffairs, 2016.
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BIO

Karl Pfeiffer is an ATA-certified English to German translator.

After graduating with a degree in Physics from the University of Tübingen, Germany, he focused on translating engineering documents, specializing in satellite technology and the lifting industry (cranes and aerial work platforms).

He is Lead German Linguist at **Argos Multilingual**, a global language solutions provider with offices in Krakow, Poland, and Overland Park, Kansas.

At prior ATA conferences, Karl has presented topics ranging from the German spelling reform to DIN standards and Word macros.