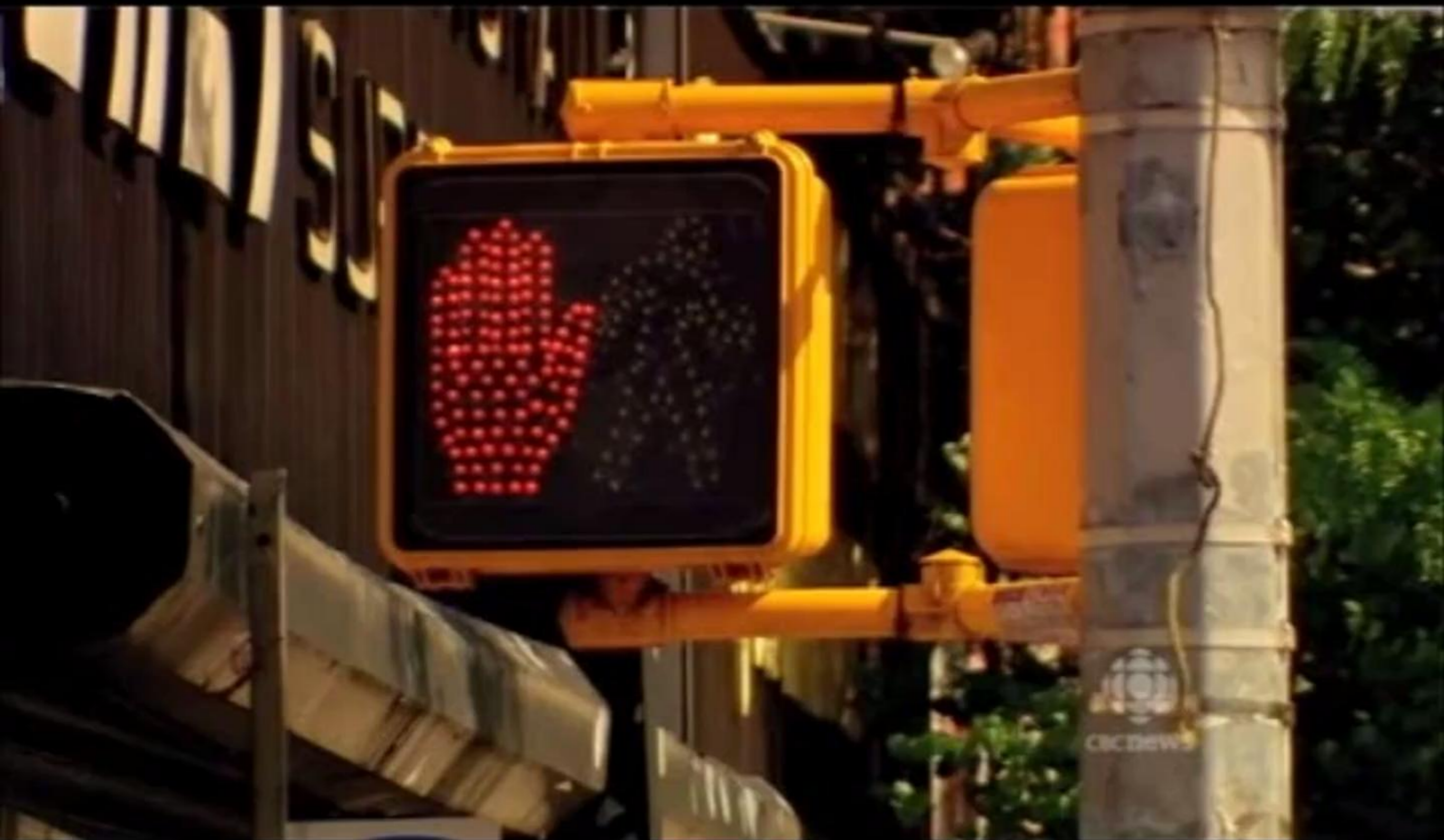




Satellites As Infrastructure

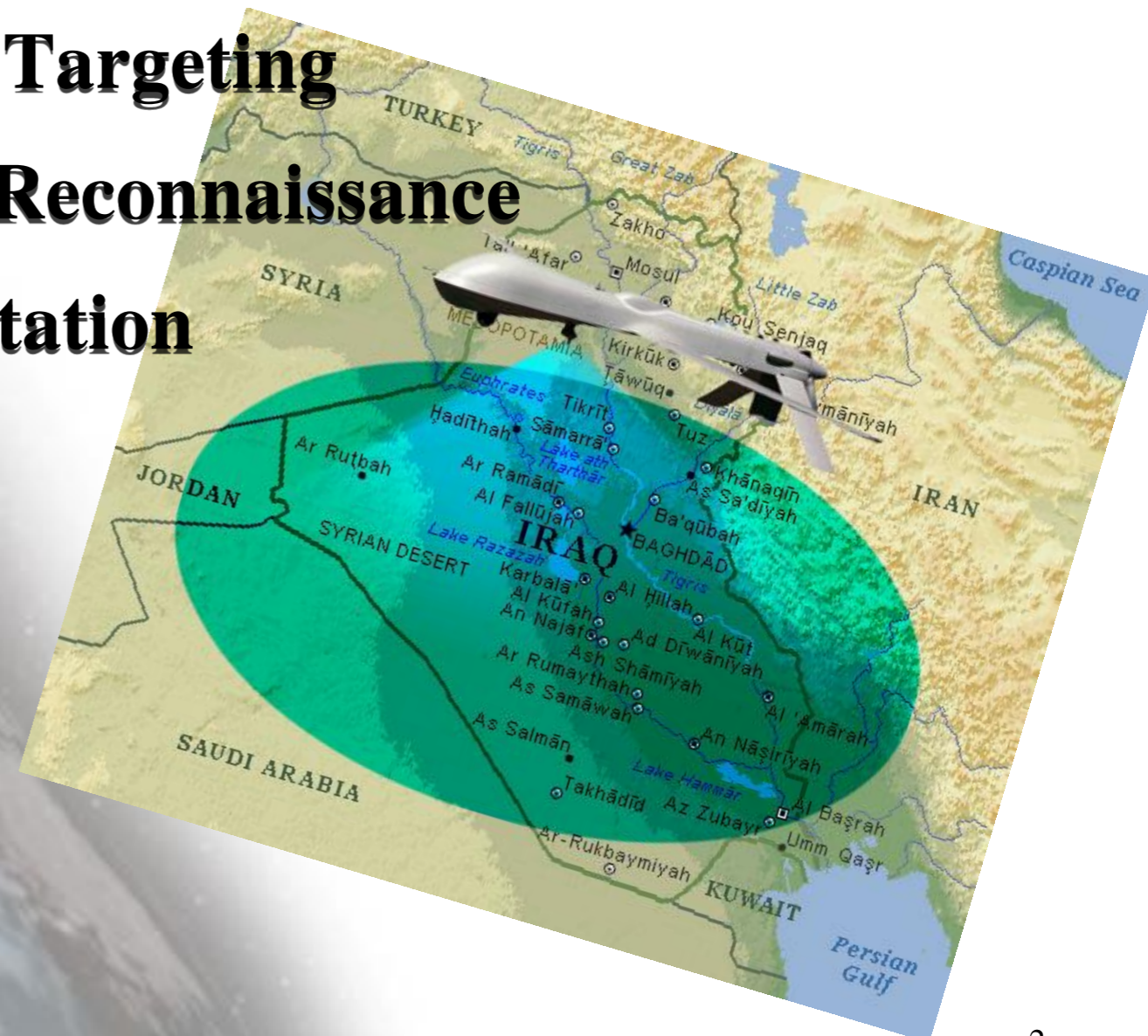
Lets Make A Smarter Planet



National Security



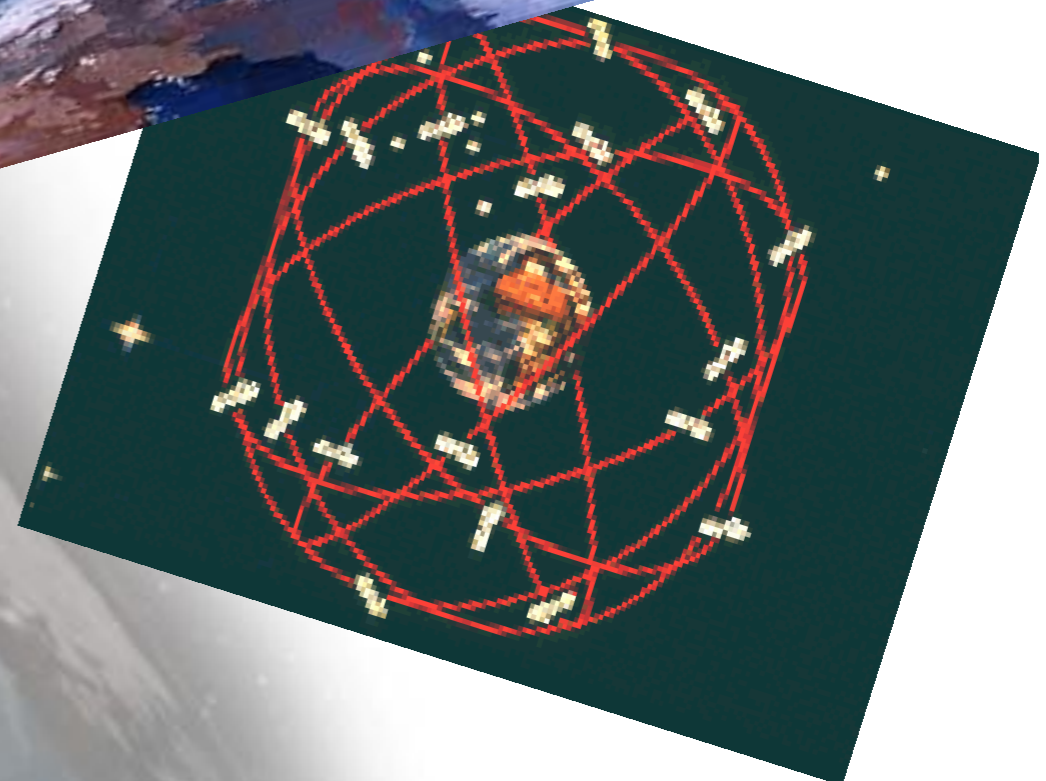
- **Communications (Voice, Data, Television)**
- **Position, Navigation and Timing**
- **Early Warning, Tracking and Targeting**
- **Intelligence, Surveillance and Reconnaissance**
- **Technology, R&D, Experimentation**
- **Meteorological Observation**



Navigation



- **Military technology which civilians can't live without**
 - **Public safety dispatch**
 - **Search and Rescue**
 - **Air Traffic Control**
 - **Telecommunications**
 - **Transportation**
- **Increasing military uses**
 - **Precision Munitions**
 - **Cruise Missiles**
 - **Unmanned Aerial Vehicles**



Economy



- **Backbone of national TV, radio, and print media distribution**
- **Billions of data, credit, banking transactions daily**
- **Allows decentralized telecommunications and document storage**
- **Inventory management**



Broadcast Industry



- **Newsgathering – First choice for live coverage**
- **Program Delivery – Primary feeds for network TV and radio broadcasts**



Internal Security



- **Lifeline for emergency workers and military planners**
- **Reliance on satellite phones and satellite trucks**
- **Enable data telemetry**
- **Primary information source**



Search & Rescue



- **Global Maritime Distress and Safety System**
- **Medical emergencies, crew overboard and air evacuations**
- **Vessel fires, mechanical failures**
- **Piracy and coordination of law enforcement**



Remote Sensing



- **Provides high-resolution images**

- **Natural resource monitoring**

- **Urban planning**

- **Crop assessments**

- **Insurance and risk management**

- **Oil and gas exploration**

- **Mapping**

- **Disaster/emergency response**

- **Sub Meter commercial imagery**





Growth Trend



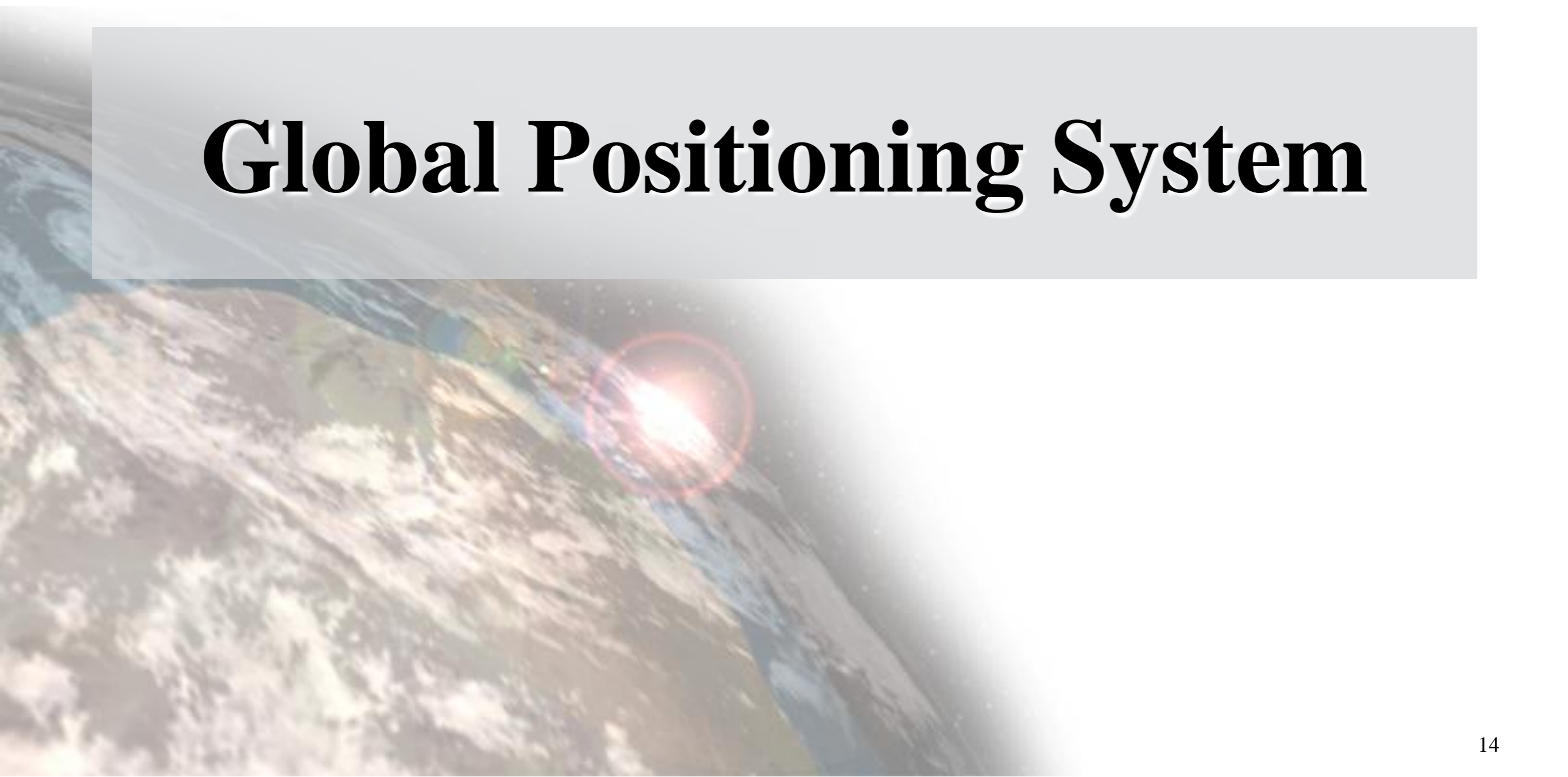
Growth Trend

- Continued overall growth in commercial space industry
- World commercial space revenues ranges at \$250 billion
- Declining commercial launch costs
- Increased commercial access to space
- GEO launch costs have declined to about \$25000 /Kg
- Government subsidies
- National security concerns





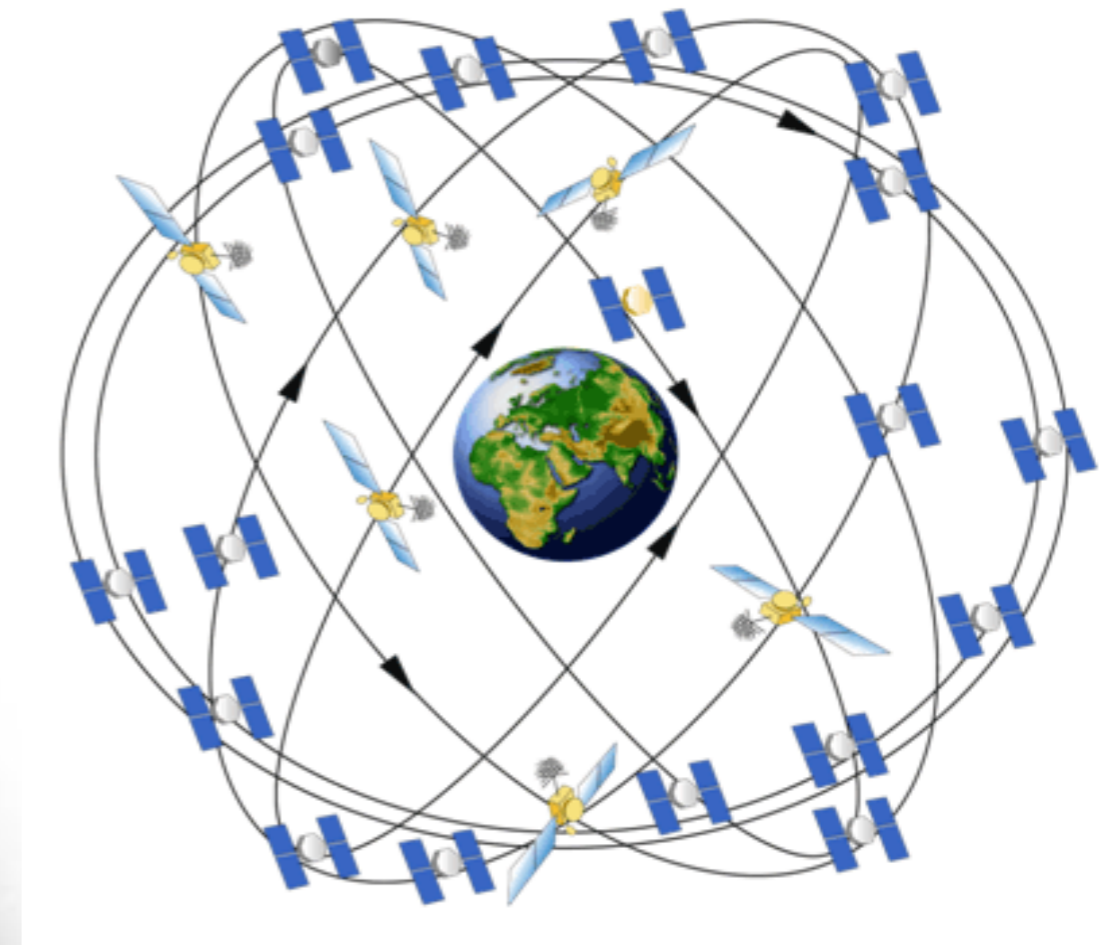
Global Positioning System



The Global Positioning System



- **24 satellite constellation in medium earth orbit**
 - **31 satellites currently available**
- **Anytime, any where , all weather**
- **Precise time and orbit information**
- **Two types of service:**
 - **Standard (No user fees)**
 - **Precise (U.S. and NATO)**
- **Owned and operated by U.S. Govt**

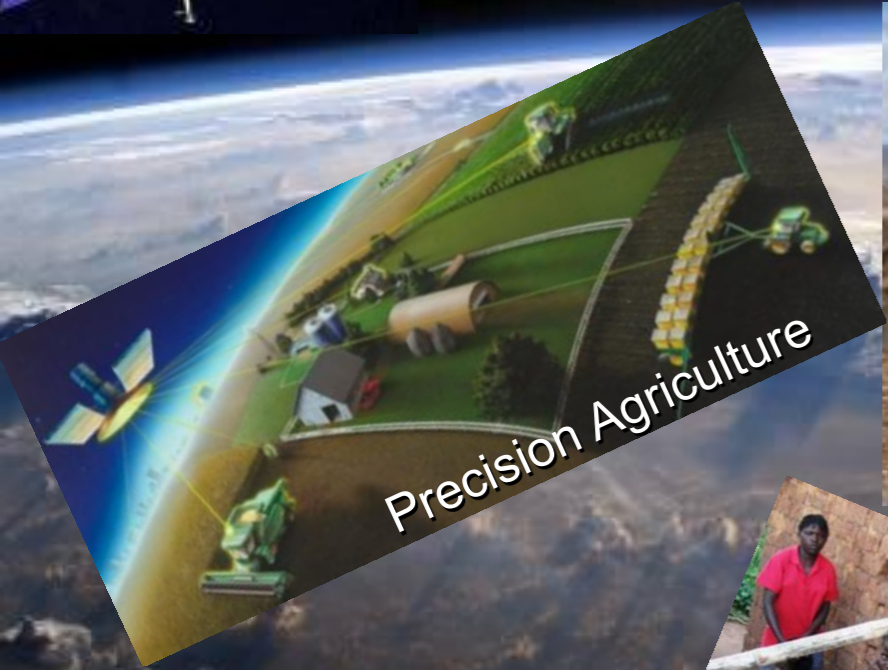


Policy



- **No direct user fees for civil GPS services**
- **Open access for development of applications**
 - **Anyone can develop applications, equipment, and VAS**
 - **Encourages market-driven competition**
- **Global compatibility with other GNSS**
- **Protection from disruption and interference**

GPS - Global Information Infrastructure



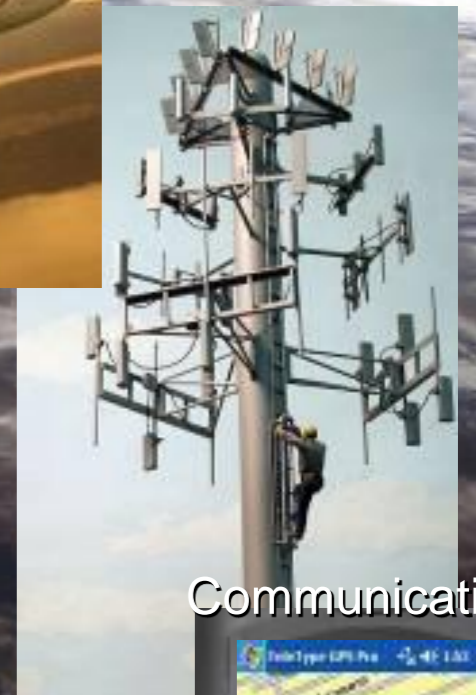
Precision Agriculture



Surveying & Mapping



Satellite Operations



Communications



Trucking & Shipping



Disease Control



Power Grids



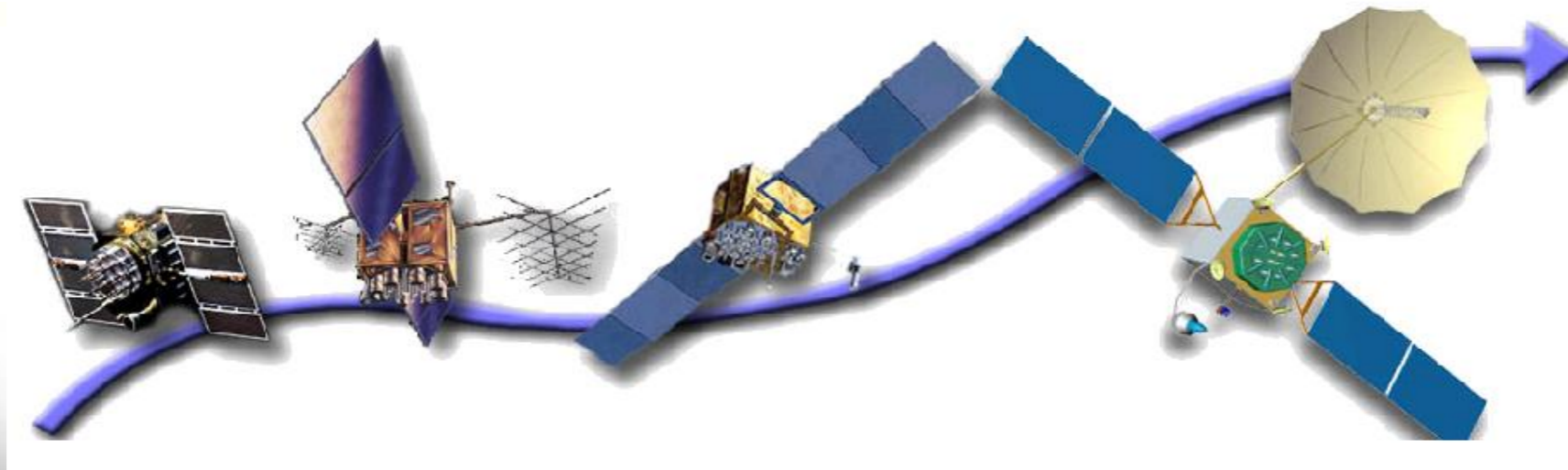
Oil Exploration



Fishing & Boating



New GPS Capabilities



- **Three new civil GPS signals in the form of L2C, L5, L1C (in addition to existing L1 C/A)**
- **New GPS capabilities will drive user equipment upgrades**
- **New signal designs will spur new applications**

New Civil GPS Capabilities (L2C)



- **Designed to meet commercial needs**
 - **Higher accuracy via ionospheric correction**
 - **Required upgrades will drive equipment sales**
- **User productivity benefits**
- **Currently available on 7 operational satellites**
 - **On 24 satellites by 2016**



Benefits existing professional receivers



Increases accuracy for consumers



Supports miniaturization, possible indoor use

New Civil GPS Capabilities (L5)



- **Designed for transport safety**
 - Uses highly protected Aeronautical Radio navigation Service (ARNS) band
 - Dual-frequency equipment for aircraft and other vehicles
- **Commercial innovation**
 - Sub-meter, standalone positioning
- **Opportunity for international interoperability**
- **Demo signal activated in April 2009**
 - GPS satellites with L5 began launching in June 2010
 - 24 satellites by 2018



New Civil GPS Capabilities (L1C)



- **Designed with international partners for interoperability**
- **Modernized civil signal at L1 frequency**
 - **More robust navigation across a broad range of user applications**
 - **Improved performance in challenged tracking environments**
 - **Original signal retained for backward compatibility**
- **Launches with GPS III in 2014**
 - **On 24 satellites by ~2021**



Under trees

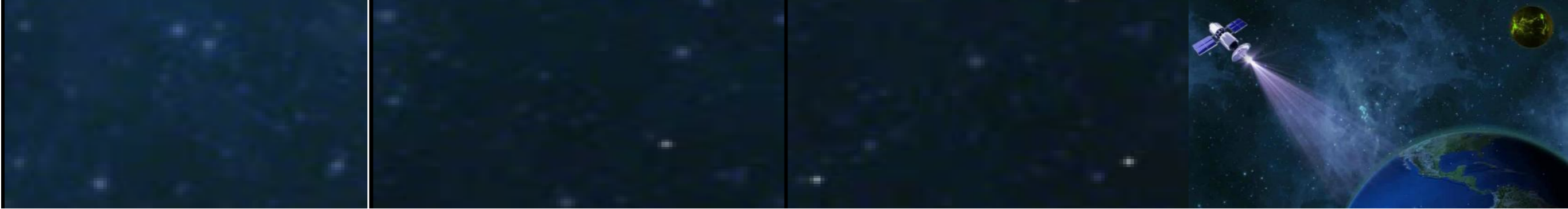


Inside cities

Integration of GPS with Other PNT Capabilities



- **Growing dependence on GPS for critical applications creates potential vulnerabilities**
 - **GPS signal is susceptible to interference**
- **Integration of GPS technology with complementary or backup capabilities has begun**
 - **Cell-based positioning**
 - **WiFi hotspot location**
 - **Digital compasses, accelerometers, inertial sensors, etc.**
- **As users recognize limitations of GPS, demand for integrated PNT capabilities may increase**



GLONASS



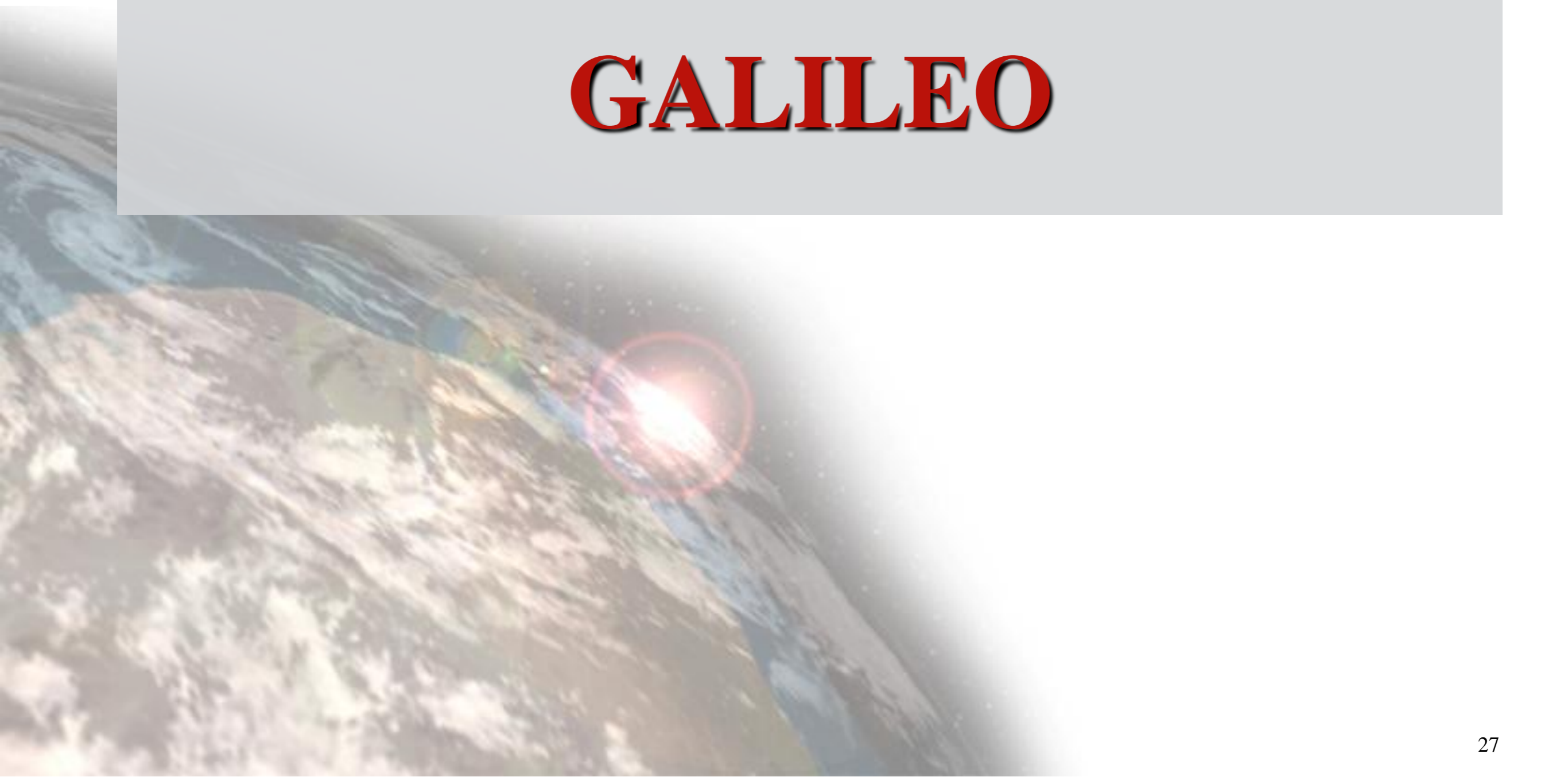
GLONASS



- **The Russian GLONASS consists of a constellation of 24 (21 active and 3 spare) KOSMOS satellites**
- **The KOSMOS satellites orbit every 11 hours and 15 minutes on three orbital planes separated by 120**
- **Life expectancy - 3-5 years**
- **Next gen satellites life expectancy - 10 years**
- **All ground based stations located within former Soviet Union territory**



GALILEO



GALILEO



- **The European Union Galileo consists of 30 satellites (27 active and 3 spare)**
- **The satellites orbit every 14 hours on three orbital planes angled at 56°**
- **Life expectancy not determined as yet**
- **Ground based stations located throughout Europe**





Military Applications



Military Applications of GPS



- **Navigation**

- To find objectives in the dark or in unfamiliar territory
- To coordinate the movement of troops and supplies

- **Target Tracking**

- To track potential ground and air targets before they are flagged as hostile.
- To guide munitions to engage the targets accurately
- Military aircraft, particularly those used in air-to-ground roles

- **Bomb and Missile guidance**

- Accurate targeting for ICBMs, cruise missiles and precision-guided munitions
- Artillery projectiles with embedded GPS receivers

Military Applications of GPS

- Search and Rescue
- Facility Management
 - To operate large bases which cover extensive areas.
 - To prepare an accurate base map. GPS with Geographic GIS can effectively tackle this task.
- Map Creation
 - To aid mapping and reconnaissance.

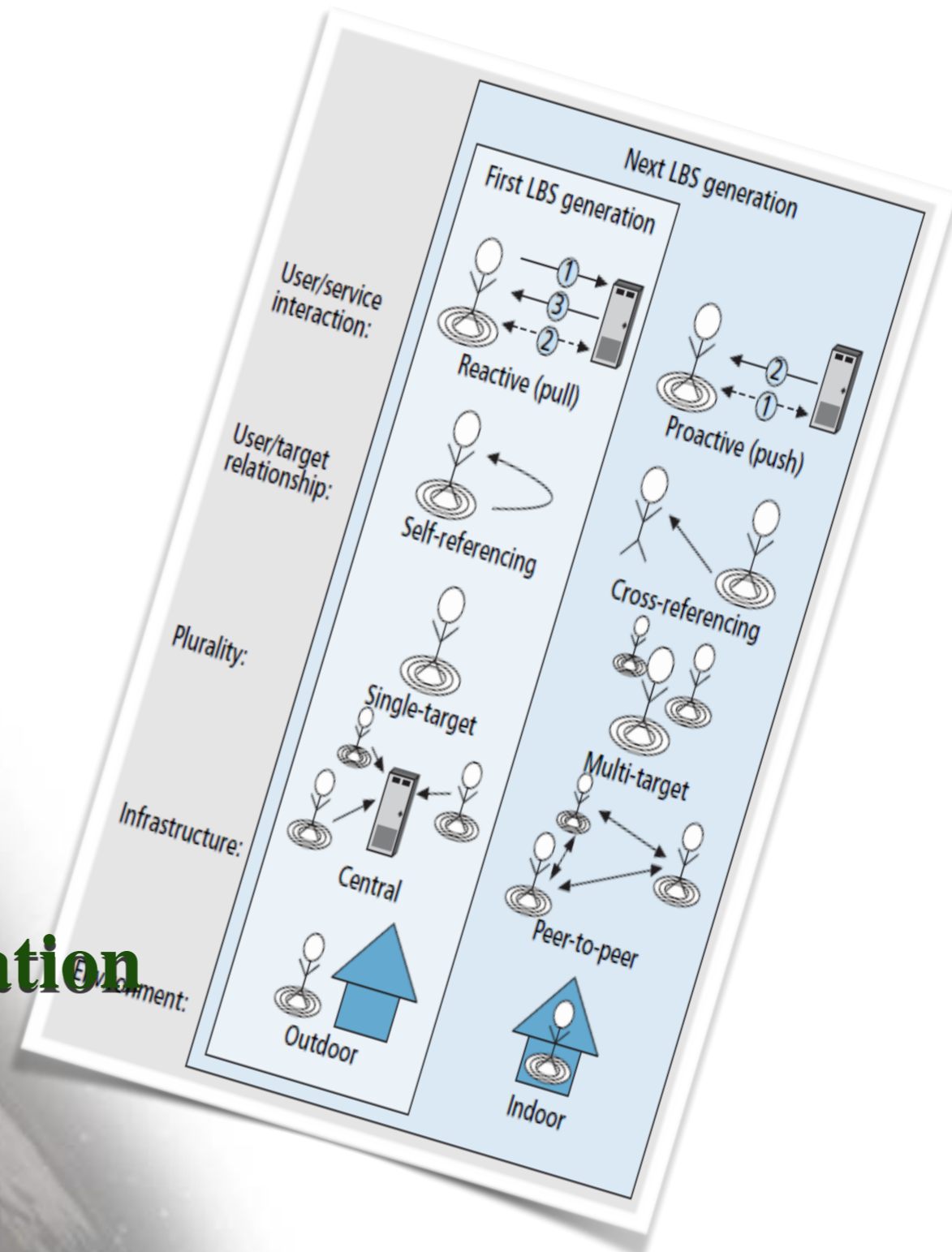


Challenges & Opportunities for GNSS



Challenges & Opportunities

- **LOCO GPSI**
- **Web-enabled Location Based Services**
- **Mobile AR Visualisation**
- **Assisted GPS**
- **Geoslavery**
- **Mobile Robot Way Point Navigation**
- **Indoor Tracking**





Indian Efforts



Indian Efforts



- **GPS Aided Geo Augmented Navigation(GAGAN)**

- SBAS

- Provides reference signals to improve accuracy

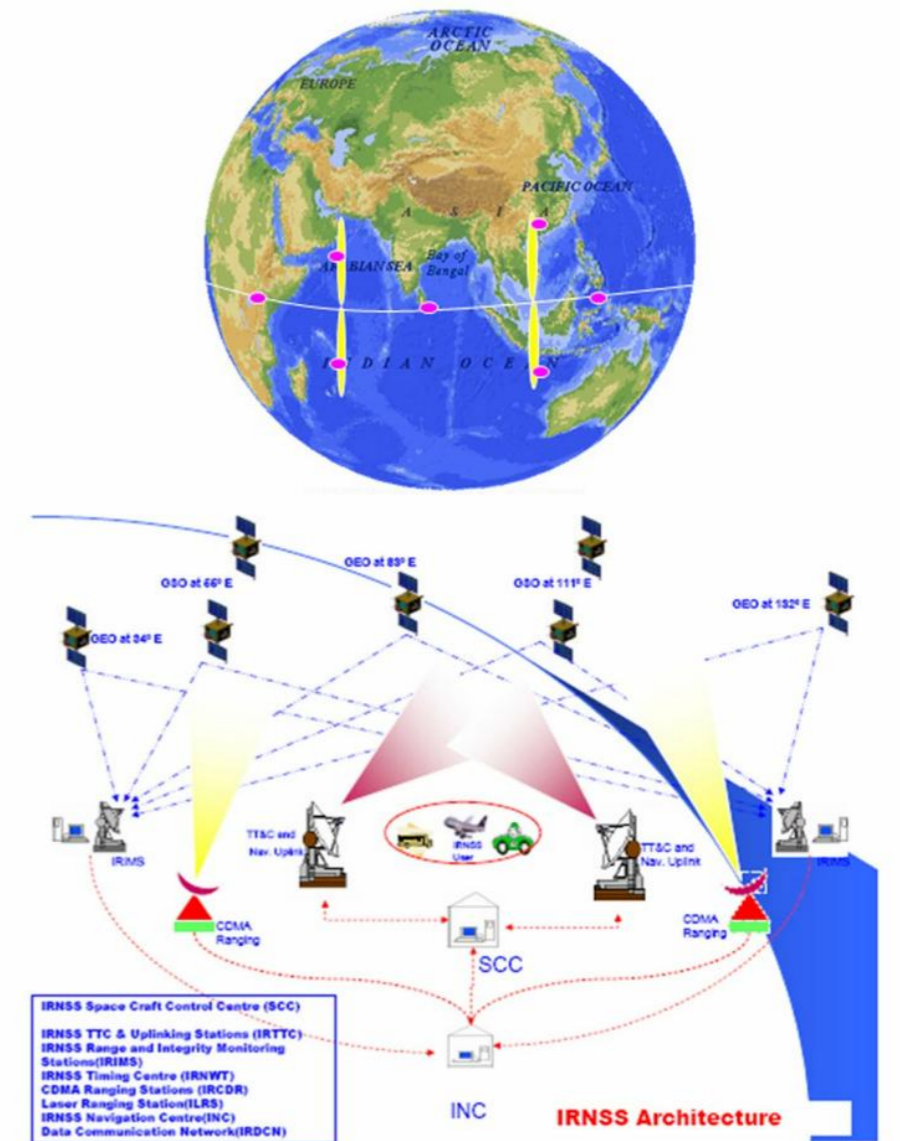
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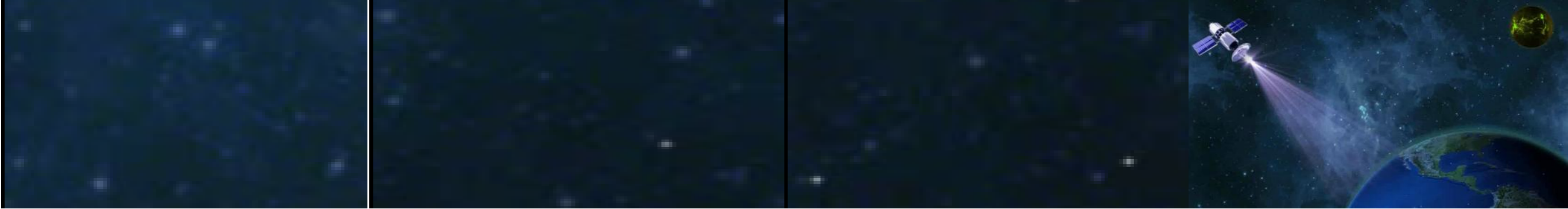
- **IRNSS**

- 7 satellites

- 2000km around India

- Position Accuracy – 10m



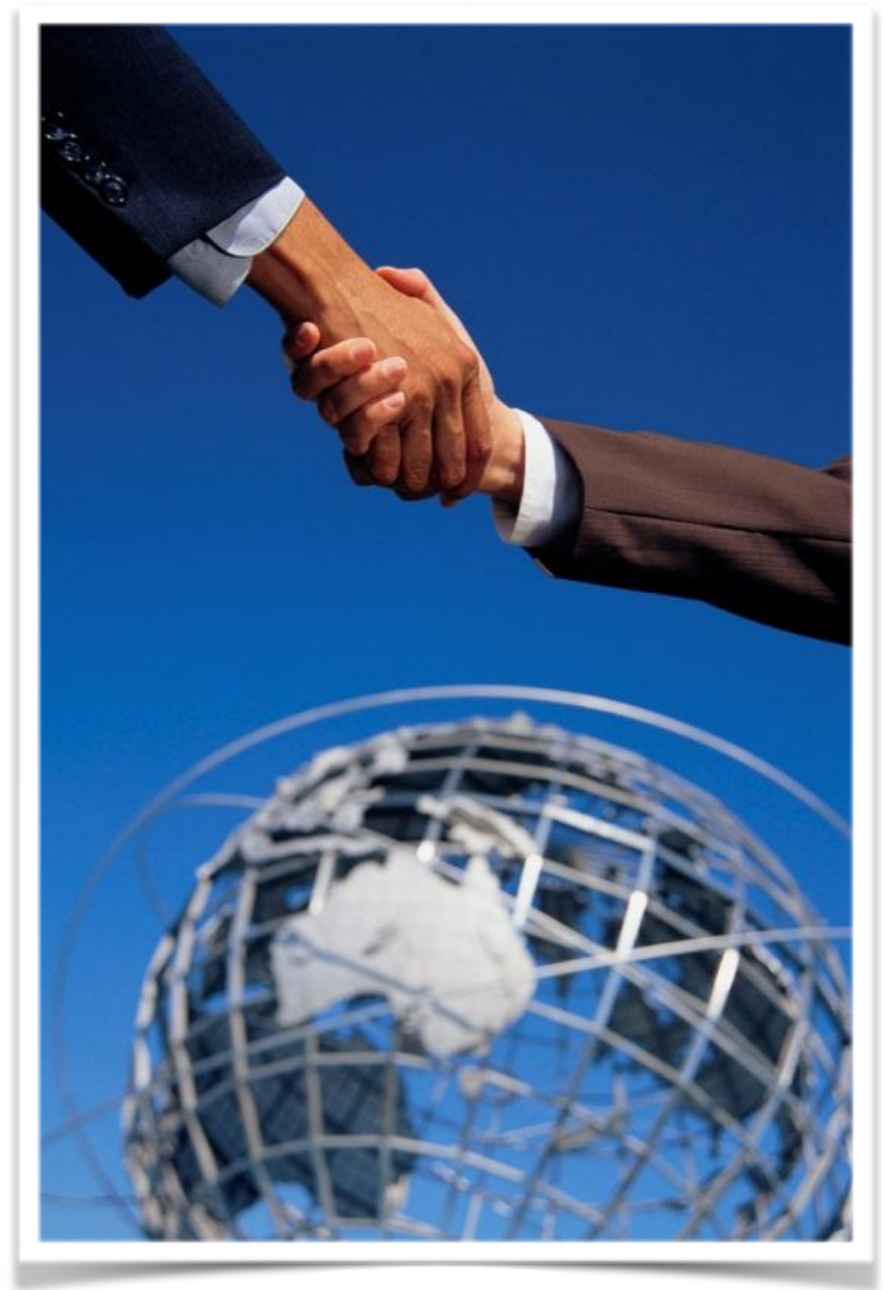


International Cooperation



International Cooperation

- Positive results in the offing
 - **New satellite constellations and regional augmentation systems are designed to be interoperable**
 - Coordination mechanisms are being created to promote interoperability, promote GNSS use



GPS-Galileo Cooperation

- In 2004, US and EU signed landmark agreement on GPS-Galileo cooperation
 - Recognizes importance of compatibility/interoperability
 - Agreed to spectrally separate signals for military and civilian services
 - Agreed to implement a common, open, civil signal on both Galileo and GPS III
- Working Groups established to continue dialogue
 - Compatibility & Interoperability
 - Trade & Civil Applications
 - Next-Generation GNSS
 - Security Issues



June 26, 2004, press conference at U.S.-EU Summit in Ireland (U.S. Sec. of State Colin Powell, Irish Foreign Minister Brian Cowen, EU Vice-President Loyola De Palacio)

The slide features a dark blue space-themed background with a satellite in the upper right corner emitting a beam of light towards the Earth. The title 'GPS-GLONASS Cooperation' is written in a large, white, serif font. A yellow horizontal bar is positioned below the title. The main content area has a white background with a faint satellite image of the Earth's surface.

GPS-GLONASS Cooperation

- Working groups are pursuing GPS-GLONASS interoperability
 - Enhanced PNT availability through common open service civil signals
 - Cooperative search and rescue capabilities


Asia Pacific Regional Concerns



- **Japan's QZSS and Australia's GRAS are of interest**
- **Australia employs GIS for ATM, agriculture, and mining; it aspires to share its expertise with others in the Asia-Pacific region**
- **China has full constellation of navigation satellites, COMPASS**
- **APEC economies —beyond transportation into infrastructure, social, and economy improvements**

US-India Cooperation



- Policy and technical consultations have been held since 2005
 - US-India Joint Statement on GNSS Cooperation issued in February 2007 in Washington
 - Aims to ensure interoperability
 - India's GAGAN augmentation system based on GPS
 - Ionospheric distortion reduction solutions
- 



Conclusion

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