GPS World
The Business and Technology of
Global Navigation and Positioning

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Geospatial solutions

# GNSS is Changing A Lot:
# Future of GNSS Mapping and Surveying

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Editor - *Geospatial Solutions*

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*October 5, 2010*

# Outline



1. GPS Status
2. GPS changes (semicodeless sunset, 24+3)
3. SBAS status/changes
4. GLONASS status/changes
5. Galileo significance
6. Looking Forward

## ACTIVE GNSS:

-GPS (USA)

-GLONASS (Russia)

-SBAS:
WAAS (North America), MSAS (Japan)
EGNOS (Europe)

-DGPS/NDGPS

-RTK Networks

## PLANNED GNSS:

-Galileo (Europe)

-SBAS: GAGAN (India)

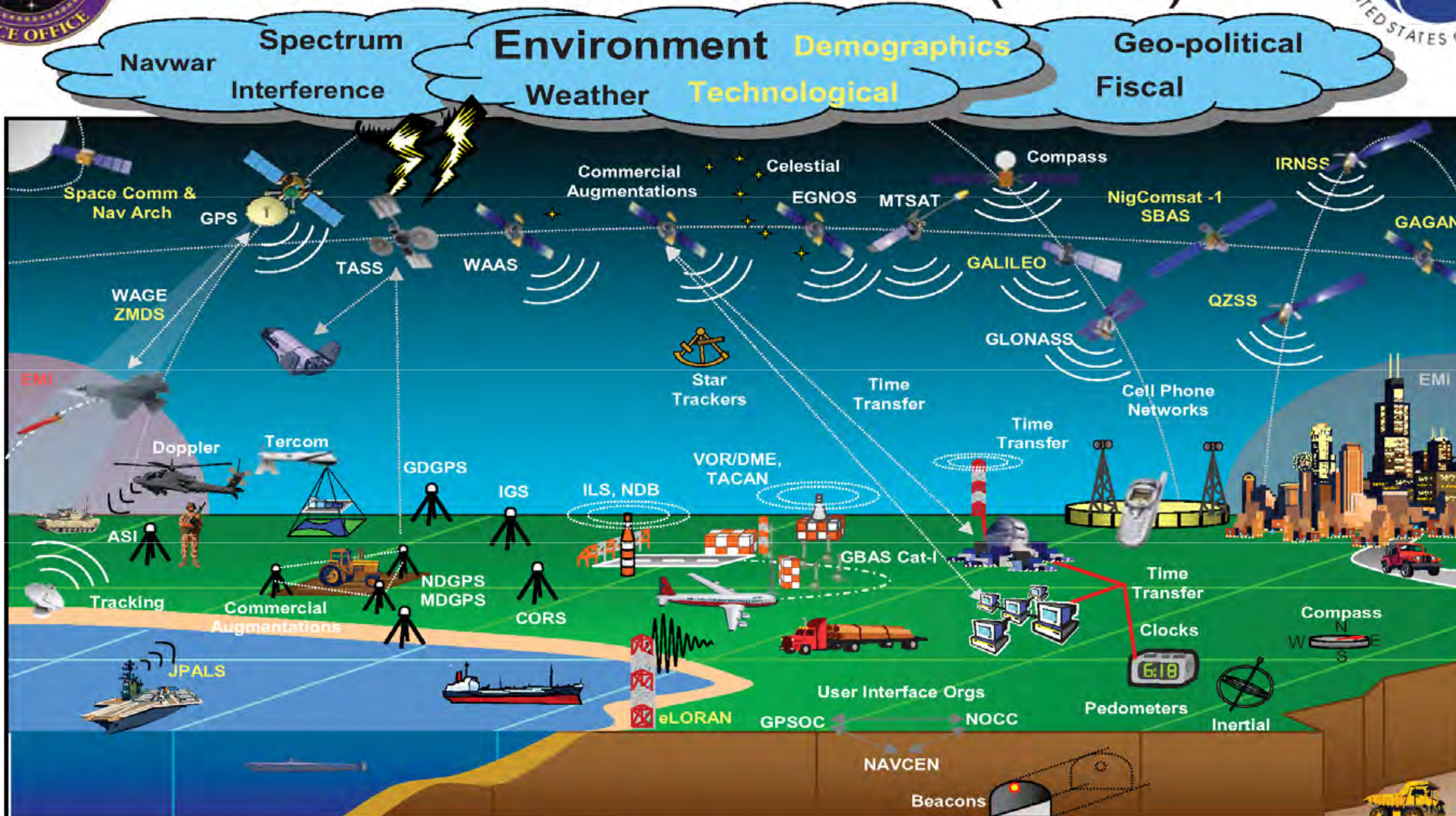
-QZSS (Japan)

-Compass/BeiDou (China)

UNCLASSIFIED

Yellow font = New compared to "As Is" 2007 Architecture

# PNT Evolved Baseline (2025)




Standards Reference Frames Cryptography Science & Technology USNO NIST NGA NGS
Star Catalogs Launch **ENABLERS & INFRASTRUCTURE** NSA Industrial Base
Electro Optical Info. Modeling Mapping/Charting/Geodesy Laser Ranging Network Policies Testing

Version 21 Aug 2007

# Constantly Changing

- Not only is GNSS receiver technology constantly evolving and so is the GNSS infrastructure (satellites, signals and control).
- This is one of the reasons that the GNSS industry is so dynamic and will be for the foreseeable future.
- These changes will affect the way that GNSS mapping and surveying users perform their work.

# Current GPS Status

- There are currently 31 operational GPS satellites. Well above the government commitment of 24.
- 23 x GPS Block IIA/IIR. L1 C/A, L1/L2 P(Y)
- 7 x GPS Block IIR-M. L1 C/A, L1/L2 P(Y), **L2C**
- 1 x GPS Block II-F. L1 C/A, L1/L2 P(Y), L2C, **L5**
- **L2C** = More robust iono correction for high precision positioning. No need for cross-correlation (semi-codeless).
- **L5** = Similar to L2C, but stronger signal @ 1176

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# GPS L5

# The Beginning of a New Era

- L5 = broadcast signal four times more powerful than L2C, frequency further separated from L1 which enhances mitigating the effect of the ionosphere.
- L5 designed for safety-of-life apps (eg. aviation) and frequency (1176.45 MHz) is in the highly protected aeronautical navigation band.
- Compatible with Galileo design.

# Gotchas of the GPS L5 Signal

- It will be many years before enough satellites are broadcasting L5.
- Equipment interoperability between manufacturers is an issue.
- RTK Networks (RTN) will have compatibility problems due to equipment interoperability issues.
- RTCM format doesn’t support L5 at this time.

# Semicodeless Sunset

# The End of an Era

- The U.S. Government announced it will stop supporting semicodeless receivers on Dec. 31, 2020. This will affect ~300,000 dual frequency GPS receivers.
- There is discussion that the USAF will find a workaround, but users should be aware.
- 12/31/20 is not a "hard" date but rather a date after which there's no guarantee the affected receivers will operate properly.

- Any dual frequency (L1/L2) receiver not utilizing L2C or L5 will be affected.
- Some manufacturers are still selling receivers that rely solely on semicodeless technology (at discounted prices).
- Don't panic – still ~10 years away.

# GPS 24+3 Configuration

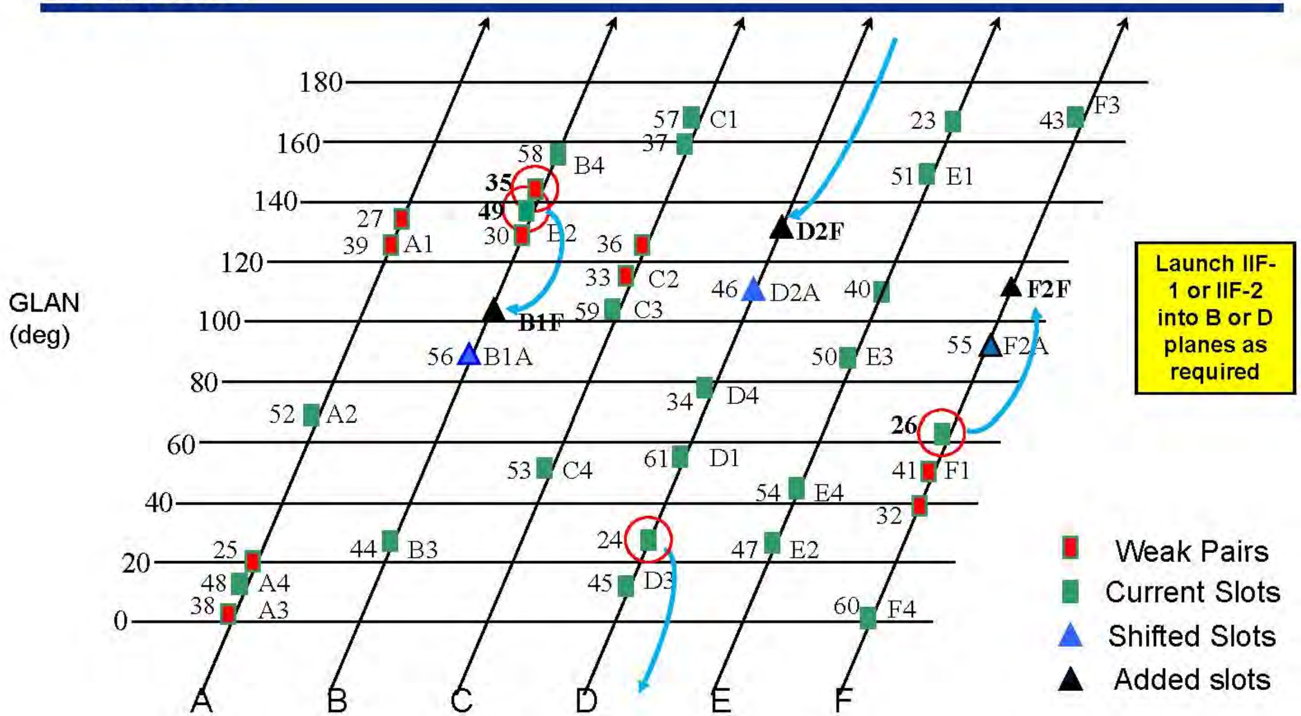
# The Beginning of a New Era for Mapping/Surveying Users

- In January 2010, the U.S. Government announced a new expanded 24+3 GPS config.
- GPS satellites have traditionally been configured in a 24 satellite config. Since there are 31 operational GPS satellites, there were several redundant pairs.
- The purpose is to increase GPS satellite availability and decrease GPS "brownouts".
- >70% of users polled said they've suffered from GPS "brownouts".

- 24+3 will have a positive affect on all GPS users, but particularly high precision users such as surveyors, mapping/GIS, const./machine control and engineering.
- The effect of 24+3 is that it will reduce/eliminate the times when there are only 4-5 GPS satellites in view above a 15° elevation mask.

U.S. AIR FORCE

# Expand to 24+3 in B/D/F Planes

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# 24+3 Implementation Schedule

- The 24+3 design involves significantly moving three satellites and shifting three others.
- SVN30 and SVN26 have been rephased.
- SVN24 is en route and due 1/2011.
- SVN's 46, 55, 56 are being slightly shifted and due to arrive June/July 2011.
- Satellites will remain healthy during their journey (except the first day).

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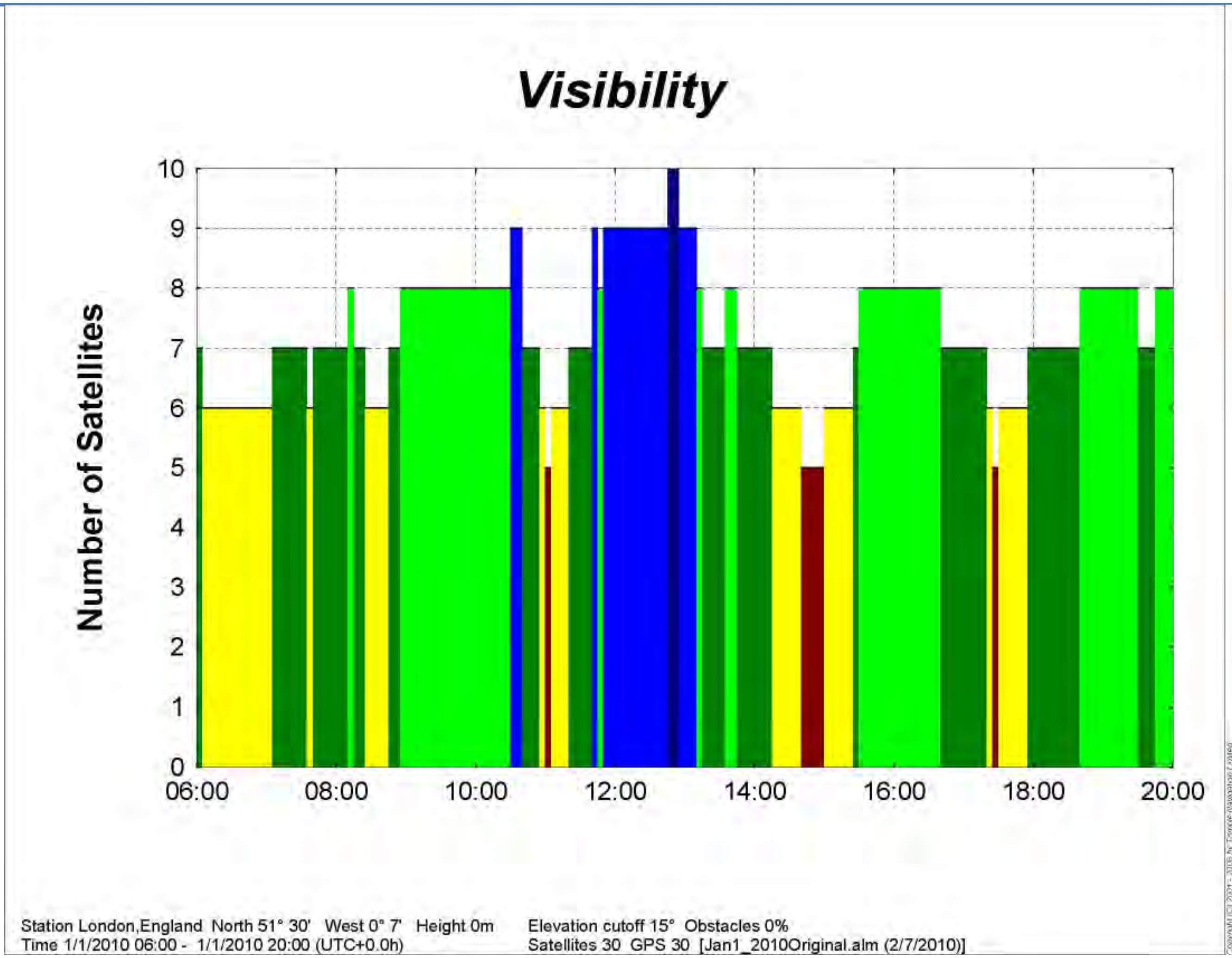

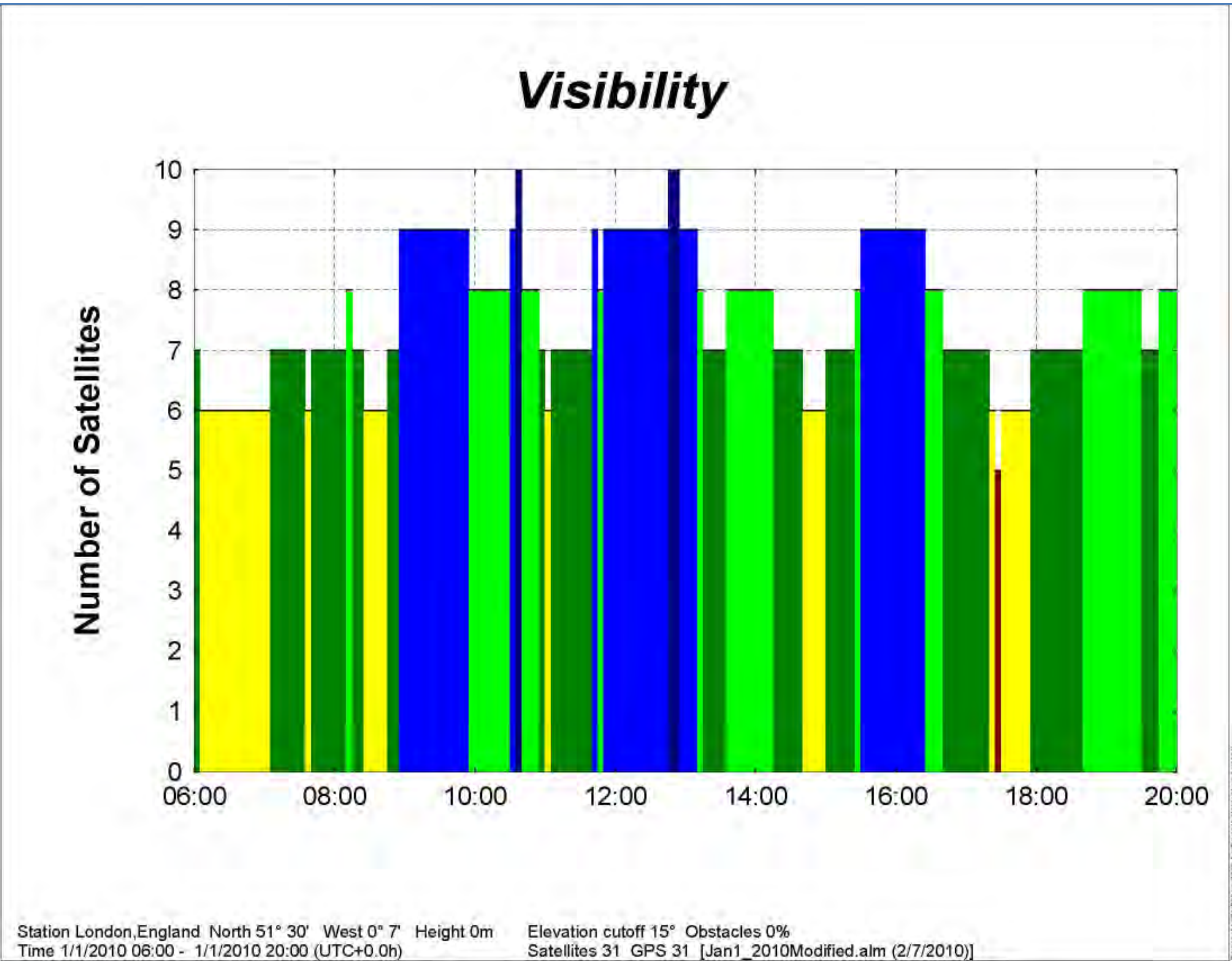

Visibility
Number of Satellites
10
9
8
7
6
5
4
3
2
1
0
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
Station London,England North 51° 30' West 0° 7' Height 0m
Time 1/1/2010 06:00 - 1/1/2010 20:00 (UTC+0.0h)
Elevation cutoff 15° Obstacles 0%
Satellites 31 GPS 31 [Jan1_2010Modified.alm (2/7/2010)]

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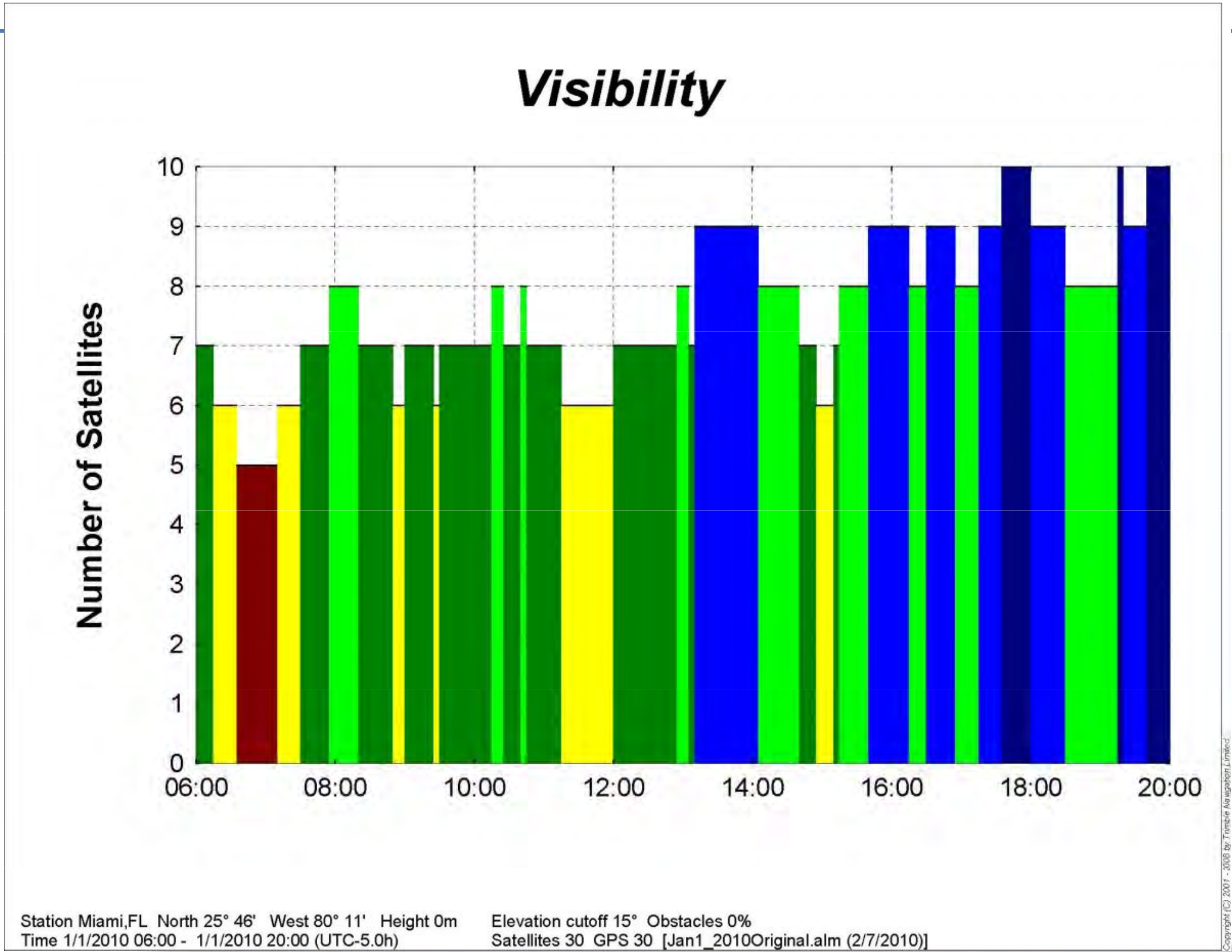

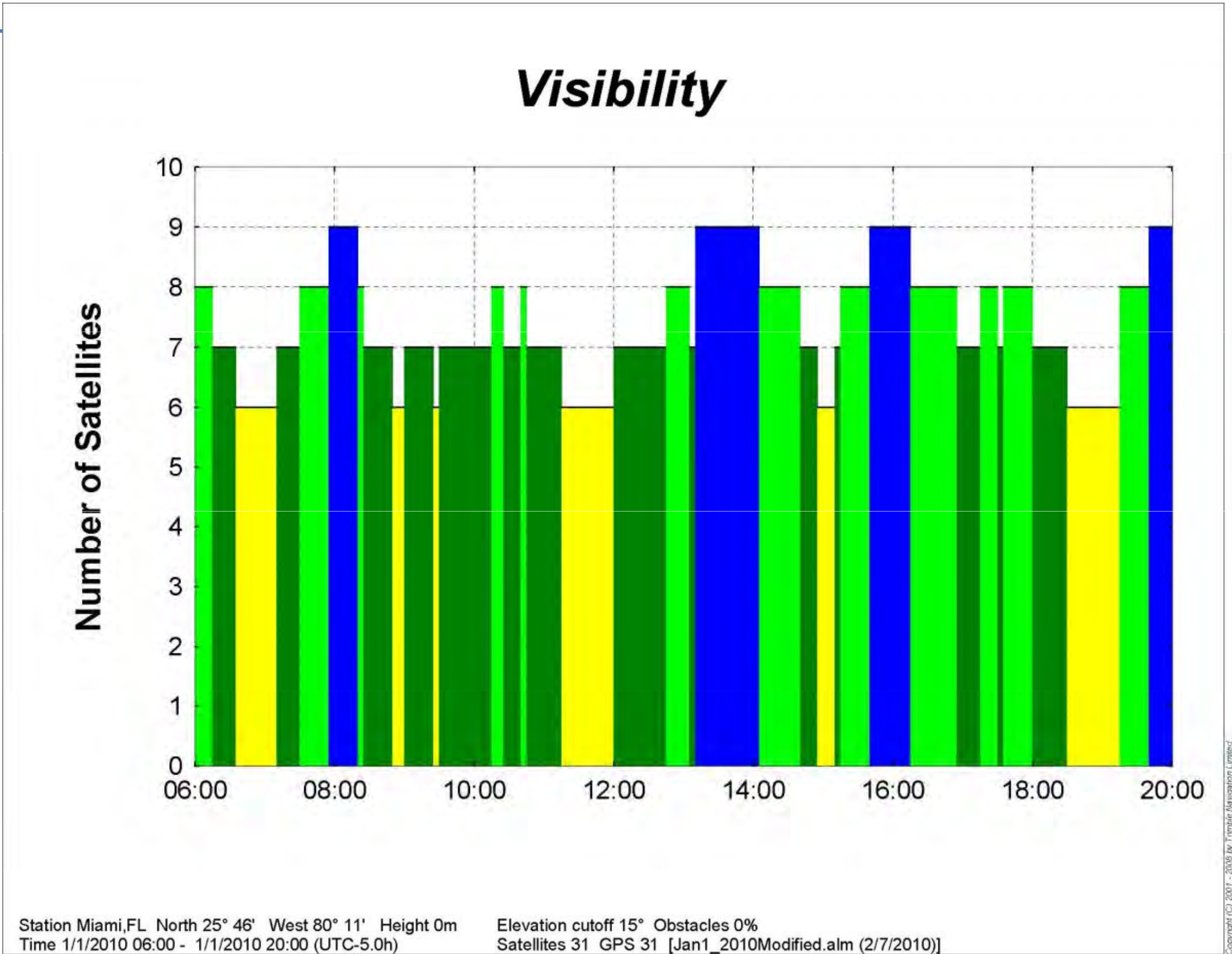
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Station Miami,FL North 25° 46' West 80° 11' Height 0m
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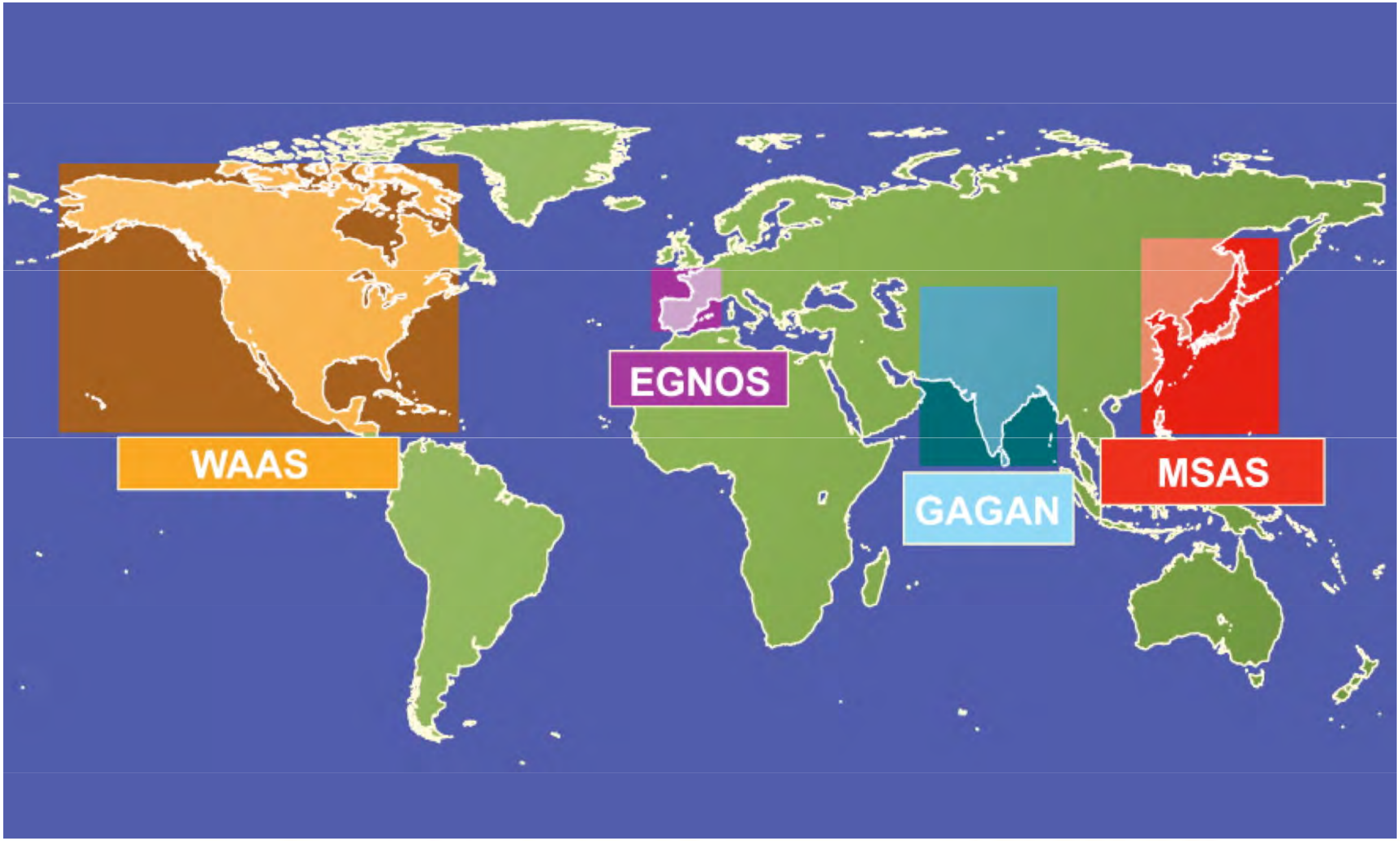
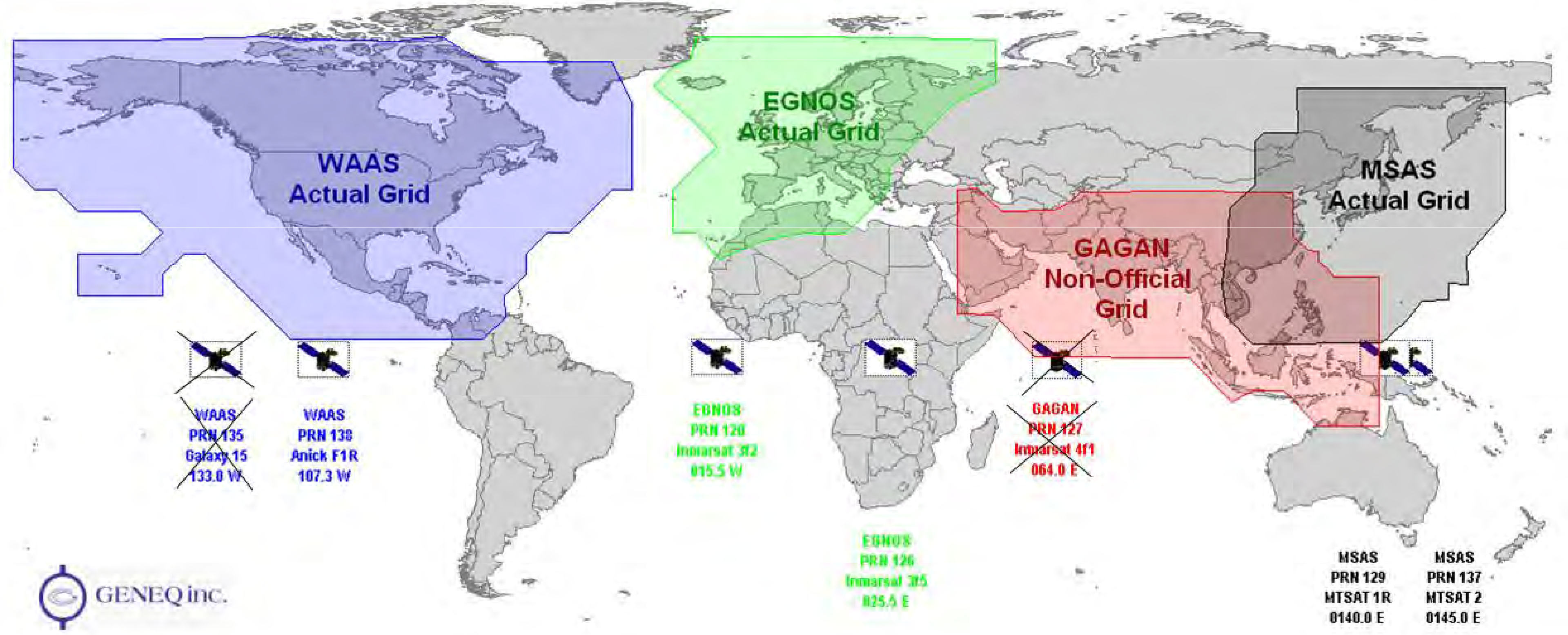
Elevation cutoff 15° Obstacles 0%
Satellites 31 GPS 31 [Jan1_2010Modified.alm (2/7/2010)]

# SBAS

# Satellite-Based Augmentation System


WAAS
EGNOS
GAGAN
MSAS


WAAS Actual Grid
EGNOS Actual Grid
MSAS Actual Grid
GAGAN Non-Official Grid
WAAS
PRN 135
Galaxy 15
133.0 W
WAAS
PRN 138
Anick F1R
107.3 W
EGNOS
PRN 120
Inmarsat 3f2
015.5 W
EGNOS
PRN 126
Inmarsat 3f5
025.5 E
GAGAN
PRN 127
Inmarsat 4f1
064.0 E
MSAS
PRN 129
MTSAT 1R
0140.0 E
MSAS
PRN 137
MTSAT 2
0145.0 E
GENEQ inc.

# SBAS for surveying/mapping


-Mapping and agricultural guidance GPS use SBAS for sub-meter corrections.

Some surveying receivers use SBAS to enhance cm-level positioning (eg. L1 RTK)

# GLONASS

# Russia's Satellite Navigation System

- 20+ operational satellites. Most since 1997.
- Russia has an aggressive launch schedule.
- A valuable augmentation to GPS. Not used as a stand-alone system yet.
- Valuable to RTK users because it increases productivity.
- 4-8 satellites are added when using GLONASS.

- Among the six new GLONASS satellites this year will be the first GLONASS-K model. It will include a new radio frequency design (CDMA) that will enhance its compatibility with GPS.
- Given the GPS 24+3 initiative and aggressive GLONASS launch schedule, GPS/GLONASS users should see a substantial improvement in satellite availability going forward.
- Some new mapping-grade receivers with GLONASS being introduced.

# Galileo

# Europe's Satellite Navigation System

- Schedule is a concern. Will GLONASS CDMA be first to arrive or will Galileo be first?
- Highly interoperable with GPS L1/L5.
- No L2 support.
- GPS+Galileo = 20 average satellites in view.

| | GPS | GALILEO | GPS+ GALILEO |
|---|---|---|---|
| Satellites | 24+3 | 27+3 | 51+6 |
| Avg # in View | 8 | 12 | 20 |
| RAIM Integrity | Fair | Fair | Excellent |
| Coverage | Good | Good | Excellent |

# GNSS Technology Trends

# What's Going to Happen When High Precision GNSS is Cheap?

1. High-precision GNSS technology in the next 10 years is going to advance significantly faster than the past 10 years.
2. Crowd-sourced data is scaling up and becoming more accurate.

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High-precision GNSS technology in the next 10 years is going to advance significantly faster than the past 10 years.

# High-Precision GNSS Technology

## The Last 10 Years

## Significant developments

- SBAS became operational.
- GLONASS matured.
- RTK Network proliferation.
- OPUS and OPUS-like online post-processing introduced.
- L2C introduced.

# High-Precision GNSS Technology

# The Next 10 Years

## The Next 10 Years

- Complete L5 constellation (2019).
- Deployment of Europe's Galileo.
- Deployment of Russia's CDMA GLONASS
- Continued proliferation of RTK Networks.
- Continued proliferation of wireless networks.
- Complete L2C constellation (currently 8).

- The new GPS L5 signal will result in very low-cost L1/L5 receivers capable of cm-level horizontal/vertical precision.
- High-precision GPS receivers will be available at a very low cost.
- Europe's Galileo could accelerate a full L5 constellation.

# The Next 10 Years

## High-Precision GNSS Technology – <u>Eng./Const./GIS service sector</u>

- The value of high-precision data (horizontal and vertical) will reduce substantially.
- The skill and time required to collect high-accuracy data will fall substantially.
- Manpower requirements will shrink as productivity increases. Spending less on people and more on equipment
- Projects will be completed more quickly.

# The Evolution of GPS Mapping
## Cost of recording a utility pole at sub-meter precision

- Year 2000 – $10,000 GPS receiver. $2,000 post-processing software. Days of training.
- Year 2010 - $2,000 GPS receiver. Hours of training.
- Year 2020? - $100 GPS receiver. Minutes of training.

# The Next 10 Years

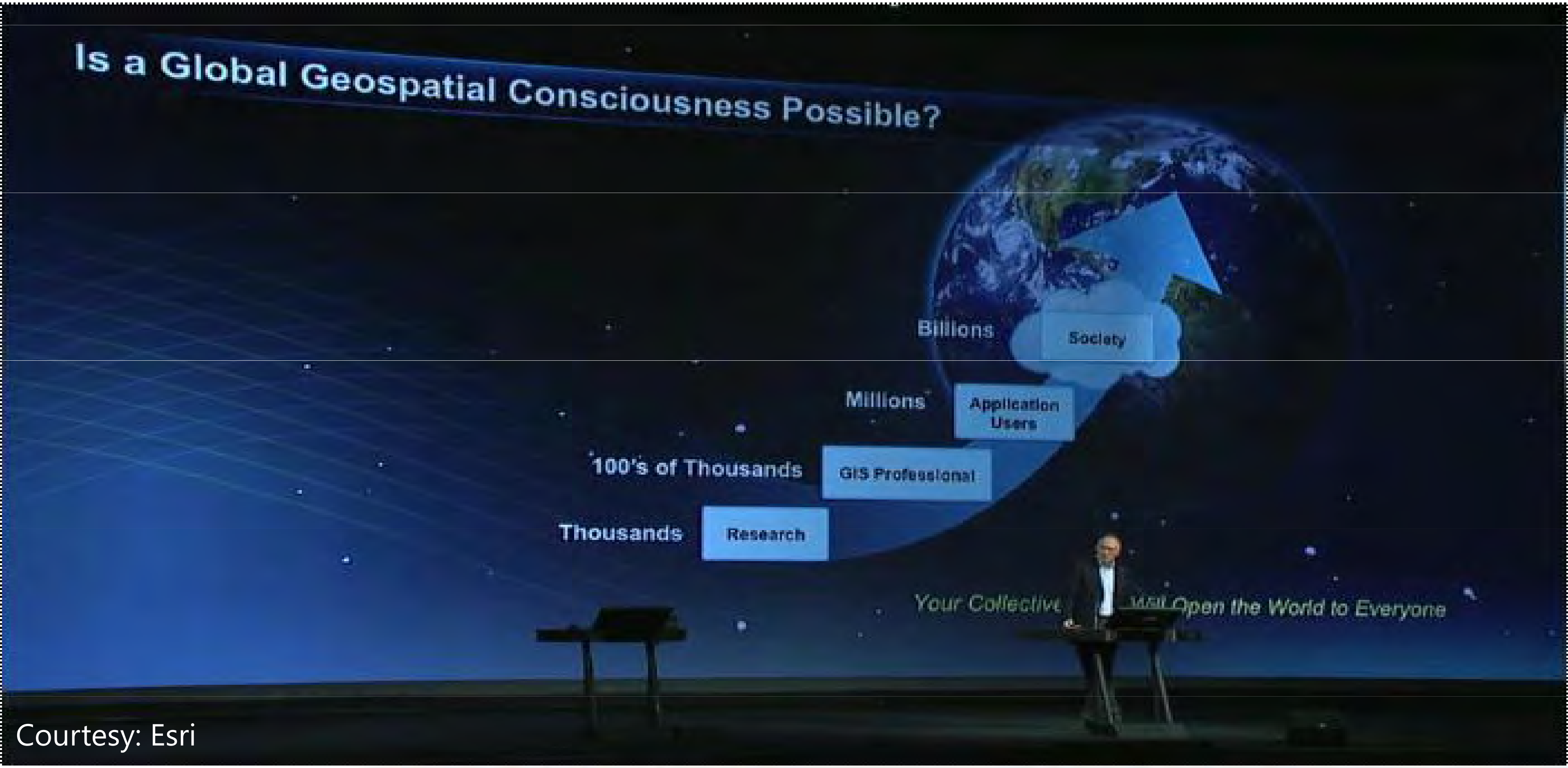
## High-Precision GNSS Technology - Implemented

- GIS - a data-hungry technology (infrastructure mapping, 3D mapping).
- Machine control. 23% CAGR over the next five years.
- Crowd-sourced data using mobile devices.
- Crowd-sourcing…

# The Next 10 Years

## High-Precision GNSS Technology - Implemented

Crowd-sourced data

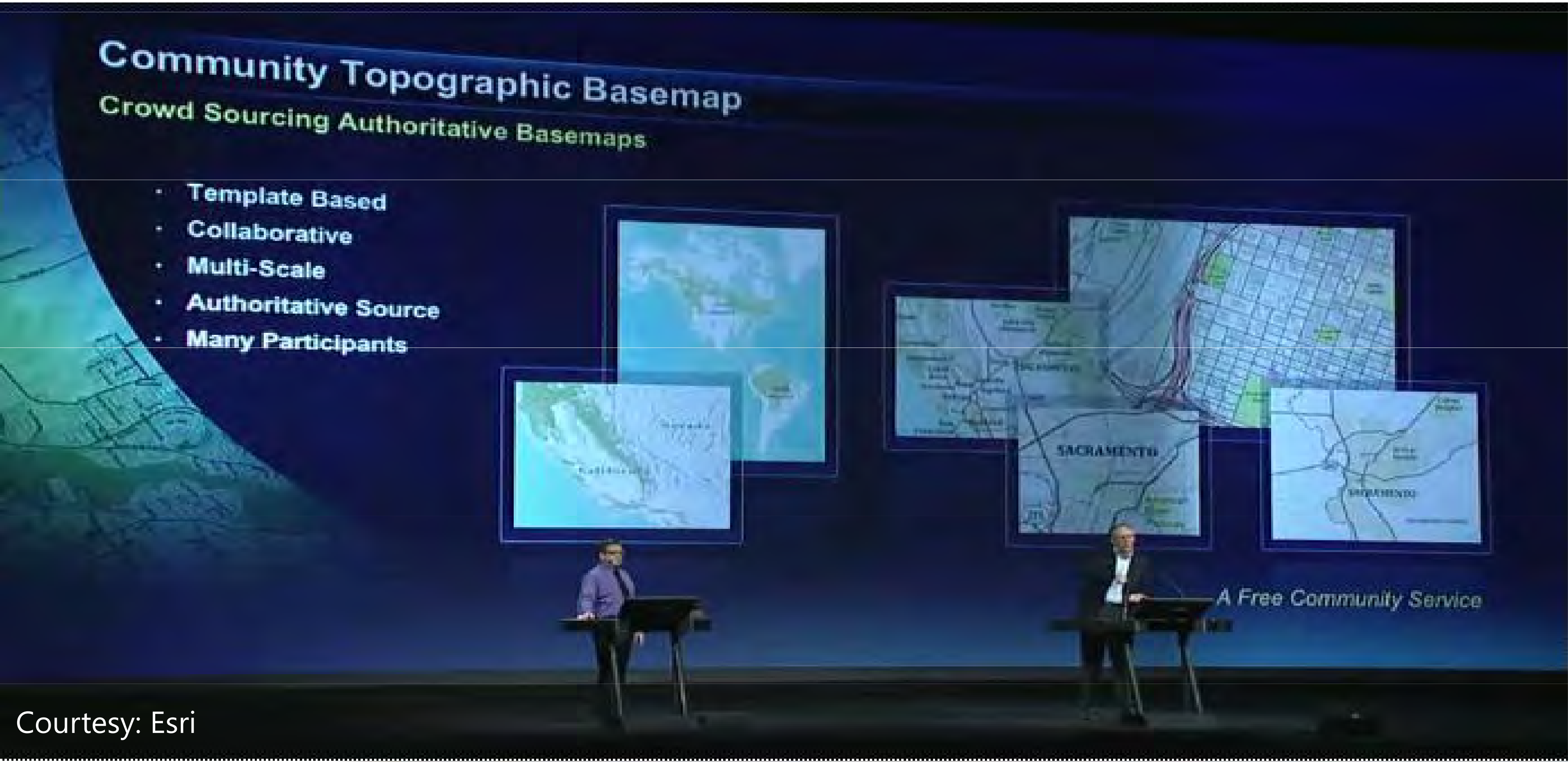



Courtesy: Esri

# The Next 10 Years

## High-Precision GNSS Technology - Implemented

Crowd-sourced data




Courtesy: Esri

# The Next 10 Years

## High-Precision GNSS Technology - Implemented

Crowd-sourced data

Courtesy: Esri

# The Next 10 Years

## High-Precision GNSS Technology - Implemented

Crowd-sourced data


Courtesy: TomTom

- TomTom Travel Times
- Road usage and speed pattern reports.
- Based on two trillion pieces representing 15 million miles of road data collected world-wide from TomTom users.

# Trends

- Trending from measurement skills to data management and data analysis skills.
- Trending from relying solely on one's own geographic data to incorporating geographic data from external sources (eg. crowd-sourced data).
- Trending towards huge volumes of more precise and rich geographic data.

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