

# GNSS History: *Making a Difference*

## 1990–1994 SYSTEMS RISE

Simultaneously with the first appearance of this magazine in January 1990, the 11th operating GPS satellite in orbit, GPS Block II-5, was activated on January 6, 1990. The 12th satellite was launched weeks later, on January 24, 1990.

By the end of the half-decade, 18 more had risen; with some decommissionings, this brought the total number of GPS satellites set healthy to 25.

GLONASS, meanwhile, started at nine and finished at 16 for the same period.

### 1990



#### INDUSTRY DEVELOPMENTS

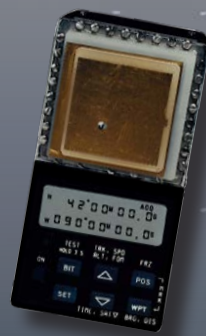
- Litton Guidance & Control Systems Division is named systems integrator on a miniature aerospace nav system sponsored by DARPA. Rockwell and Boeing are also on the team.
- An initiative is launched to establish the first comprehensive trade association focused on commercial usage of GPS. The association of manufacturers and users would seek to promote commercial use of GPS and to address issues affecting those groups.
- Trimble announces a contract award from various agencies of the U.S. government, totaling \$7 million.

### 1991



#### DOUG LLOYD Senior Director, Navigation Products, Rockwell Collins

“As part of DARPA’s Miniature GPS Receiver program, in 1991 Rockwell Collins successfully developed the ‘Virginia Slims’ single-channel handheld digital correlation receiver — an industry first.”



**Rockwell  
Collins**

### 1992



#### INDUSTRY DEVELOPMENTS

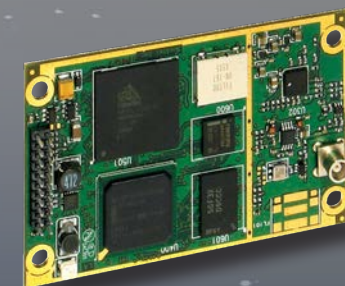
- NASA and Wilcox Electric, using avionics and DGPS ground stations incorporating the NovAtel OEM Performance line of 10-channel, C/A-code GPS receivers, successfully complete differential GPS-aided precision approach and landing trials, meeting Category 3B accuracies in an automatic landing mode.
- FAA issues its first technical standard order C129 certification of a GPS system with full receiver autonomous integrity monitoring (RAIM) to Trimble Navigation for the company’s TNL 2000T and TNL 2100T units.

### 1993



#### MICHAEL RITTER President and CEO, NovAtel

“The invention of the Narrow Correlator was unprecedented: it allowed receivers to significantly reject multipath signals. With the patent in 1993, NovAtel became a key player in the GNSS market.”



**NovAtel**

### 1994



#### INDUSTRY DEVELOPMENTS

- Canadian Marconi Company (CMC) displays working models of its micro-GPS family of GPS engines and starts taking orders for its All-Star product using all available signals.
- The International GPS Service for Geodynamics (IGS) begins regular operations, with a mission to support timely generation and distribution of highly accurate and highly reliable GPS satellite orbits, Earth rotation parameters, tracking station coordinates and velocities, and satellite and receiver clock information.

# GNSS History: Making a Difference

## 1995–1999 SYSTEMS MATURE

The U.S. Air Force Space Command declared Full Operational Capability (FOC) for the GPS constellation on April 27, 1995, signifying the system met all requirements with 24 operational Block II/IIA satellites in their assigned orbital slots and providing both the military PPS and the civil SPS.

By the end of 1999, there were 27 usable GPS satellites in space.

GLONASS reached a high of 24 satellites in 1996, but by 1999 the number had fallen to 15.

1995



### INDUSTRY DEVELOPMENTS

- The U.S. GPS Industry Council publishes a study forecasting an \$8 billion per year worldwide market for GPS products by the year 2000.
- “Two trends are emerging in the GPS market,” said USGIC executive secretary Michael Swiek. “The first is the continuous 30 percent per year decline in the cost of the hardware content. The second is the increased contribution of embedded software in the end-user application.”

1996



### JOHN F. CLARK Vice President, Engineering, CAST Navigation LLC

CAST Navigation enters into an exclusive arrangement with both Honeywell and Litton (now known as Northrop Grumman) to develop a system that allows for the integration and test of their respective tightly coupled GPS/INS navigation systems (EGIs).



“In 1996 CAST entered into an exclusive arrangement with both Honeywell and Litton (now known as Northrop Grumman) to develop a system that allows for the integration and test of their respective tightly coupled GPS/INS navigation systems (EGI’s). We called this system the Embedded GPS/INS Tester (EGIT).”



1997



### INDUSTRY DEVELOPMENTS

- The worldwide GPS automotive navigation semiconductor market will experience rapid growth, with revenue increasing from \$246 million in 1996 to nearly \$1.7 billion by 2001, according to Dataquest market research firm.
- “The single most important development for the electronics industry is the emergence of in-car GPS navigation systems.”

1998



### INDUSTRY DEVELOPMENTS

Javad Ashjaee, founder and former CEO of Ashtech, founds JAVAD Positioning Systems (JPS) and introduces Legacy, Odyssey, and Regency products, followed by HiPer, a 76-channel geodetic receiver.

1999



### INDUSTRY DEVELOPMENTS

- SiRF Technology introduces the 12-channel SiRFstarII in a chipset configuration, as well as a hardware/software architecture that can be licensed for integration into such consumer platforms as cellular phones. It includes real-time differential processing capability using WAAS corrections.
- NovAtel and Sokkia Co. form a jointly owned subsidiary, POINT Inc., to develop, build, and market GPS-enabled systems for surveying, mapping, geographic information systems, construction, and machine-control markets.

# GNSS History: *Making a Difference*

## 2000–2004 ONE SYSTEM DOMINATES, THE OTHER SUFFERS

In December 2004, the GPS constellation count stood at 30: 18 usable Block II/IIA satellites and 12 Block IIRs.

After hovering around a total of 10 satellites for most of this five-year period, GLONASS finished out at eight set healthy, with three newly launched satellites not yet made operational.

2000

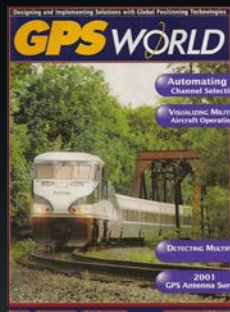


### NAVCOM TECHNOLOGY

2000: NavCom now operates as a wholly owned subsidiary of Deere & Company. As early adopters of GPS technology for agricultural applications, Deere believes satellite positioning and StarFire technology innovations developed by NavCom to be an integral part of its current and future business. As a member of Deere & Company, we are dedicated to its 177 year-old tradition of product integrity, reliability, and customer satisfaction.



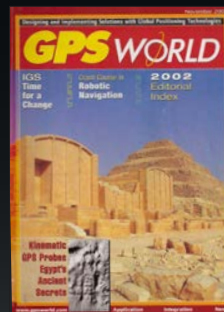
2001



### INDUSTRY DEVELOPMENTS

- Interstate Electronics Corporation, a subsidiary of L-3 Communications, rolls out its next-generation of military GPS receivers. Among them, the TruTrak 12-channel SAASM-based receiver is configurable for range avionics or handheld navigation platforms.
- NavCom Technology, a subsidiary of Deere & Company, and NASA's Jet Propulsion Laboratory (JPL) collaborate to combine JPL's Global Differential GPS (GDGPS) with the Deere/NavCom StarFire Network, accelerating NASA's ability to develop and test global real-time precise positioning with GPS.

2002



### INDUSTRY DEVELOPMENTS

- Datum, a manufacturer of GPS-based timing and frequency products, becomes a wholly-owned subsidiary of Symmetricom, a maker of network synchronization, timing, and broadband access products for wireline and wireless communications. Symmetricom also announces the purchase of TrueTime, a provider of time and frequency products for government and commercial applications.

2003



### GEORGE ZHAO CEO, CHC Navigation

"Founded in 2003, CHC Navigation has experienced the fastest growth of any GNSS company, now supported by a portfolio of 200+ quality products and 500+ technical employees.

"Tens of thousands CHC's GNSS receivers are today used in more than 100 countries. We constantly aim to remove cost barriers to GNSS technology adoption."



2004



### INDUSTRY DEVELOPMENTS

- Septentrio Satellite Navigation delivers the first Galileo receiver to the European Space Agency as part of the Galileo Test User Segment activities.
- ITT Industries, provider of payload systems for GPS satellites, purchases Allen Osborne Associates, manufacturer of GPS systems for precise time and frequency transfer, surveying, ionospheric calibration, and military use.
- NovAtel announces shipment of the first Wide Area Augmentation System receivers and L1/L5 signal generators to Raytheon for the WAAS Final Operational Capability program and the Geostationary Communications & Control Segment, respectively.

# GNSS History: Making a Difference

## 2005–2009 NEW SYSTEMS RISE

Galileo launched its first satellite, GIOVE-A, on December 28, 2005, and its second on April 26, 2008.

Compass/BeiDou launched two satellites, in 2007 and 2009, but by the end of the year neither was usable.

GPS maintained Full Operational Capability throughout this period, ending with a total of 30 satellites: 11 usable Block IIA satellites, 12 Block IIRs, and seven Block II-RMs.

In December 2009, GLONASS had 16 satellites set healthy.

Of satellite-based augmentation systems (SBAS), there were three EGNOS satellites, one GAGAN, two MSAS, and two WAAS.

2005



### INDUSTRY DEVELOPMENTS

- Hexagon AB acquires Leica Geosystems and takes the company private.
- SiRF Technology acquires Motorola's GPS chipset product lines and becomes a preferred GPS technology supplier to Motorola.

2006



### INDUSTRY DEVELOPMENTS

- Raytheon successfully acquires and tracks the new M-code military signal transmitted by the first modernized satellite, GPS Block IIR-14(M).
- Septentrio releases a compact high-end single-frequency GNSS receiver for industrial and professional applications. The AsteRx1 will make use of the Galileo L1 signal, and has been tracking GIOVE-A since it began broadcasting in January.
- Lockheed Martin and EADS Astrium sign a teaming agreement to ensure interoperability of GPS III and the Galileo satellite navigation program.

2007



### INDUSTRY DEVELOPMENTS

- Javad Ashjaee founds JAVAD GNSS and introduces TRIUMPH products: 216-channel receivers, integrated with several communication channels. The company is the first to offer European Galileo and Japanese QZSS tracking in mass production. It also introduces GLONASS inter-channel (group/carrier delay) calibration to 0.2 millimeter, making GLONASS FDMA comparable to GPS CDMA.
- Hexagon AB acquires NovAtel, supplier of GPS engines to another Hexagon subsidiary, Leica Geosystems.

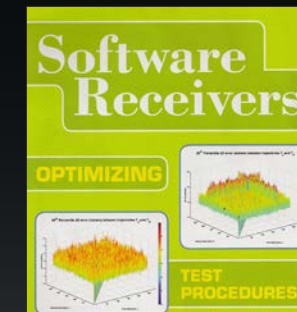
2008



### INDUSTRY DEVELOPMENTS

- The Secretary of the U.S. Air Force announces that the \$1.4 billion development and production contract for the first eight GPS III satellites goes to a team headed by Lockheed Martin. Team members include ITT Corporation and General Dynamics.

2009



### INDUSTRY DEVELOPMENTS

- Trimble introduces its AP Series of embedded GNSS-inertial OEM boards plus an inertial measurement unit from Applanix in a compact form factor, for continuous mobile positioning in poor signal environments.
- SiRF Technology and CSR, formerly Cambridge Silicon Radio, merge.
- EADS Astrium acquires Surrey Satellite Technology Ltd., maker of the GIOVE-A, Galileo's initial satellite.

# GNSS History: *Making a Difference*

2010

2011

2012

2013

2014

## 2010–2014 THE GANG OF FOUR

The GNSS Constellation Almanac published in the August 2014 issue carried these system totals for active and healthy satellites:

- ▶ **GPS: 31**
- ▶ **GLONASS: 24**
- ▶ **BeiDou: 14**
- ▶ **Galileo: 3**



**MATTHEW G. GILLIGAN**  
GPS OCX Program Manager  
& Vice President,  
Raytheon

The new GPS-OCX:

- Dramatic performance improvements
- Unparalleled cyber-protection
- Effective use of modern signals
- Flexible, open architecture built for the future.



**CARLO DES DORIDES**  
Executive Director,  
European GNSS Agency (GSA)

2011 was a turning point for the GSA:

- Implementation of EU Regulation establishing the European GNSS Agency.
- EGNOS certified for civil aviation.
- Galileo Security Accreditation Board was fully functional.

"The GSA is ready to become the key player for Galileo."



**DOUG LLOYD**  
Senior Director,  
Navigation Products,  
Rockwell Collins

"A leader in GPS technology for over 35 years, Rockwell Collins has delivered its 450,000th Defense Advanced GPS Receiver (DAGR)."



**NUNZIO GAMBALE**  
Founder & CEO,  
Locata

"Our LocataLite creates ground-based, centimeter-level, totally autonomous local replicas of GPS — a world first. Satellite + terrestrial positioning is now inevitable. Welcome, GPS 2.0!"



**DAVID SMALL**  
Founder & CTO,  
Locata

"The multipath 'devil' must be overcome before reliable indoor and urban positioning can be delivered. Our VRay technology is the breakthrough that makes it possible."

