Future Navigation Signals: Need for Flexibility

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GPS Signal History

- GPS satellites have lasted in operation as long as 24 years
- Continued growth expected in signal needs

**Legacy**
- Single civil signal (L1C/A)
- P(Y)-code (L1&2)

**Modernization**
- 2nd civil frequency (L2C)
- 3rd civil signal (L5)
- Military-code (L1M & L2M)

**Block III**
- 4th civil signal (L1C)

**Block III 11+**
- 4th civil signal (L1C)

History shows more signals will be desired
International Signal Growth

- **GLONASS**
  - Moving to CDMA

- **BeiDou**
  - Regional going global, B1, B1-2, B2, B3

- **Galileo**
  - E5, E6, E2-L1-E11

- **Navic**
  - Regional L5, S

- **QZSS**
  - Regional, L1, L2, L5, LEX
Need for Additional Signal Capability - Authentication

- Pilot reports regarding incidents of GPS signal loss have increased.\(^1\)
- In April last year, South Korea said that around 280 vessels had to return to port after experiencing problems with their navigation systems.\(^2\)
- Truck accidentally driver jams Newark airport. \(^3\)

\(^1\) Aviationtoday.com
\(^2\) Hellenicshippingnews.com
\(^3\) CNET.com
Emerging Applications

- Large vehicles relying on navigation need evolving signals and integrity
  - Self-driving cars
  - Drone delivery
  - Autonomous mass transportation

Source: U.S. Department of Transportation
Signals in Development

- There are multiple companies and institutions working on new signals
  - Stanford and Boeing are working on civil authentication signals
- Galileo has authentication on civil signals
- University of Cambridge – navigation digital signatures
- Software defined navigation receivers – allowing for new signals
- Multiple reports on practical cryptographic for civil signal authentication
Technology Available

- Today’s satellite systems technology can accommodate changes
- Commercial communications satellites are successfully deploying reprogramming capabilities today
  - Intelsat 37e: "This latest launch is an example of our emphasis on quality and reliability to deliver the right products and capabilities to our customers," said Paul Rusnock, vice president and general manager of Boeing Satellite Systems. "Boeing’s digital payload technology gives our customers the flexibility to adapt to surges in demand for connectivity when and where it is needed, as well as adapt to any changes in their business needs or missions."