

A Common Clock Reference For All GNSS

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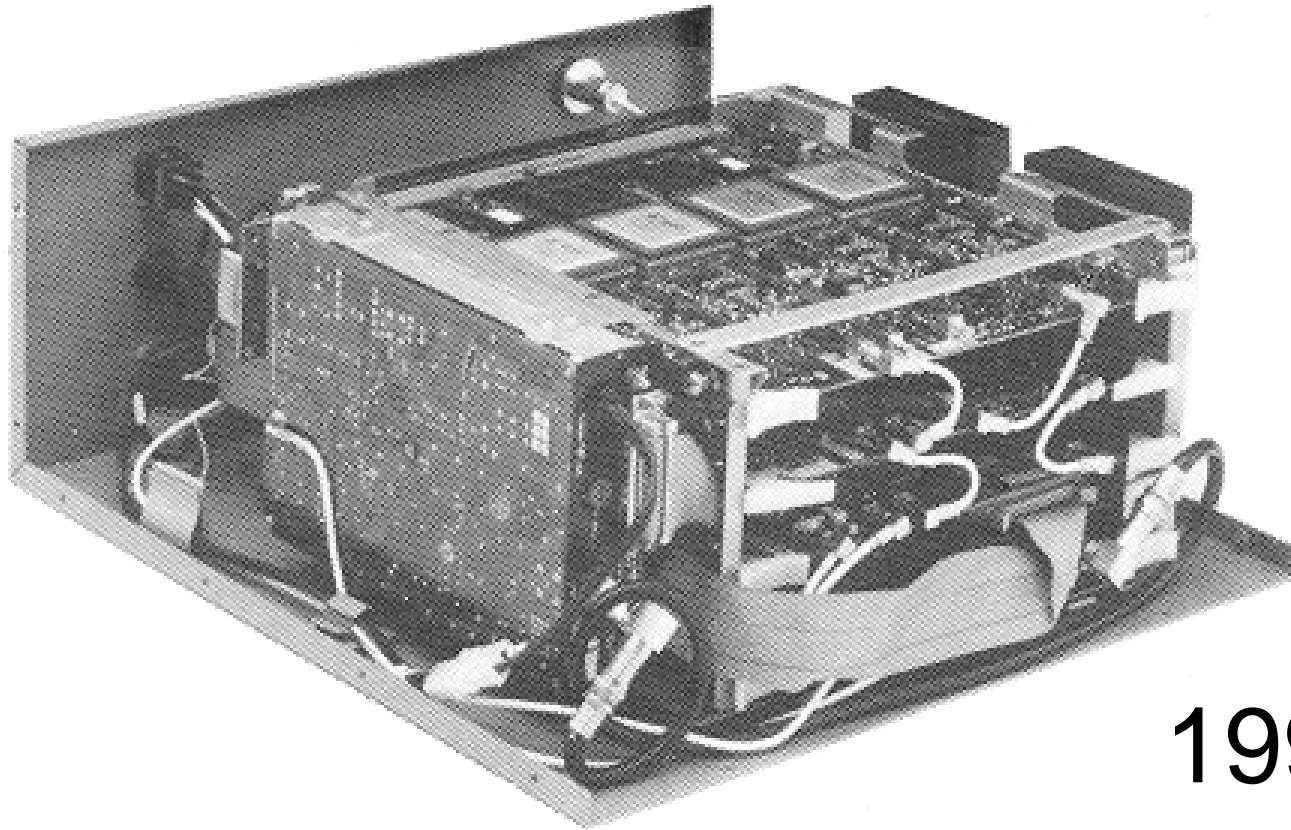


Perspectives

- ◆ My focus is Navigation and Positioning
 - Not time dissemination
 - 1 μs satisfies MOST time dissemination needs
- ◆ For Navigation and Positioning, the MOST important thing is to minimize time offsets between the satellite clocks, whether intra or inter system
 - GPS satellite clock offsets are $<$ about 3 ns (1 m)
 - Hopefully other systems will do as well
 - Users must reduce inter-system offsets equivalently
- ◆ Satellite data bits should not be “wasted” and GGTO messages are infrequent and uncertain in urban areas

Shaping My Perspective

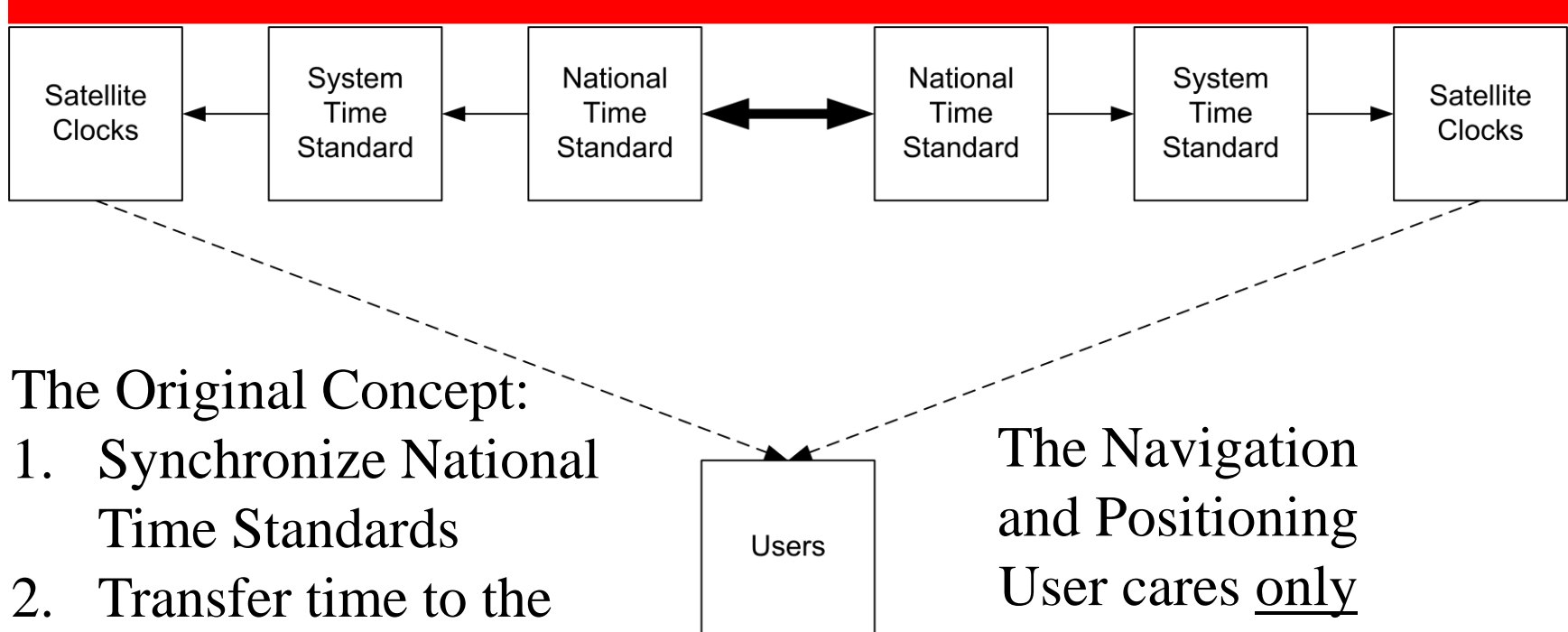
GPS + GLONASS Navigator



1990

Receiver had to compute GPS-GLONASS time offset

Original GGTO Concept



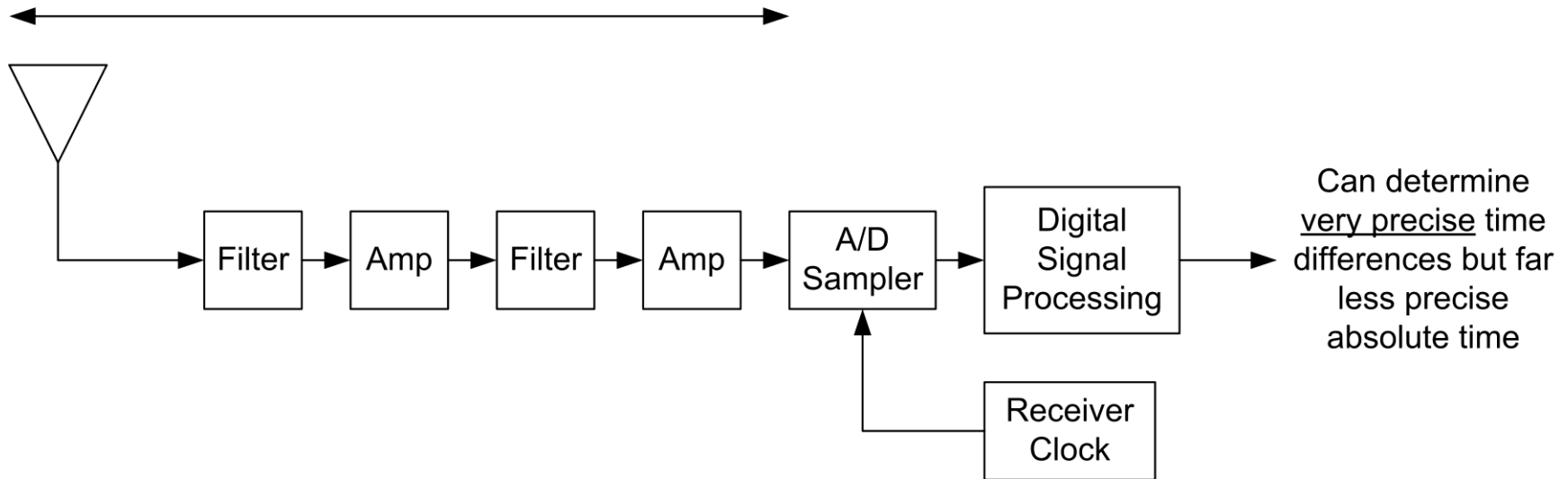
The Original Concept:

1. Synchronize National Time Standards
2. Transfer time to the GNS Systems
3. Transfer time to the Satellites
4. Transmit the time differences as GGTO messages

The Navigation and Positioning User cares only about having common satellite clock times

Receiver Processing

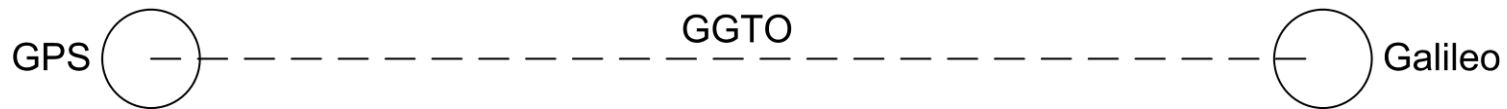
Unknown Variable Time Delays – but Common to all signals with the same Center Frequency and Spectrum



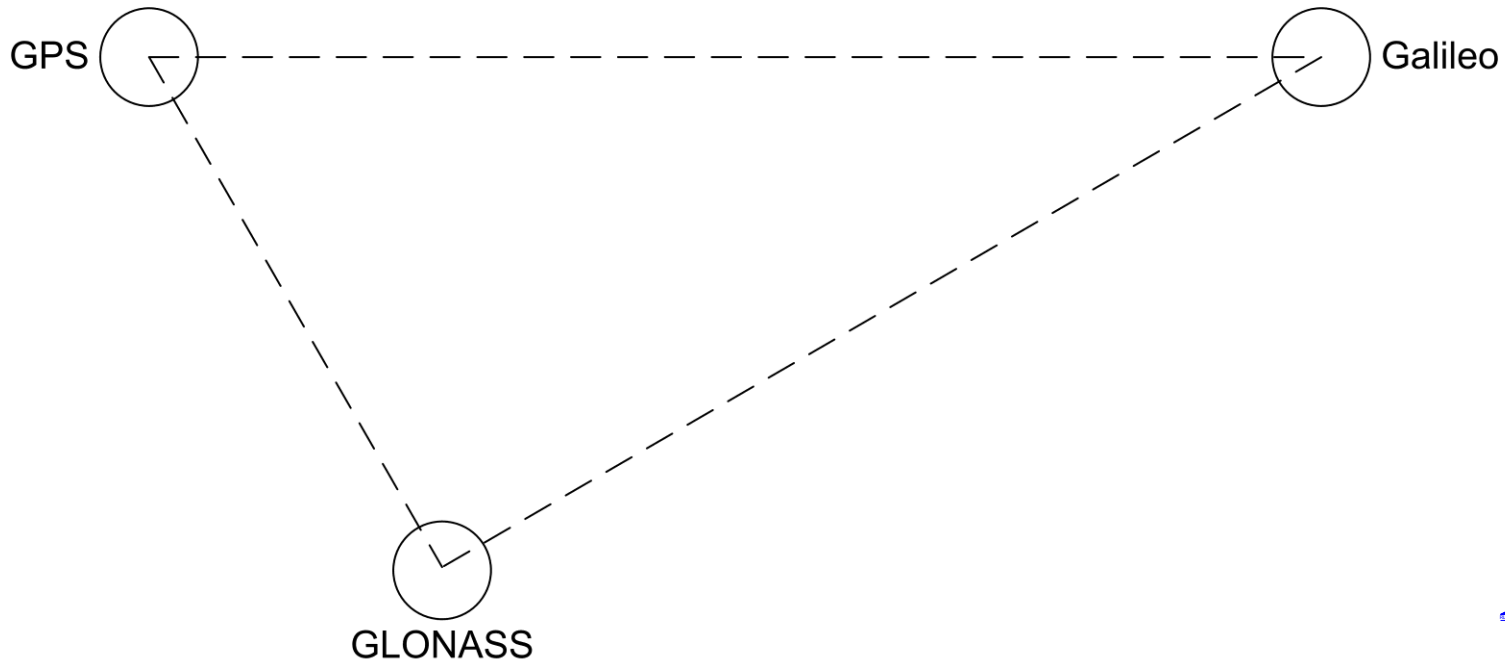
Modern Multi-GNSS receivers can observe and **PRECISELY** calculate system time offsets in each band

The requirement is to use a common antenna, common RF filters and amplifiers, common A/D sampler, and common receiver clock, processing signals with a common center frequency and spectrum

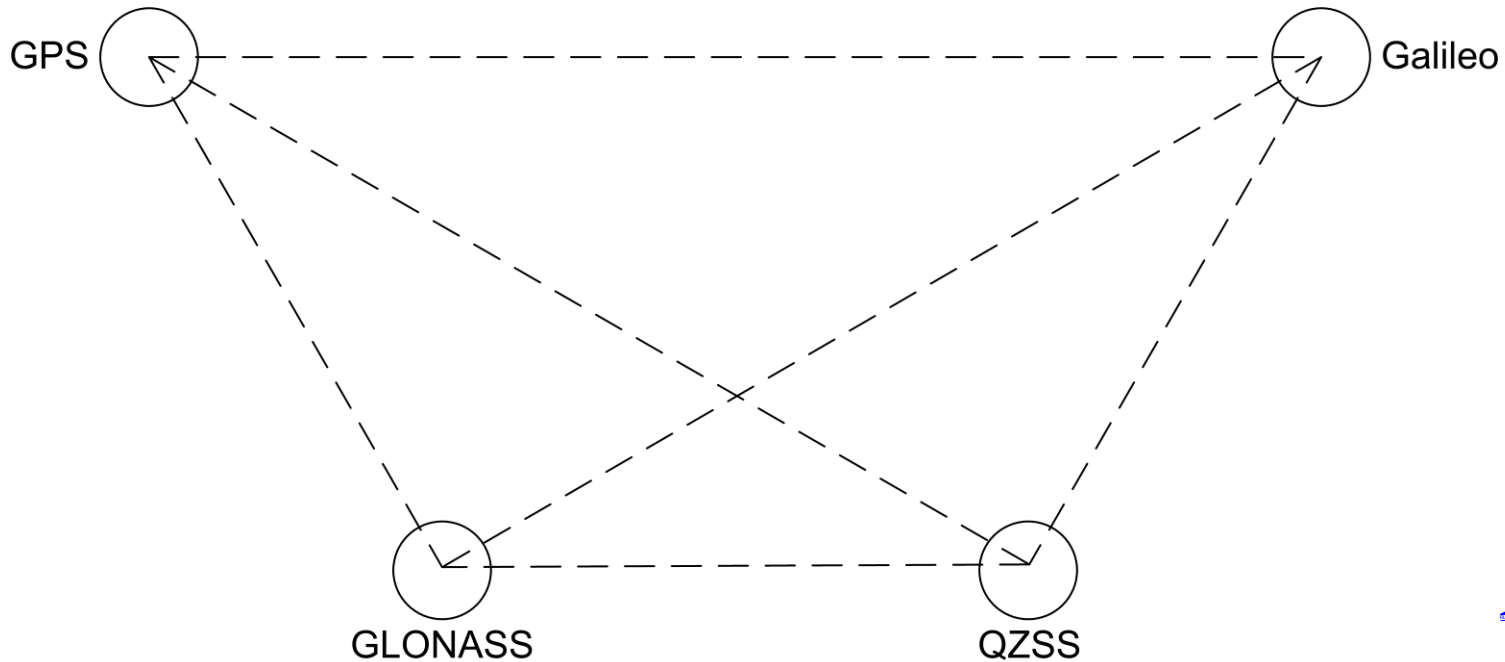
Simple Initial Idea



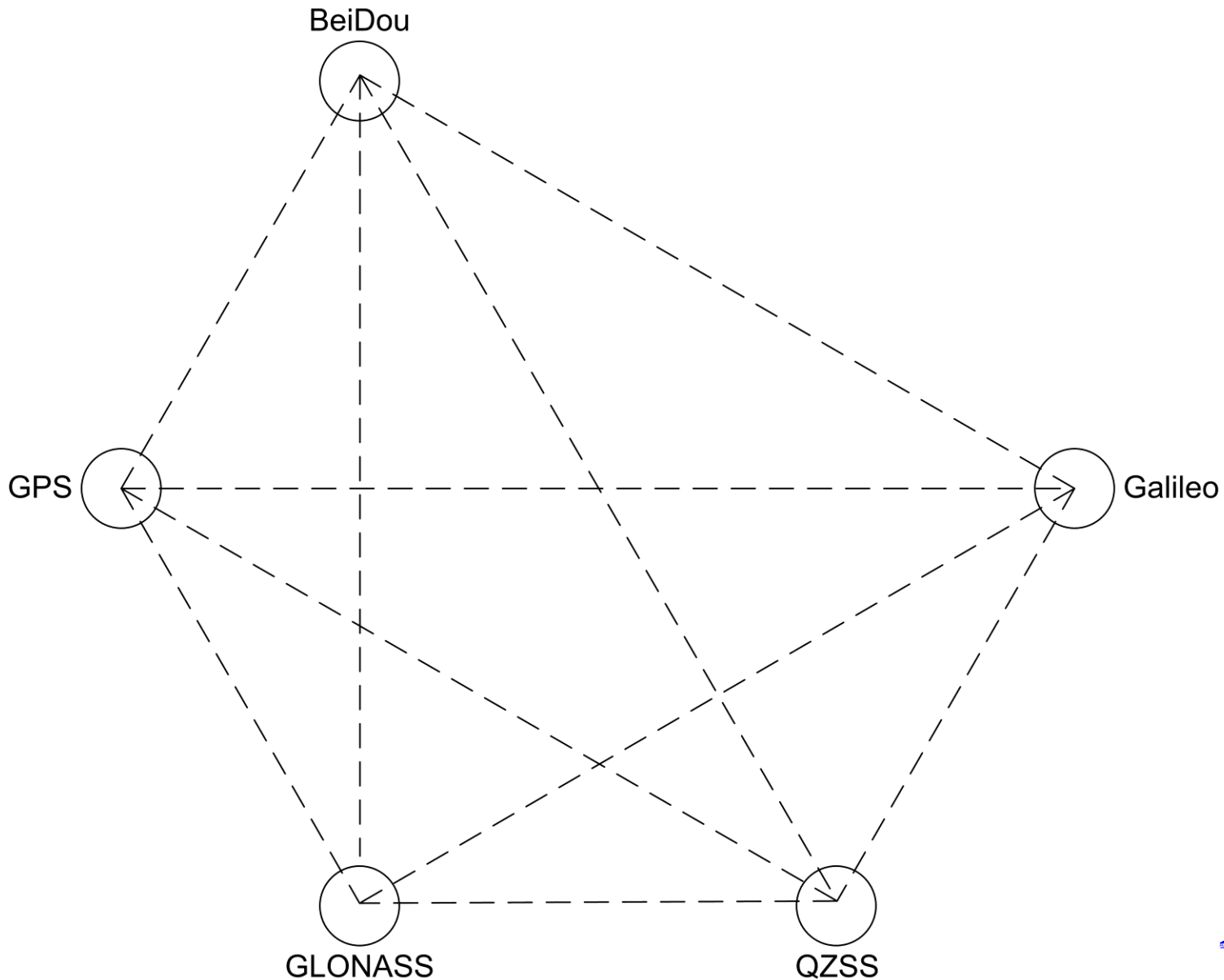
Began to Become More Complex



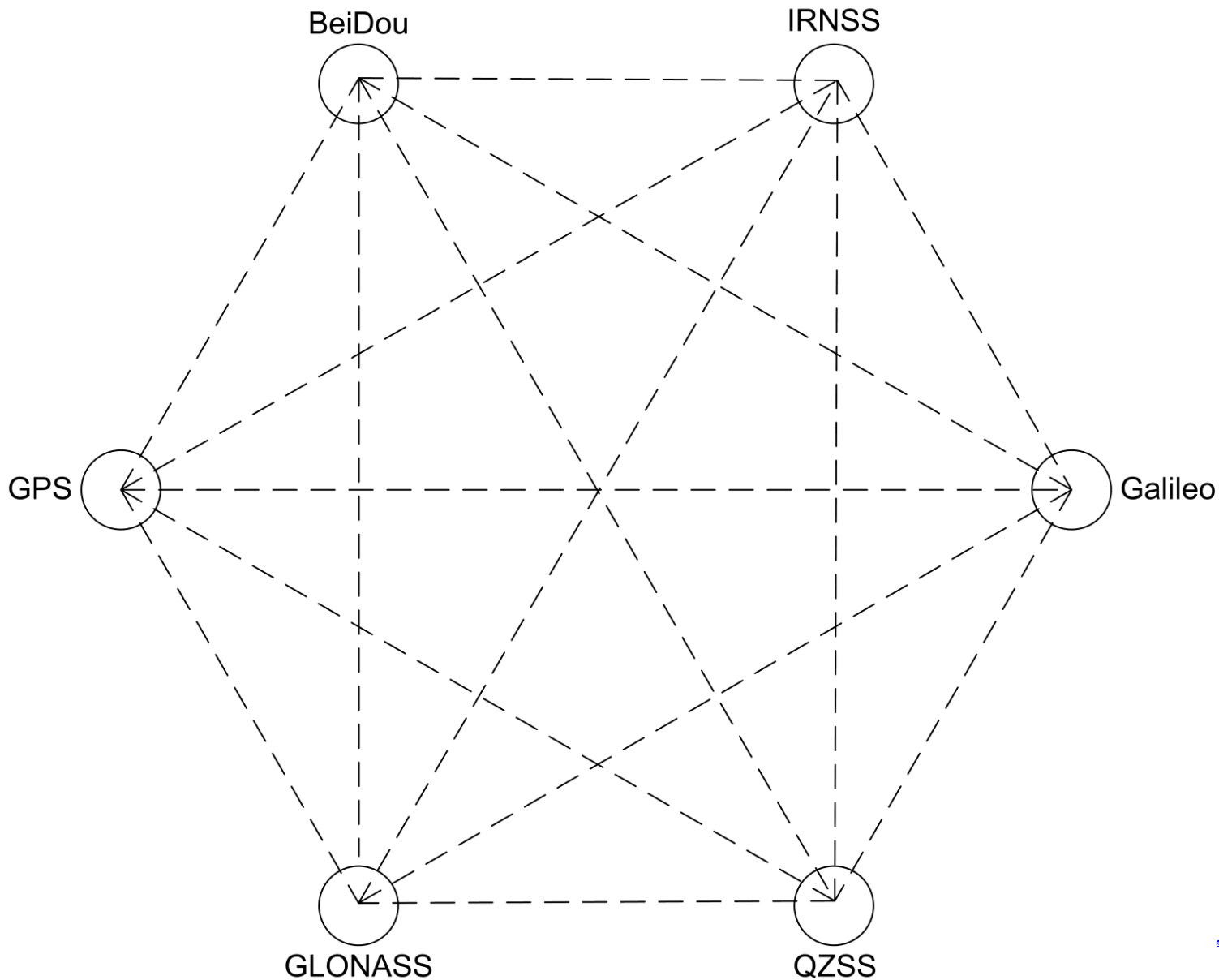
And More Complex



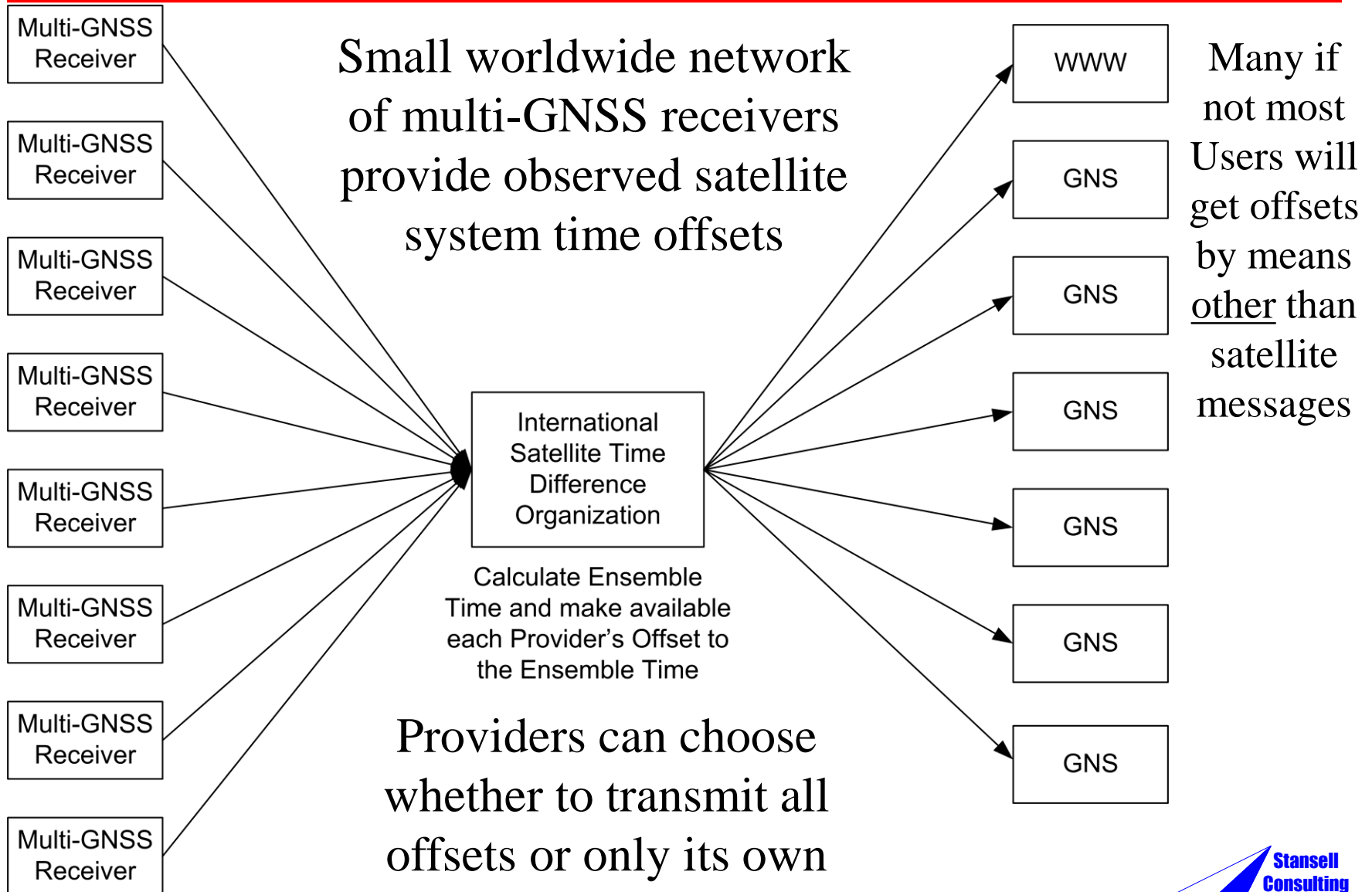
And More Complex



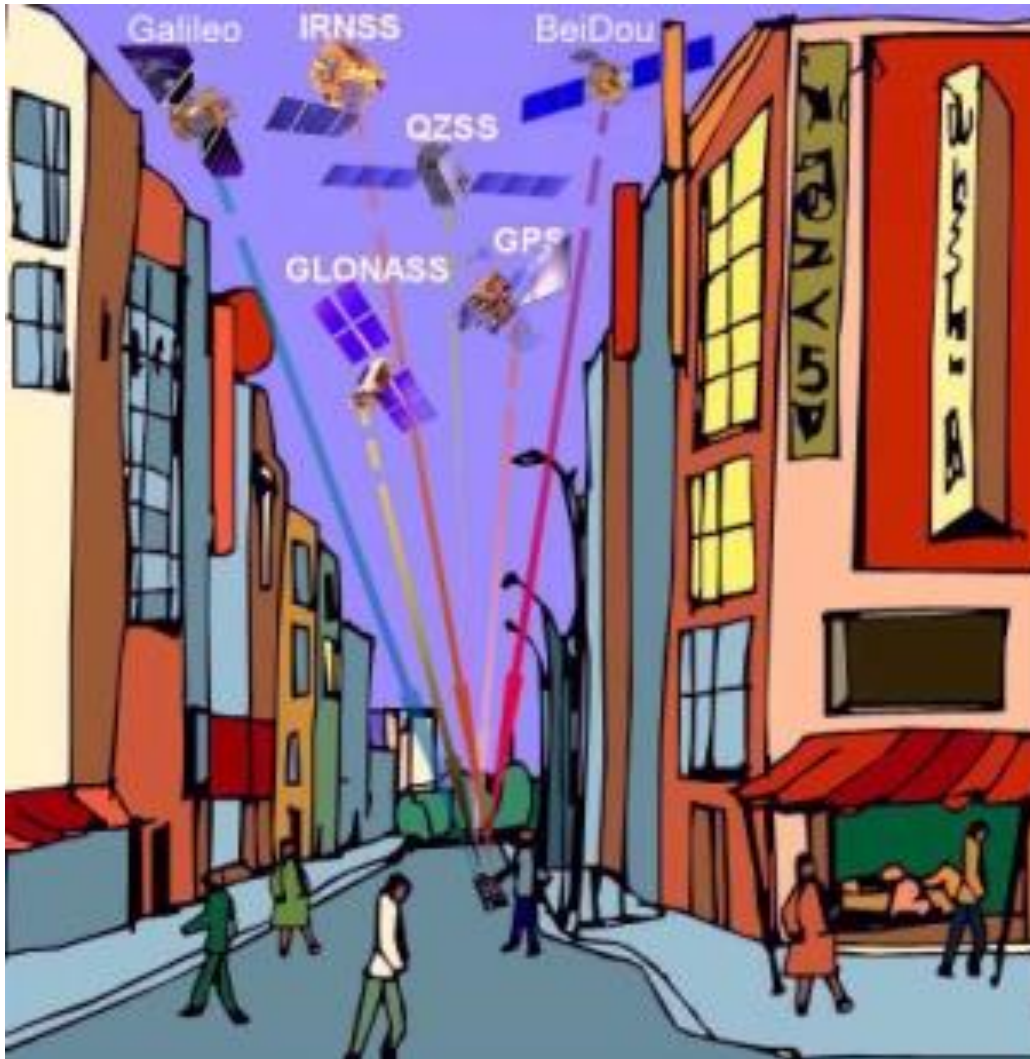
Five GGTO Messages Each



Providing Ensemble Time Offsets



The Goal of Interoperability



Interoperable = Better Together than Separate

- ◆ Ideal interoperability allows navigation with **one signal each** from four or more systems **with no additional receiver cost or complexity**
- ◆ Success requires signal designers to think globally while also satisfying national interests

Summary and Conclusion

- ◆ System time offsets best seen by the user receiver
- ◆ But, they are needed immediately on power up
- ◆ The Internet is increasingly the source of choice
- ◆ If each GNSS Provider transmitted only its own offset to an Ensemble Time, bits would be saved and the update rate could be faster
- ◆ Relieves Providers of performing this function
- ◆ Provides a common source of all time offsets
- ◆ Recommend some international organization take the Ensemble Time Offset responsibility
 - BIPM? IGS? Other?