Realizing Geodetic Reference Frames on a Global Scale

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Bangkok, Thailand
November 2, 2012

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Emerging Markets and Funded Projects

Trimble Navigation Ltd.

Industry's Role in Global Geodetic <u>Infrastructure</u>

What Technology Exists Today That Is Supporting National/Regional/Global Reference Frames?

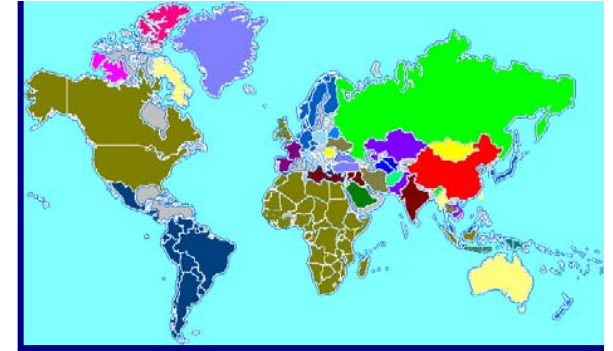**Is the shift from legacy datums to GNSS-supported reference frames technically difficult? Costly? Both?**

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Where is GNSS heading?

GPS	30 (current)
GLONASS	24 (current)
Galileo	27 (2019)
QZSS	3 (2013)
COMPASS	35 (2020)
IRNSS	7 (2014)

visible sat = 12
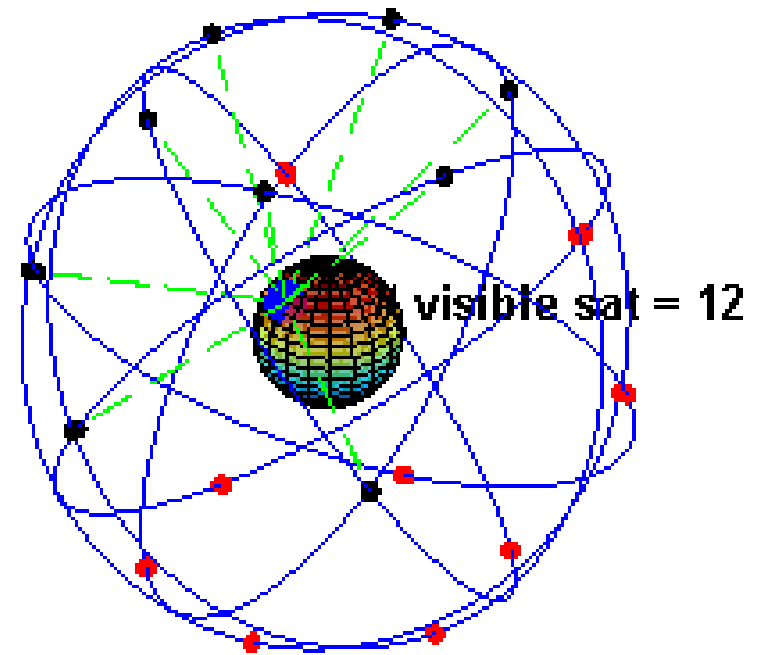
Streaming More Bands: L1, L2, L5, etc

All of these developments are good news

5,500 stations Worldwide,
      300+ Real Time Networks

ITRF (benefits, challenges)

-**Excellent Starting Point for CORS development**
- - **ITRF2008 needs updating, but is the best proxy for current sub-regional network establishment**

-**Tracks linear Δ, but non-linear Δ is what is happening**
- - **cm-based, needs to be mm-based**
- - **Long-term focus, short-term ignored**
- - **Network RTK does not work well without significant adjustment**

-**Gravity is key variable**
- - **Gravity variables not adequately incorporated, no "| |" w/ gravity consideration!**

  Now we need to choose a strategy:
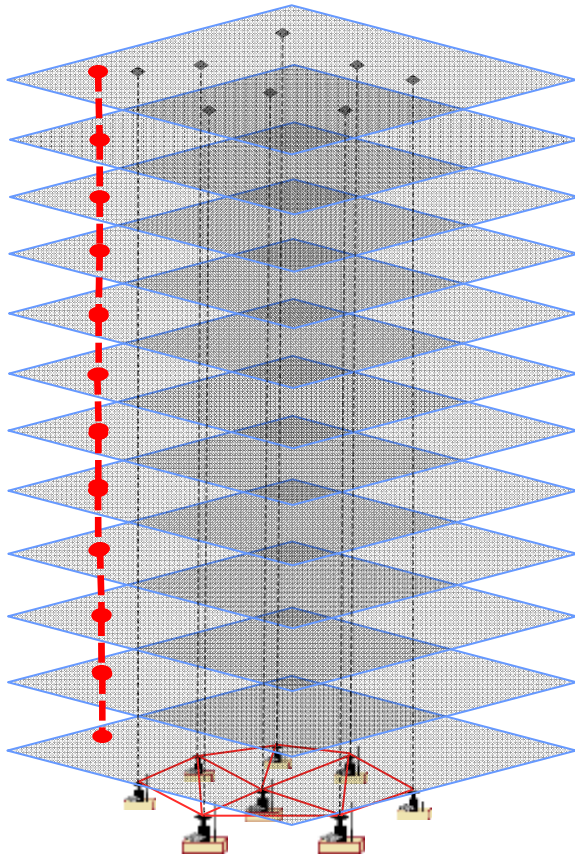   **Scientific, Commercial, Government (or a mix)**
        Sparse Density vs. Optimal Density
        Static (Passive) vs. Dynamic (Real Time)
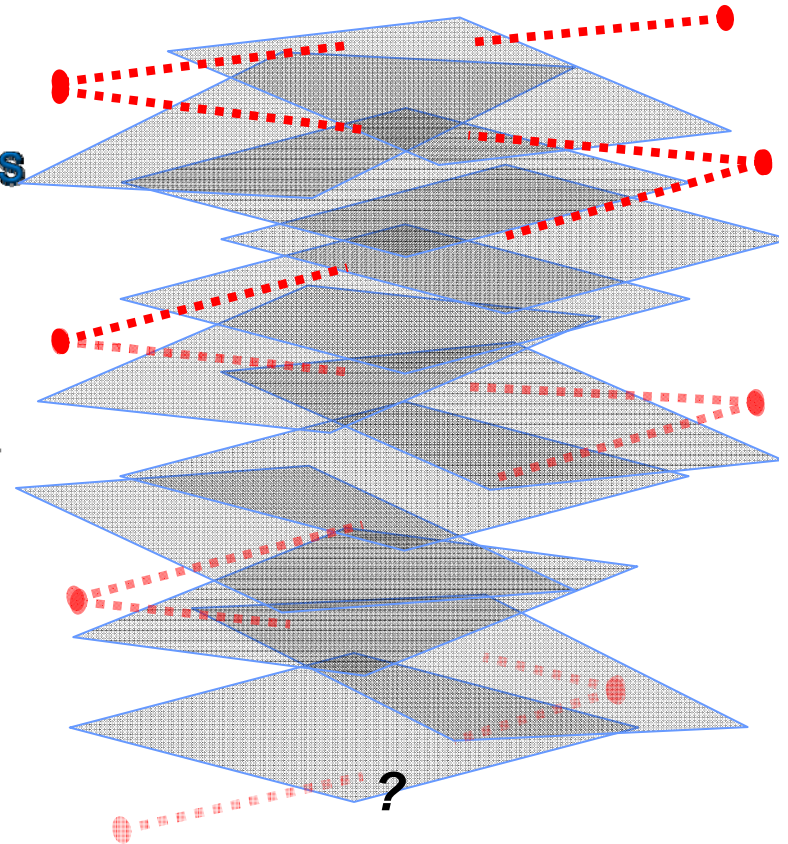   **PROGRESSION PLAN –** *remember that technology changes!*

A Global Reference Frame for what?

$$ERR = r, where \sum_{i=1}^{N}\left[(Economic\ Benefits_i - Economic\ Costs_i)/(1+r)^i\right] = 0$$

METEOROLOGY
NATURAL RESOURCES
CROSS BORDER UTILITIES
BOUNDARY DISPUTES
URBAN DATA
CONSTRUCTION
MILITARY
GEOLOGY / SEISMOLOGY
REGIONAL PLANNING
TRANSPORTATION
DTM, DEM
NATIONAL BOUNDARIES

Regional Reference Frame   •----- = spatial "dialogue"   **Discrete Reference Frames**

Reference Frame Integrity

Understanding the challenge of "Networking" our reference frame

Interference

Longer Baselines (what is acceptable)

Required Communications

Local Buy-in

Capacity Building for Control

Dissemination of Data

What is *NEW* in the market that will help us?

Satellite-based Augmentation + Ground Based Augmentation

Differential Positioning Services

Network-free 2cm Accuracy

Rapid Initialization

Speed in Data Acquisition

Can Integrate with CORS

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What is **NEW** in the market that will help us?

Network Baselines are Growing Longer and Longer: *HOW?*

Advances in signal processing algorithms
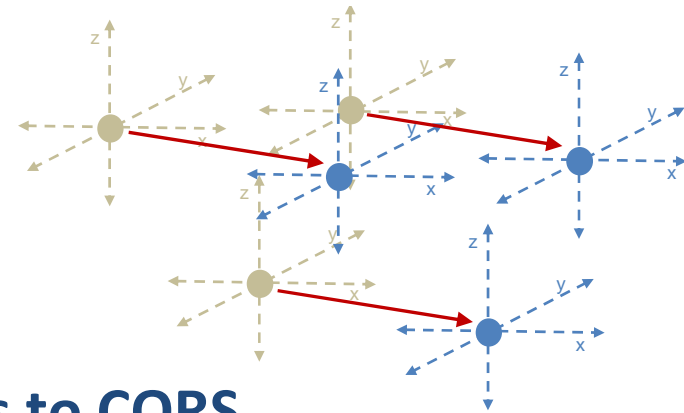
$$I(\lambda, \phi) = I_0 + a_\lambda \Delta\lambda + a_\phi \Delta\phi + \ldots$$
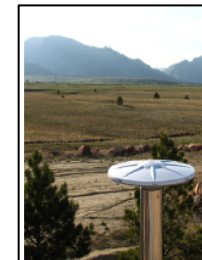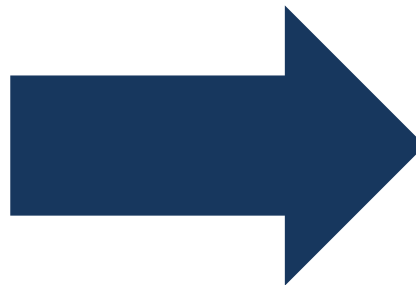
Significant Advances in Control SW….

NEW APPs!

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Datum Transformation
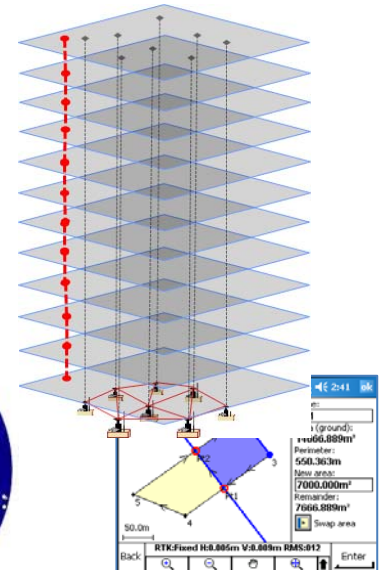

Transferring Passive Datums to CORS

- starting at zero order and utilizing software

- can be cost effective and easy if well-planned

- technology aside, understand the social impact
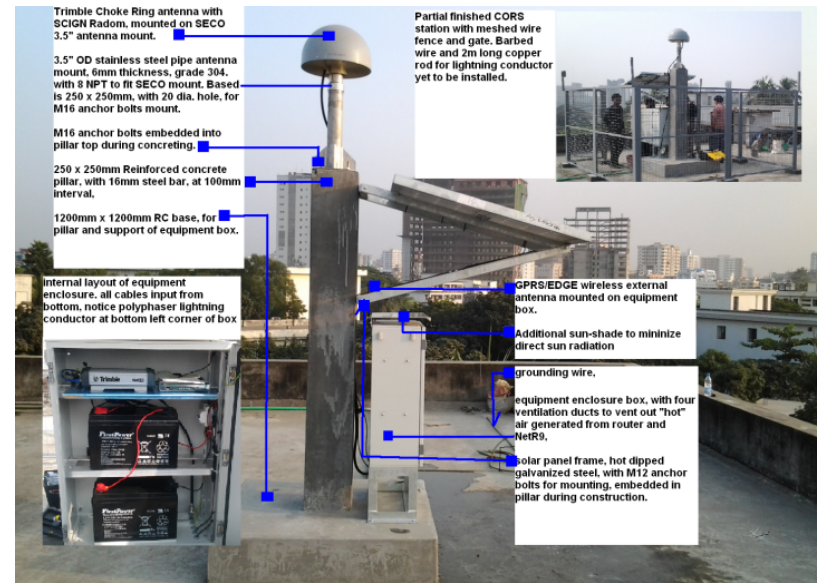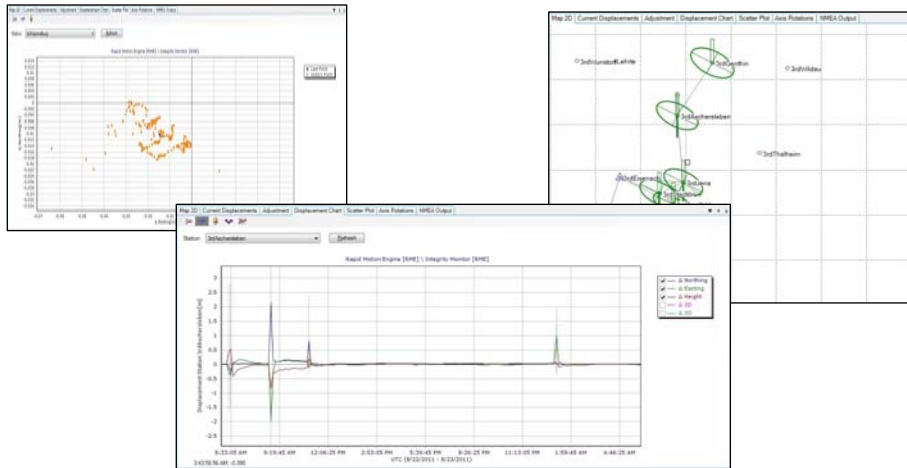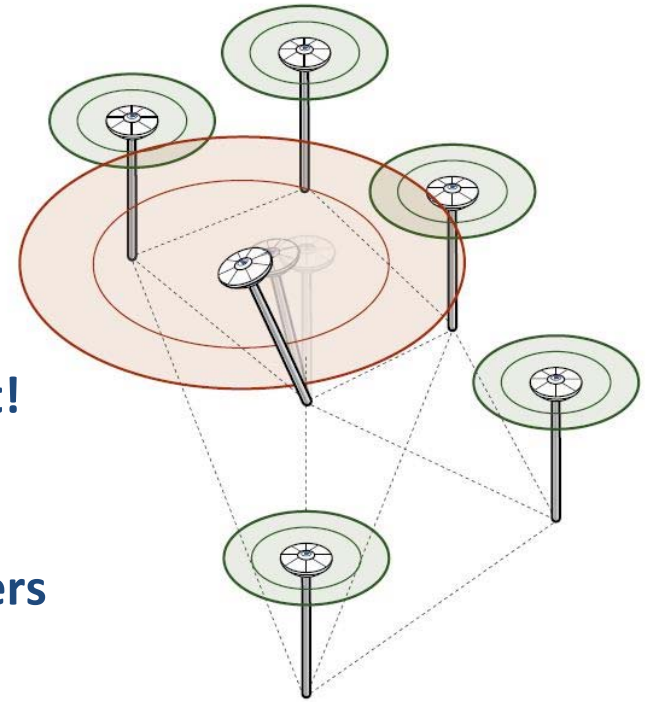

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Reference Frame Integrity

Control Software must be flexible
- Not everyone has network-supporting communications – but should not be left out!
- Some countries may only have one or two stations
- Inter-frame communication among members requires some capacity/knowledge of the network for each member country

Concluding Thoughts

The technology available today (and under development) can support the establishment of large regional and even global reference frames.

Adoption of CORS and other GNSS technology for geodetic control is an inevitability, but needs to be carefully planned at the national and regional level.

Technology can be used to facilitate greater participation in regional reference frame development, and may improve overall adoption of CORS and other GNSS technology at the national level.

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