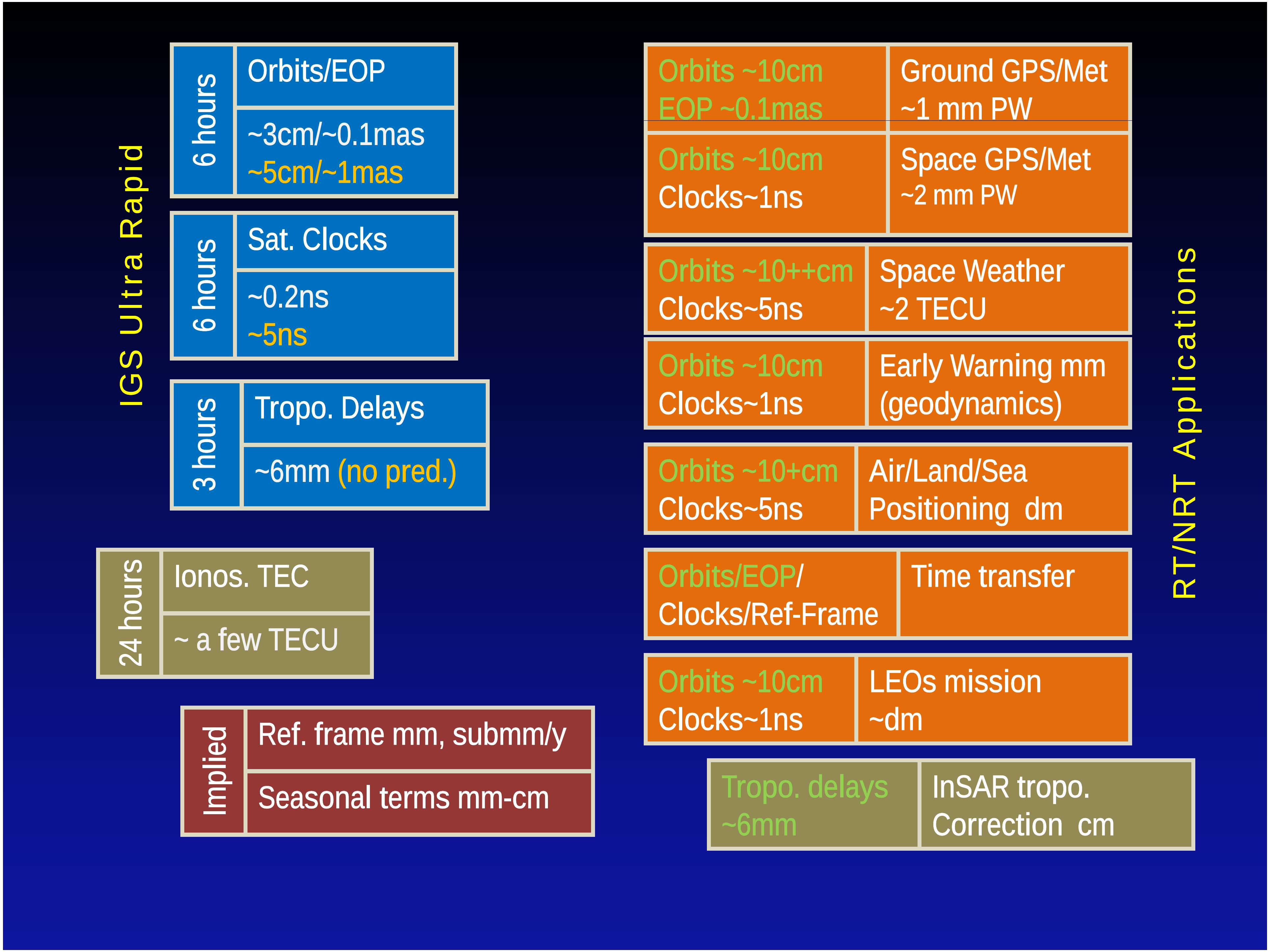
Survey of Requirements of Realtime/Near Realtime applications in terms of Current and Potential IGS Ultra Rapid Products

Peng Fang
Scripps Orbit and Permanent Array Center
University of California San Diego

IGS Analysis Center Workshop 2008
2-6, June 2008, Miami, Florida, USA



IGS Ultra Rapid
6 hours
Orbits/EOP
~3cm/~0.1mas
~5cm/~1mas
6 hours
Sat. Clocks
~0.2ns
~5ns
3 hours
Tropo. Delays
~6mm (no pred.)
24 hours
Ionos. TEC
~ a few TECU
Implied
Ref. frame mm, submm/y
Seasonal terms mm-cm
Orbits ~10cm
EOP ~0.1mas
Ground GPS/Met
~1 mm PW
Orbits ~10cm
Clocks~1ns
Space GPS/Met
~2 mm PW
Orbits ~10++cm
Clocks~5ns
Space Weather
~2 TECU
Orbits ~10cm
Clocks~1ns
Early Warning mm
(geodynamics)
Orbits ~10+cm
Clocks~5ns
Air/Land/Sea
Positioning dm
Orbits/EOP/
Clocks/Ref-Frame
Time transfer
Orbits ~10cm
Clocks~1ns
LEOs mission
~dm
Tropo. delays
~6mm
InSAR tropo.
Correction cm
RT/NRT Applications

How to come up with the requirements

A. Sort out the analytic/semi-analytic/empirical relationship between the cause and effect

No so simple: causes are CO-related usually and the one to one relationship can not be easily established or simplified. Assumptions may also in conflict.

B. Using reported cases to infer

Two problems:

1. generalization may not be possible
2. cases often report best scenario. So it is hard to put a lower bound.

So mostly just conceptual

Important

(focus on applications of relatively high accuracy or demanding absolute quantity)

- IGS Products have to be used in a consistent manner
  - Individual products are not so independent. They are always coupled.
  - There are “pieces or objects” implied in the products, such as reference frame, error modeling applied, and conventions used.
- Application software has to “understand” IGS products
  - Including the product’s precision, accuracy, and certain limitations (Best Ref. Kouba, 2003, Guide to using IGS Products)

Helpful Relationship and Conversions

- Orbit error propagation into baseline/network

  *|db|/b = |dr|/(k*r) $4<k<10$ Ziekinsk 1988*

  b := baseline length

  r := mean distance between satellite and station

  k := scale accounting for over conservative

  1 cm orbital error => sub mm position error over 1000km

- EOP

  Pole X/Y: 1 mas => 2cm   UT: 1mas => 3cm

  (on the ground. there is a latitude dependence>

- Clocks

  1ns = 30cm or 1cm = 0.033ns

Ground based GPS/Met

- Orbits (currently 5 cm, not a problem)
- Clocks (only for PPP)
  - Currently at 5ns level. Need to be improved to 1ns or better

Space based GPS/Met (RO)

- Double/triple differencing scheme
  - Orbits (OK), Clocks not involved
  - High quality tropo. and high spatial resolution TEC will help (used for controlling ground station related errors)
- PPP scheme
  - Orbits (OK)
  - Clocks need to be improved to 1ns or better

Early Warning/High Precision Monitoring

- Orbits (Not a problem)
- EOP (currently at 1 mas level.)

  Desirable to have sub-daily estimates available for high temporal resolution applications.
- Clocks (only for PPP applications)

  Currently at 5ns. Need to get down to 0.2ns.
- Reference frame

  May need periodical term be included
- Tropo.

  High spatial resolution may help
- TEC mapping

  Timely available high temporal and spatial resolution TEC will be extremely useful over iono. active region.
- Per site multipath corrections (t)

Realtime/Near Realtime Positioning

(for local or regional applications in baseline or network mode)

- Orbits (Not a problem)
- EOP (Not a problem)
- Clocks (no need)
- Ionospheric mapping

  highly desirable
- Troposheric mapping

  high temporal and spatial resolution highly desirable

  but may not be IGS' business

Time Transfer (for PPP type of application)

- Orbits

  Currently IGS ultra rapid prediction at ~5 cm level (=~ 0.2ns)

- NRT TEC with short term prediction (for single frequency receiver time transfer)

  Should significantly improve the performance even at lesser accuracy. In the single frequency case, ionospheric error is dominant in comparison to orbit (and clock).

Space weather

- Orbits (not an issue)

  for NRT space weather applications, the dynamics of ionosphere activates is of major interest while orbit errors mostly translate into spatial dislocation of the estimate.

- Clocks (for using PPP scheme)

  Again clock errors are actually range errors which will proportionally degrade TEC estimates.

LEOs Mission

High profile projects do orbits/clocks on their own. So the IGS infrastructure is important, e.g. high quality data, data availability with good geographical coverage. But doing one's own orbit/clock is expensive. So IGS NRT products may still be useful. In such cases:

- Orbits (the accuracy is OK)

  Hi rate precise orbit velocity is critical
- Clocks (really dependent on the application)

  High temporal resolution is required

InSAR Tropospheric Correction (candidate for NRT products)

- NRT Tropo. Product is now available with a precision at cm level, which is good enough for removing major tropo. effects.

  In this application, only the precision and spatial distribution matter. Tropo product biases will be removed through image differencing.

- Current spatial distribution is highly uneven. This product will only be useful in those regions having relatively dense station coverage.

Desirable Product Addition/Upgrade

- NRT TEC mapping with short term prediction

  in form of grid or spherical harmonic coefficients with a good user algorithm recovering correction values at arbitrary points
- Subdaily EOP

  will improve single epoch or short session (seconds to hours) applications
- Reference frame with well known periodical term included

Possible Improvements

- Clocks without discontinuities (done already?)
- Supply satellite DCB in SP3
- Timely receiver DCB update and make it more visible