



The GPSTk with RINEX 3 and a Multi-GNSS Future

Applied Research Laboratories
The University of Texas at Austin

December 4, 2009

Motivation

- ▶ The future of geodesy is multiple GNSS data in concert.

There is a need for tools that:

- Can handle GLONASS, QZSS, Galileo, etc. data.
- Conform to a standard – logically, RINEX 3.

The GPSTk is being expanded to fill this need.

Its core library copied to a separate development branch, `rinex3_dev`. This will soon become release 2.0.

- ▶ This required major changes to the Toolkit.
 - Some applications modified to use the new library.
 - Many applications still require updating.
- ▶ What is the future of the official GPSTk release?

Major Changes Summary

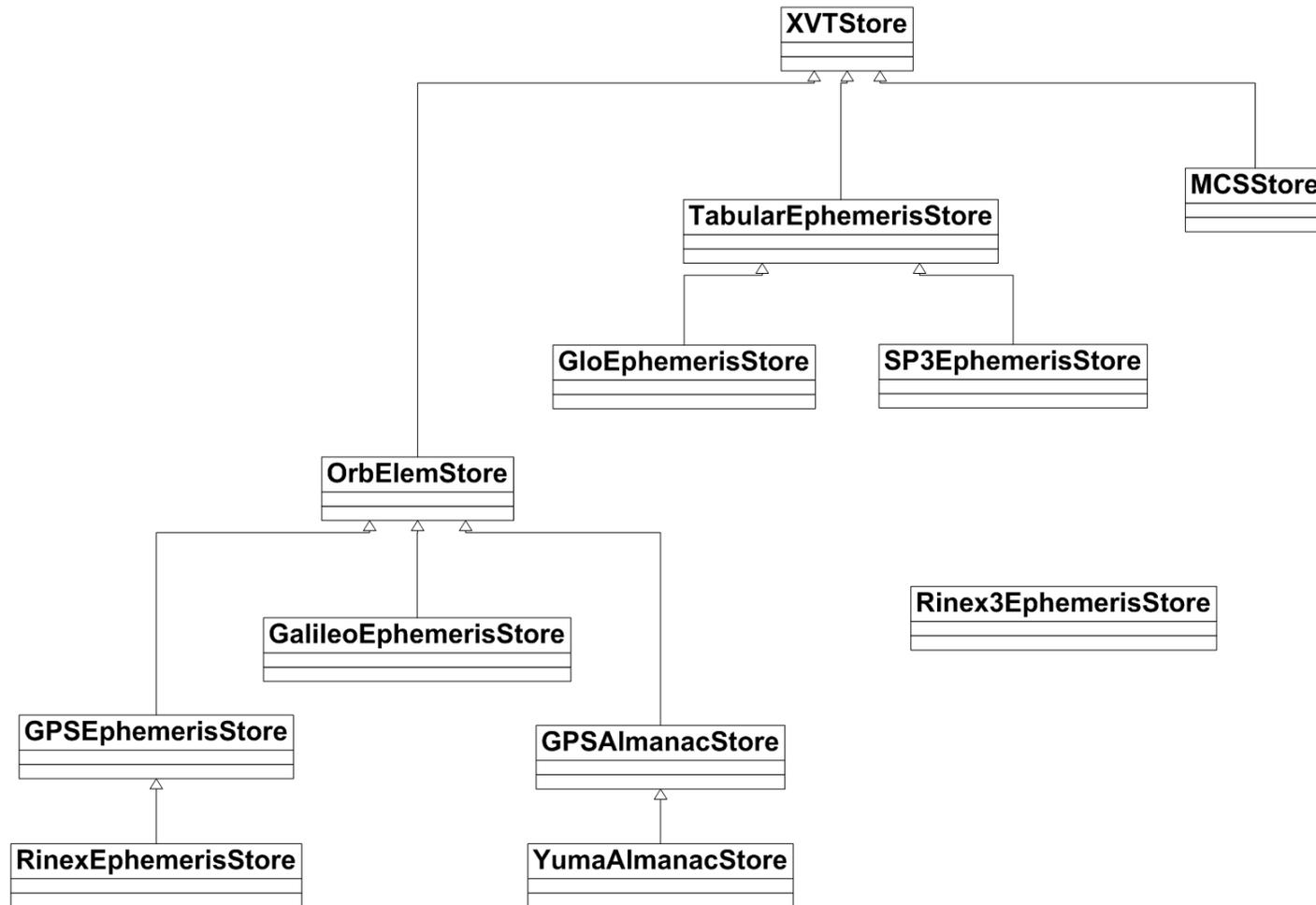
1. Added RINEX 3: new storage class structure
 2. Added full GLONASS (and other GNSS) capability:
 - a. via RINEX
 - b. via SP3
 3. Time class replaced:
DayTime superceded by CommonTime/TimeTag
 4. Added TimeSystem class
 5. Added ReferenceFrame & HelmertTransform classes
 6. Added RinexConverter class & RinexConvert appl.
 7. Obsoleted Geoid classes, added Ellipsoid classes
(nomenclature issue only)
- Changes are not trivial. Despite efforts to maintain backwards compatibility, they break some applications.

Adding RINEX 3: changes

- New pos/vel/time data storage & handling class structure
 - New classes for logical division of orbit data types:
 - TabularEphemerisStore (GLONASS, SP3)
 - OrbElemStore (anything with orbital elements: GPS, Galileo)
 - Rinex3EphemerisStore is new:
 - separate from storage class tree
 - instead, contains instances of actual storage classes
 - handles reading & writing of data
 - segregates data by GNSS
 - Backwards-compatible with RINEX 2 (old classes remain)
 - Anticipates other future GNSSes (QZSS, Galileo, ...)
 - Structural change to pos/vel/time data types:
Xt, Xvt, GloRecord
 - DayTime replaced with CommonTime/TimeTag

Adding RINEX 3: changes

- New pos/vel/time data storage & handling class structure

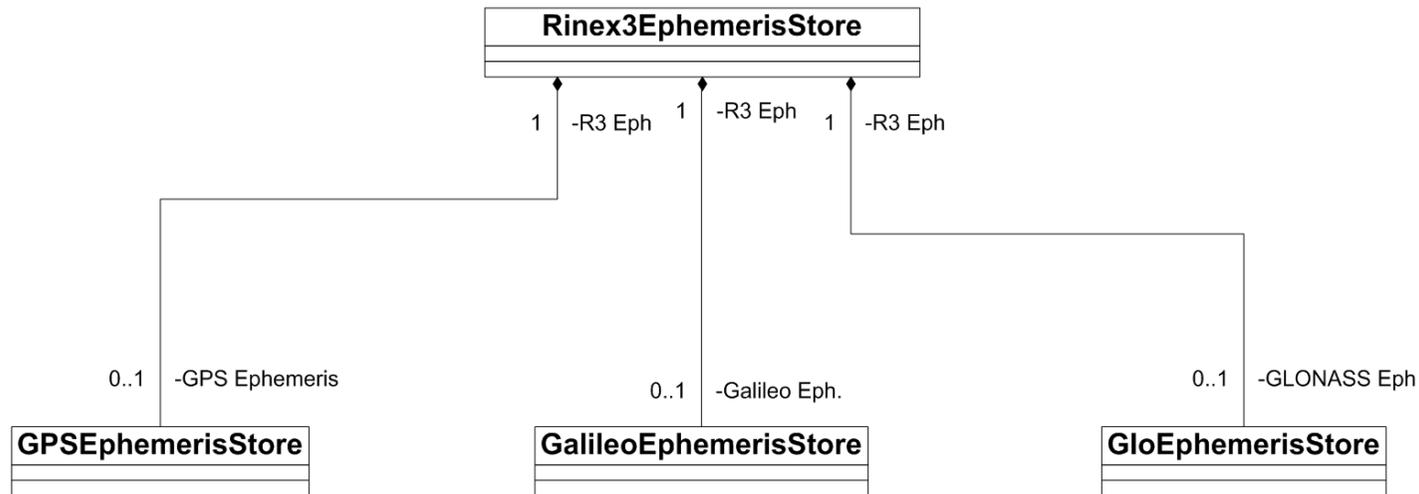


Note persistence of old class structure underneath, for backwards compatibility. New structure invisible to RINEX 2 users.

Adding RINEX 3: changes

- New pos/vel/time data storage & handling class structure

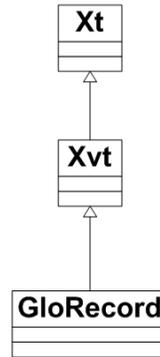
Rinex3EphemerisStore “standalone” class explained:



It contains instances of the storage classes and handles I/O.

Adding RINEX 3: pos/vel/time data types

- New data record types for tabular data



→ includes new/revised accessors: `getXt`, `getXvt`,
templated in `TabEphStore` as `DataRecord`

- `TabEphStore` & `SP3EphStore` changed considerably
(including numerous bug fixes)
- `RinexUtilities` class modified:
methods added to detect R3 Nav & Obs and to sort Obs

Adding RINEX 3: changes

- Changes to Met: None! (RINEX 3 for Met *is* RINEX 2.11.)
 - Changes to Nav: minor adaptations in Data & Header
 - Changes to Obs: deep & significant
 - many more data elements
 - vastly different data & map structures
 - major changes to ObsID for RINEX 3 Obs codes (replaces `RinexObsType`)
 - better Aux Header input/handling
- `EngEphemeris` changed quite a bit to accommodate
- Each future GNSS will require its own ephemeris interface (e.g. Galileo will need a `GalEphemeris`)
- ▶ How one uses these features is different from RINEX 2.

Adding GLONASS: changes and issues

This was the strongest motivation for moving to RINEX 3.

- Nav messages: tabular structure, not orbital elements.
However, more data than what's in P.E. SP3 files.
 - required GloRecord
 - be aware of how to handle relativity corrections
- Obs data: 15 freq. channels instead of 1
 - map searches had to know about SatID & GLO type
 - extensive changes made in PRSolution & PRSolve
 - many apps assume fixed L1 & L2 freq's

Aside on orbits: P.E.s not known quite as well as for GPS.

Time classes: changes and issues

Longstanding issue: DayTime has become a bit unwieldy, has deep bugs, and exhibits hysteresis in transformations.

CommonTime, TimeTag & derivative classes address this

► RINEX 3 branch classes touched are migrated to CT/TT

- This has touched more classes & apps than anything else.

(Rinex___, EngEph, TropModel, ___Weight, EphRange, ...)

- Data storage is CT, but reading data is via TT derivatives, e.g. CivilTime or GPSWeekSecond for RINEX epoch data.

- CT/TT were not ready for prime-time when this started, but are now in better shape than DayTime.

⇒ Recommend that DayTime be obsoleted.

Time Systems

Necessity is the mother of invention:

Each GNSS uses a different time system,
offset from each other.

- ▶ The GPSTk must keep track of this.
 - CT/TT and even DT changed significantly to include TS (done to be as backwards-compatible as possible)
 - Apps migrated to CT/TT had to include TimeSystem
 - TimeSystem is crucial, e.g. reading in R3 or SP3 data → must follow R3/SP3 std's; tag "Unknown" otherwise
 - GPSTk does not have time system transformations → up to user to select

Reference Frames

Each GNSS also uses a different coordinate reference frame.

Note: this is NOT about inertial frames.

- `ReferenceFrame` class keeps track of labels.
- `HelmertTransform` class translates data between frames.
 - `Position` and `Xt` modified to accommodate
 - Not yet directly implemented in R3 classes (e.g. readers)
→ will default to `Unknown` everywhere except in H.T.
 - Beware of accuracy of H.T. parameters in processing
not necessary for PPP, as that uses P.E.s and Obs data
 - Extent of needed accommodation in apps unknown

RINEX Converters

Obvious need for tools to convert RINEX data:

RINEX 2 \rightleftharpoons RINEX 3 (Obs definitely, Nav maybe)

Recall that RINEX 3 contains more data than RINEX 2:

- upconversion can leave holes
- downconversion is lossy

New additions:

`RinexConverter` class in library

`RinexConvert` app

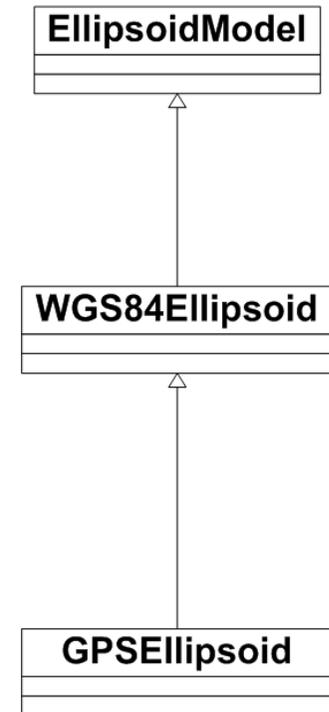
- Presently does only R2→R3, and only for Obs data.

Geoid v. Ellipsoid

An unfortunate example of confusion in the GPSTk:
Geoid classes were used as Ellipsoids

(This is a nomenclature issue.)

- New Ellipsoid classes for ellipsoids.
- Geoid classes now obsolete.
- ▶ Need for GLONASS Ellipsoid at some point.
(Should be easy, it's in the ICD.)



GNSS Mods Summary

- Adding RINEX 3 is necessary for the Tk's future.
- Same for adding GLONASS, and later QZSS, Galileo, ...
→ Big push from many directions to be multi-GNSS capable.
- Mods to Tk for above far more extensive than expected.
- Extent of changes needed in apps unknown.
→ However, see `apps/positioning/PRSolveR3`:
example of an app which needed extensive changes.

There is a new forum Wiki page at
www.gpstk.org/bin/view/Forum/WebHome.
We welcome new topics for comments and suggestions.