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Post-IAU-2000 Nomenclature for the Telescope Pointing Application

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Topics

- Application
- Customers
- Nomenclature
- Old versus new

Telescope pointing

- "Pointing" has several aspects:
  - Acquisition of celestial targets.
  - Tracking.
  - Blind offset guiding.
- Related topics:
  - World coordinate systems (pixel i,j ↔ sky α,δ)
  - FITS image interchange format.
  - Interferometers.
- A good "test case" for the new nomenclature:
  - Accuracy requirements not too demanding.
  - Must be comprehensible to non-FA users.

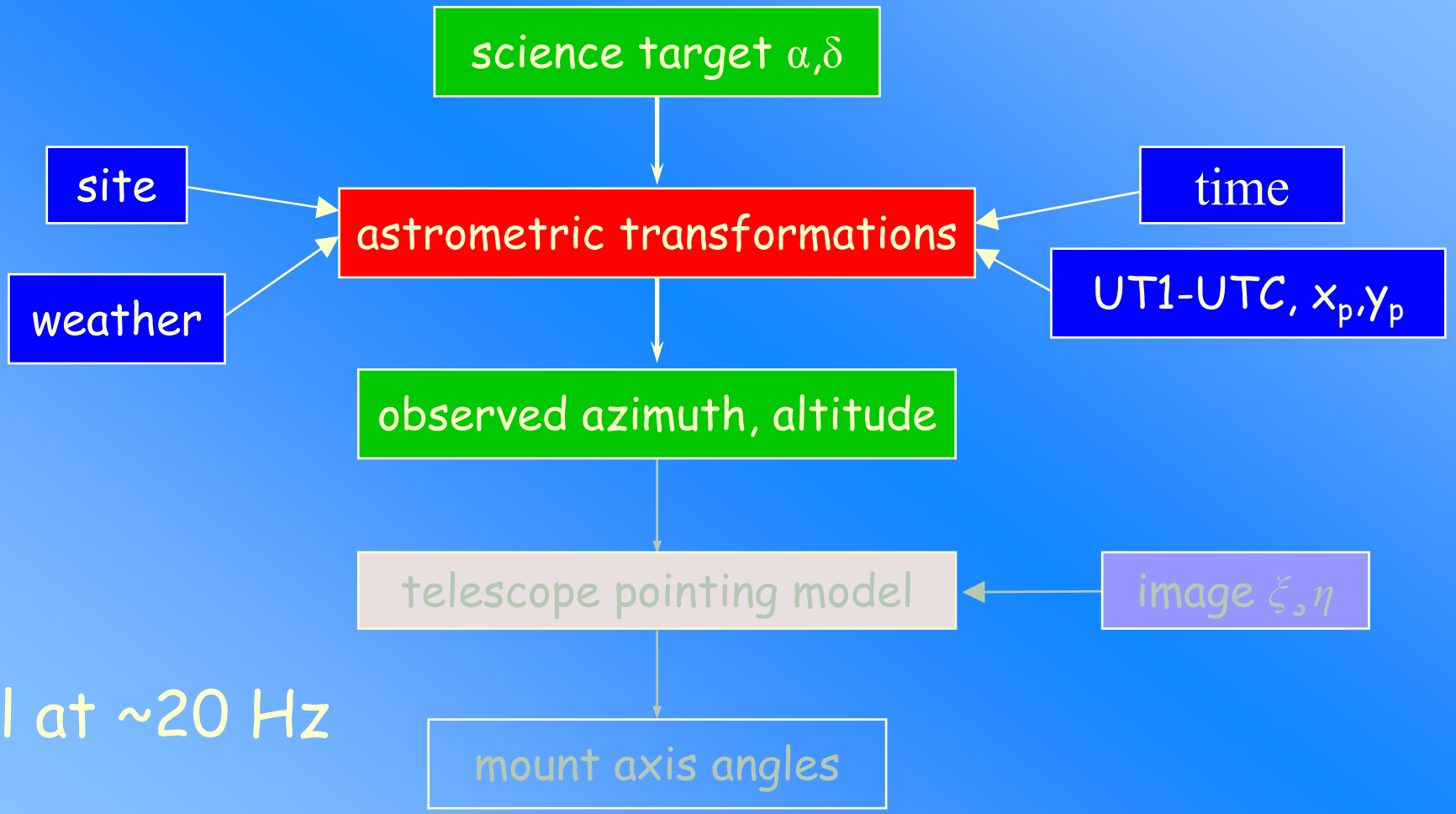
The application

- Comparatively modest accuracy requirements:
  - 0.5 arcsec absolute at best
  - 0.001 arcsec "noise level" acceptable
- Fixed models preferred:
  - polar motion is usually (but not always) neglected
  - no need for IERS corrections to nutation
  - ...but UT1-UTC is required except for some equatorials
- Has to be understood by:
  - Telescope users (astrophysicists)
  - Engineers and programmers

Target audience

- Telescope users: interested only in "J2000 α,δ" and a rough idea of the zenith distance (~ air mass).
- Engineers and software staff: need to understand everything between ICRS α,δ and telescope axis encoder readings.
- Both of the above groups
  i. will have encountered only equinox/ST methods,
  ii. will typically have only a rudimentary grasp of the general principles, and
  iii. will see no need for change.

How to point a telescope



All at ~20 Hz

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Computing considerations

- Modern CPUs are so fast that the entire pointing calculation could be done at the full 20 Hz rate (or whatever).
- But it is still usual to re-compute precession and nutation only occasionally – e.g. for each new target.
- In general, star-independent quantities can be refreshed infrequently: Earth ephemeris, precession, refraction etc.
- Only Earth rotation is time-critical.
- *All of this means that various sorts of interim coordinates are present in the software and must be clearly labelled.*

Astrometric transformations

CATALOGUE [α,δ]

proper motion, catalogue epoch to J2000

INTERNATIONAL CELESTIAL REFERENCE SYSTEM [α,δ], epoch J2000

proper motion, J2000 to date

(barycentric) ICRS [α,δ] of date

annual parallax

ASTROMETRIC [α,δ]

light deflection

annual aberration

GEOCENTRIC ICRS [α,δ]

frame bias

precession

nutation

CELESTIAL INTERMEDIATE REFERENCE SYSTEM [α,δ]

Earth rotation

TERRESTRIAL INTERMEDIATE REFERENCE SYSTEM [λ,φ]

polar motion

ITRS / GREENWICH [h,δ]

site longitude

diurnal aberration and parallax

TOPOCENTRIC [h,δ]

h,δ to az,alt

TOPOCENTRIC [az,alt]

refraction

OBSERVED [az,alt]

Unresolved

- ICRS / BCRS / GCRS?
- Out-of-date and confusing text-book definitions of "astrometric place".
- Weakness of "intermediate".
- Should we separate light direction from triad?

Was the old system any better?

- Mean place?
- True place?
- Apparent place?
- Local place?
- Virtual place?
- Epochs and equinoxes?
- Equation of the equinoxes?
- Uniform equinox?

How to sell the new system

- Start with ERA, not the CIO:
  - ERA(UT) formula is conspicuously simpler than GST(UT).
  - No equation of the equinoxes to omit or get wrong.
- Point out that if you set your sidereal clock to ERA and use α_{CIRS} instead of $\alpha_{apparent}$, it's business as usual.
- Don't give undue prominence to the kinematical definition of the CIO. The ICRS R.A. of the CIO is close enough to zero for introductory purposes (< 0.01 arcsec for the next 50 years).
- For rough-and-ready mental arithmetic, $h \approx \text{LERA} - \alpha_{ICRS}$ works *better* than $h \approx \text{LST} - \alpha_{ICRS}$, which is what people do at present.