Sentinel-6A – TRIG/PODRIX Cross-Calibration

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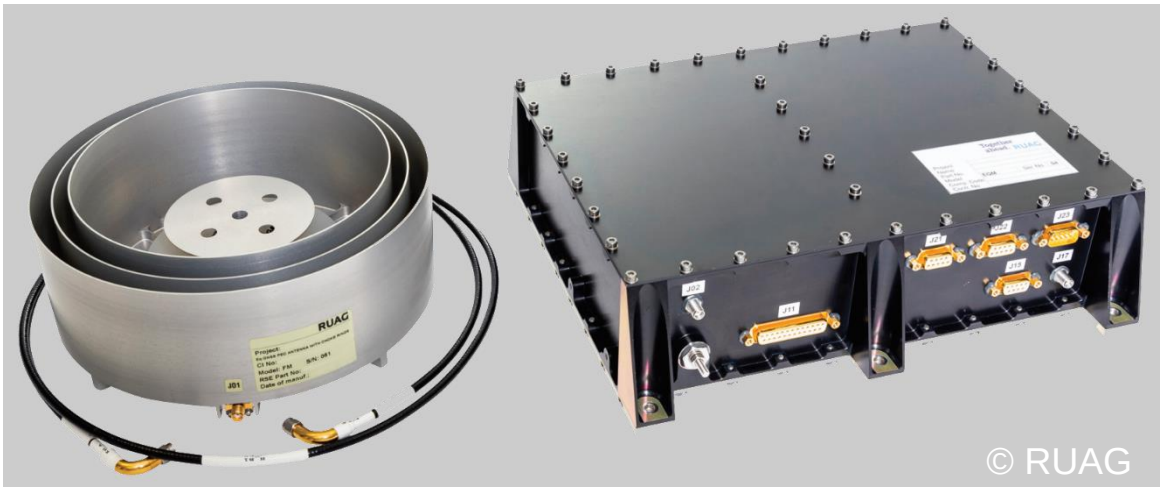
Motivation

- 3 GNSS receivers with distinct antennas
  - 2x PODRIX GPS/Galileo (RUAG)
  - 1x TRIG GPS++ (JPL)
- Check consistency of GNSS measurements and metadata for POD



Antenna Positions

Mechanical reference points (origins of antenna reference frames)

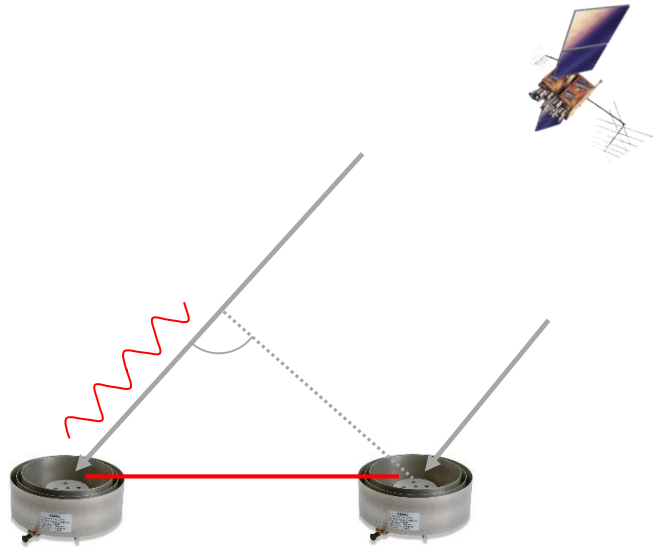
	S6AT (TRIG)	S6AN (nom PODRIX)	S6AR (red PODRIX)	S6AT-S6AN	S6AR-S6AN
X [mm]	599.95	2474.83	2874.86	-1874.88	400.03
Y [mm]	-0.41	+0.12	+0.16	-0.53	0.04
Z [mm]	-1095.06	-1080.31	-1080.54	-14.75	-0.23

Source: JC-TN-ESA-SY-0420-S6 v1.4

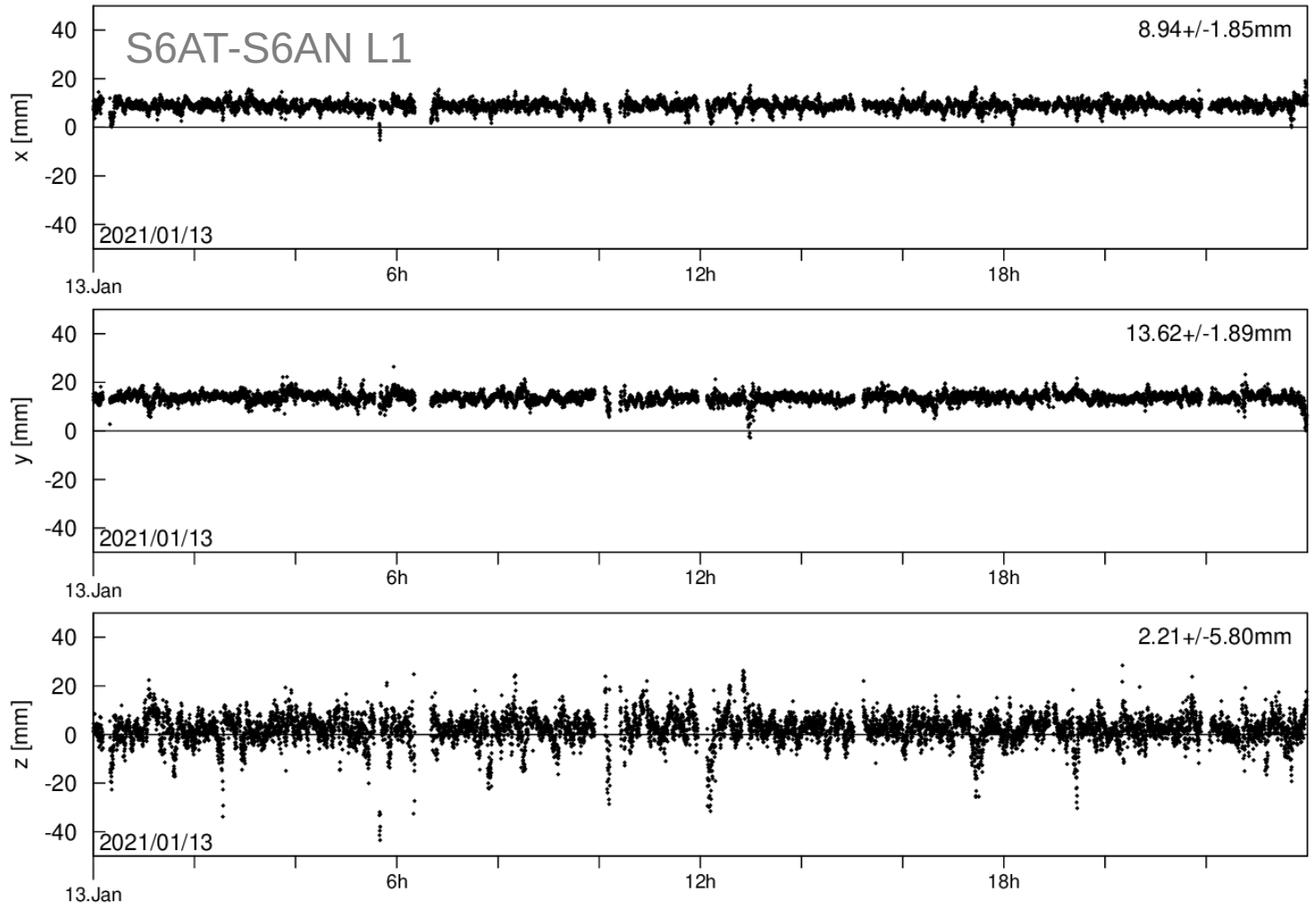
Notes:
- Different orientations of antenna reference frames
- Potentially different phase center offsets for TRIG/PODRIX antennas

Baseline Estimation

- Test data
  - 3 active receivers
  - 13 Jan 2021
  - 10s sampling
- TRIG clock offset correction, extrapolation to integer GPS seconds
- Double difference carrier phase observations for L1, L2, (E1, E5)
  - Observed values from RINEX files
  - Modelled values from nominal antenna reference point positions and line-of-sight vectors in spacecraft frame using attitude quaternions
- Epoch-wise integer ambiguity resolution by rounding of observed-minus-modelled double differences
- Epoch-wise kinematic relative positioning (correction of a priori baseline)
- Note: results are independent of center-of-mass position



Baseline Correction (S/C Frame)

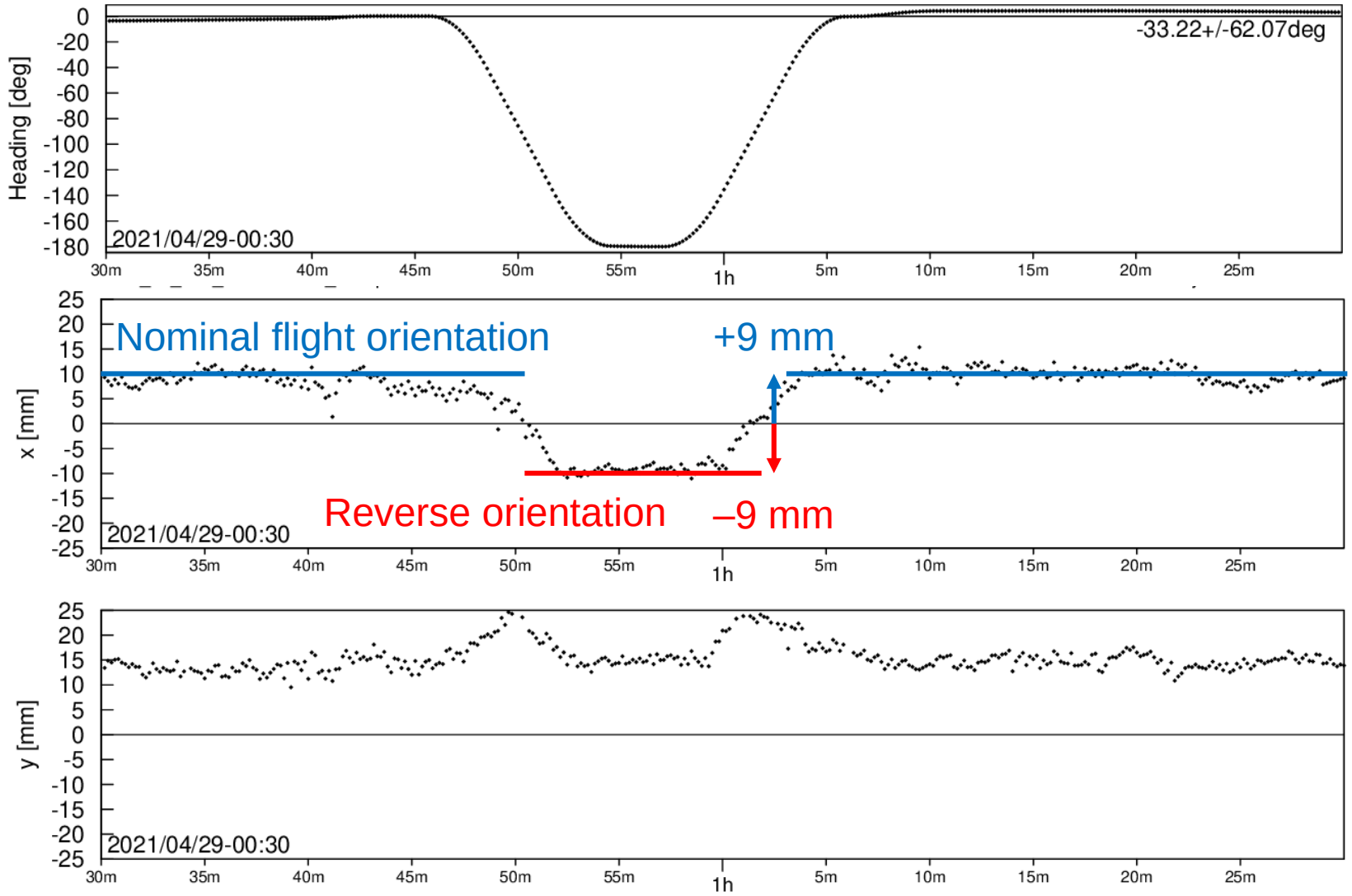


	X[mm]	Y[mm]	Z[mm]
S6AT-S6AN L1	+8.9	+13.9	+2.2
S6AT-S6AN L2	+9.8	+14.0	+6.2
S6AR-S6AN L1	-1.3	-2.9	-0.4
S6AR-S6AN L2	-1.5	-2.9	+0.9
S6AR-S6AN E1	-1.6	-2.9	-0.9
S6AR-S6AN E5a	-2.1	-3.7	+0.7

Findings

- S6AR-S6AN
  - Good overall consistency with a priori baseline
  - Horizontal offsets can be understood by small (1-2 mm) PCO offsets and 180° antenna frame offset
- S6AT-S6AN
  - Notable deviations from a priori baseline
  - Z-correction
    - L1/L2 difference: slightly different design of TRIG (GPS/GLO) vs PODRIX (GPS/GAL) antenna
  - X-correction
    - 9 mm difference may be caused by inter-receiver timing difference of ~1.2 µs *or* error of a priori coordinates *or* combination thereof
    - both contributions may be separated by 180° yaw flip of S6A as suggested by OSTS team
  - Y-correction
    - 14 mm reflect major error in reported antenna positions *or* assumed yaw angle (quaternions)

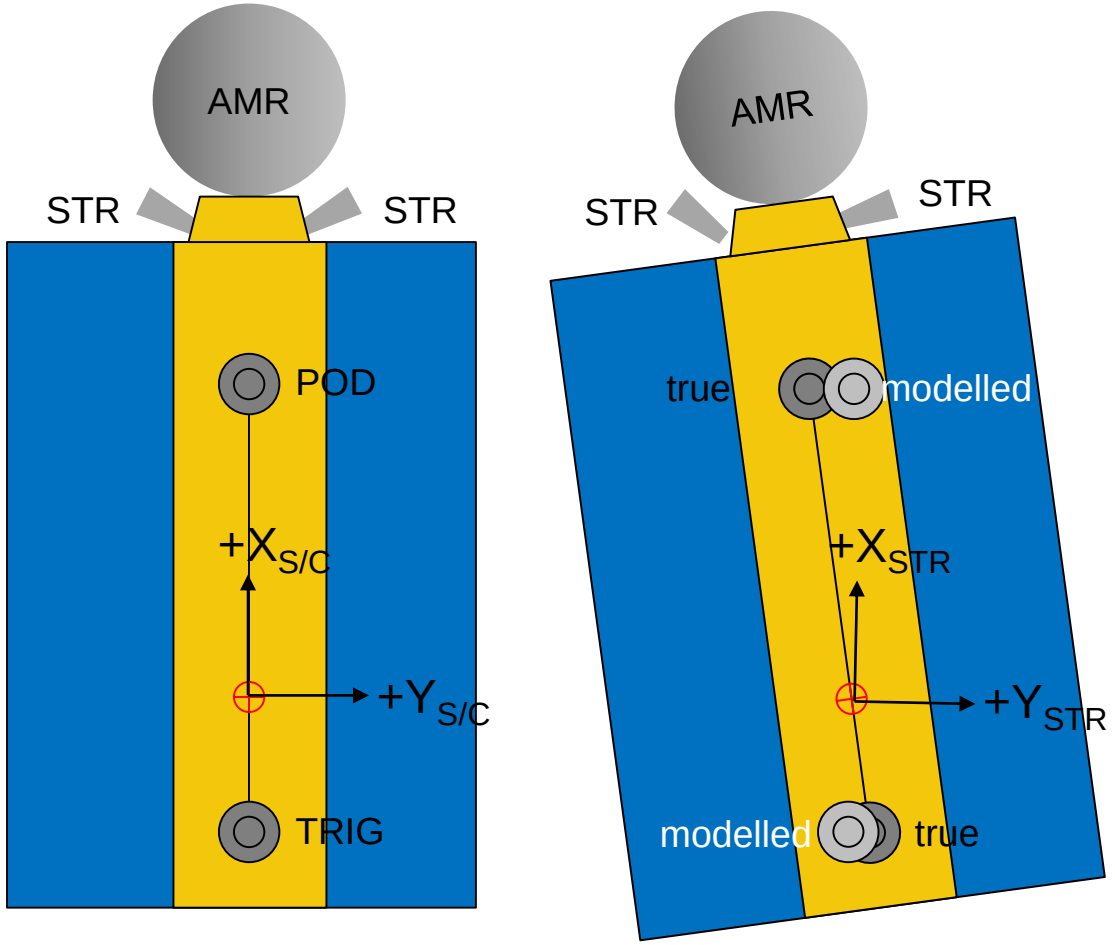
S6AT-S6AN Baseline Estimation Across Yaw Flip



- 180° yaw turn on 29 April 2021 for execution of anti-flight (break) maneuver (approx. 00:54 – 00:57 GPST)
- x-component of observed S6AT-S6AN baseline offset changes from +9 to –9 mm
  - Mean value: contribution of phase center errors
  - Difference: reversal of time error contribution

Impact of Attitude Bias (Star Camera Misalignment?)

- 14 mm offset @ 1875 mm distance (and 3 mm offset @ 400 mm distance) correspond to 0.43° yaw angle offset
- Could be caused by STR misalignment or erroneous STR-to-S/C alignment matrix in ADCS
- ADCS assumes and reports nominal attitude, but true s/c body axis shows 0.43° yaw bias w.r.t. ground track and orbit
- GNSS antennas show non-nominal CoM offset that needs to be compensated by empirical forces
  - ~ –9 mm for POD(nom)
  - ~ +5 mm for TRIG
- Consistent with observed accelerations
  - ~+ 8 nm/s^2 for POD(nom)
  - ~ –4 nm/s^2 for TRIG



Summary and Conclusions

- Different characteristics of TRIG and PODRIX antennas
- Horizontal antenna positions
  - X-component of TRIG–PODRIX antenna baseline is consistent with design information
  - Y-component of baseline shows 14 mm discrepancy of observed values vs design
- 9 mm X-difference of observed vs. nominal TRIG-PODRIX baseline is entirely due to relative timing error
  - TRIG time tag too large by 1.2 µs *or* PODRIX time tag too small by 1.2 µs *or* shared contributions
  - Note: SLR analysis suggests dominating contribution of TRIG time stamping error
- 14 mm Y-difference could be caused by antenna position error or (more likely?) STR-to-S/C misalignment

- Provide manufacturer calibration of TRIG antenna
- Double-check spacecraft design information for proper antenna locations
- Double-check star sensor alignment matrix for supected 0.43° yaw bias
- Verify TRIG-PODRIX timing bias in signal simulator