Goddard Space Flight Center

ILRS Pilot Project -- Part 8

JCET/GSFC Benchmark Report

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Van Husson (NOT on record!)

Nice, France

April 22-23, 2004

PP7 Components

Goddard Space Flight Center

- S/W Benchmark Contributions **PRIOR to LAST:**
- Data set for analysis:
  - 1999/10/10-11/07, 28-day arc of L-1 & L-2 pre-screened data
  - Solutions:
    - A: ECF Orbit, Obs. Corrections and Residuals at prescribed initial conditions
    - B: ECF Orbit, Obs. Corrections and Residuals after iterated initial state adjustment (6 elements and Constant Along-track Emp. Accel.)
    - C: ECF Orbit, Obs. Corrections, Residuals and SINEX file after iterated initial state, POS+EOP adjustmentC: ECF Orbit, Obs.
    - D: ECF Orbit, Obs. Corrections, Residuals and SINEX file after iterated initial state, POS+EOP adjustment

S/W Benchmark

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- Solutions follow the prescribed rules
- Corrections reported in **ONE** (*.res) file along with the residuals
- Tropospheric corrections reported as “dry” and “wet” components (Marini-Murray)
- EOP and nutation/precession corrections to IAU 1980 model from IERS C 04 (daily)

New (12/2003) S/W Benchmark

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- **Software Benchmarking Pilot Project**
- **Last Revised: November 5, 2003**

Based on our 2003 Analysis Working Group meeting in Koetzting, the benchmark plan has been revised again. We will call this new plan Phase IV. Hopefully the last phase.

0. A new submission has been adapted, case "0" (zero), which is similar to A in the sense that ONLY an integration is involved. Unlike A though, the force model for case 0 is rudimentary. Please consult the full invitation below for Pass/Fail criteria will be established from a combination submission. The combination submission will be based on a submissions received prior to November 30, 2003. details.

NEW S/W Benchmark (cont.)

1. Pass Submissions received after November 30 will still be analyzed, but WILL NOT be used as part of the combination solution.

2. The established Pass/Fail criteria apply only to submissions 0, A, C & D. There will be no Pass/Fail criteria for submission B.

3. The grading of each submission will be based on a weighted grade with 30%, 10%, 10% and 50% corresponding to cases 0, A, C & D. The passing grade for each submission will be 80% and above for all of the established categories (POS, EOP, ORBITS, CORRECTIONS).

4. Submission version numbers will start at 30 (versus 1, 10 or 20), to eliminate confusion from earlier submissions.

NEW S/W Benchmark (cont.)

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GEOS vs JCET

	Along(m)	Radial(m)	Cross(m)
min	-0.399	-0.078	-0.084
max	0.000	0.079	0.059
rms	0.093	0.031	0.028

ASI vs JCET

	Along(m)	Radial(m)	Cross(m)
min	-147.398	-60.395	-404.402
max	2721.784	51.766	396.411
rms	724.342	24.820	161.994

NERC vs JCET

	Along(m)	Radial(m)	Cross(m)
min	-84.055	-103.358	-4207.934
max	12087.878	88.519	4185.350
rms	3392.724	33.628	1657.097

BKG vs JCET

	Along(m)	Radial(m)	Cross(m)
min	-76.547	-103.270	-4218.527
max	12069.766	88.593	4195.866
rms	3381.675	33.597	1656

BKG vs NERC

	Along(m)	Radial(m)	Cross(m)
min	-59.136	-0.507	-22.980
max	19.581	0.546	23.028
rms	18.390	0.209	12.576

NEW S/W Benchmark (cont.)

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INITIAL STATE DIFFERENCES:

Category	delta x	delta y	delta z
ASI 0 - JCET 0	-0.008	-0.001	0.006
ASI A - JCET 0	-0.008	0.009	0.001
JCET A - JCET 0	-0.002	0.003	0.000
GEOS 0 - JCET 0	0.000	0.000	0.000
GEOS A - JCET 0	0.000	0.000	0.000
BKG 0 - JCET 0	-0.382	-17.410	8.794
BKG A - JCET 0	-0.950	0.083	0.592
NERC 0 - JCET 0	-1.211	-0.033	0.822

S/W Benchmark Summary Phase IV

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- New solutions submitted by all groups in previous step
- Large differences between all groups except for GA and JCET
- Some small and large differences seen in the initial elements
- **The ACs did not respond to the advertised differences with explanations or revised submissions.**
- **Due to the loss of Van's time, the considerable amount of work needed to troubleshoot such differences, is not available and with the PP charging ahead with products, we have put this part of the PP into hibernation until we get more people involved and a better response from all groups.**

OLD S/W Benchmark (cont.)

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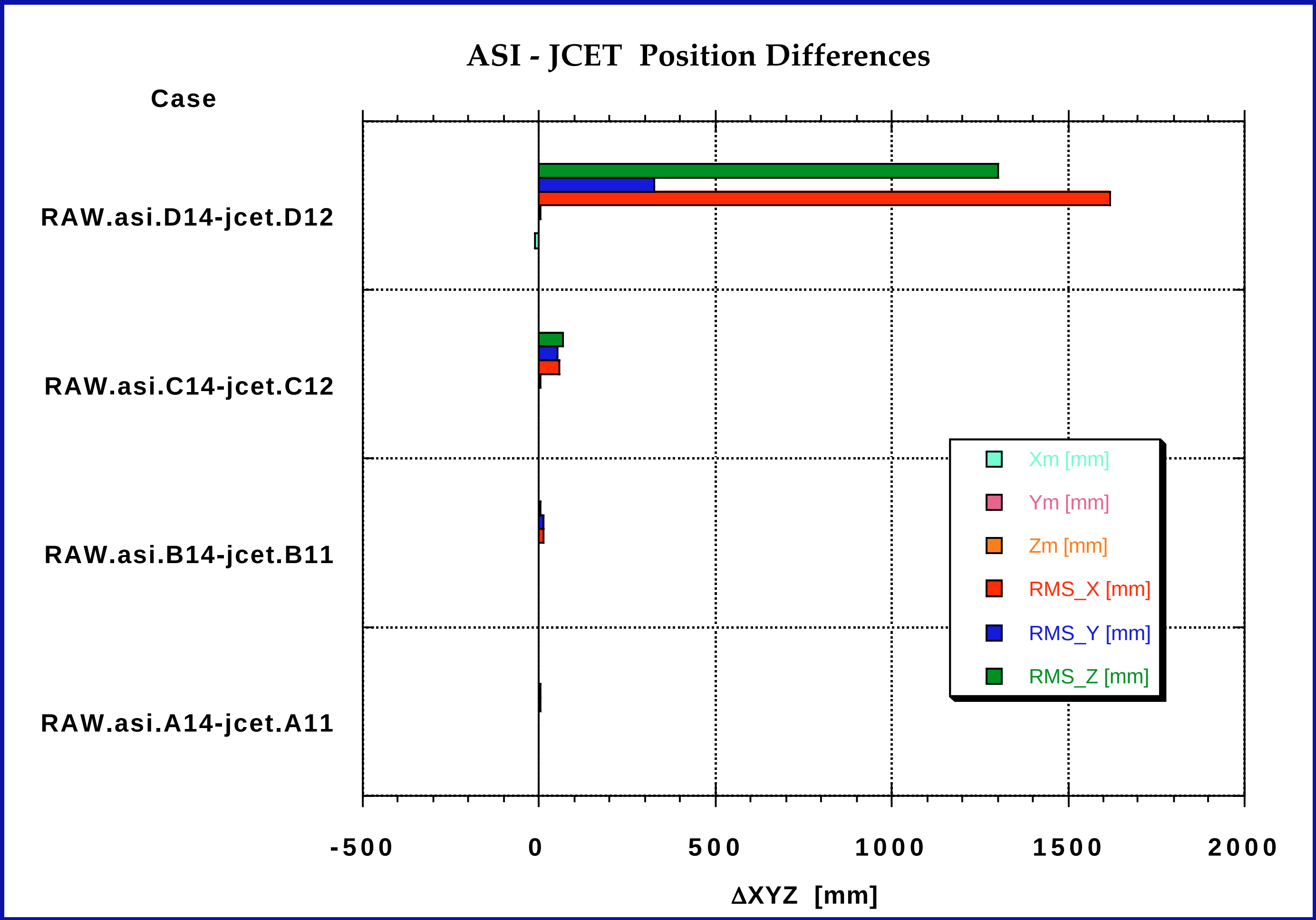
- The results of solution “C” were checked and compared to a solution using our nominal modeling (which is nearly identical to that of solution “AA”)
- A solution that is free of modeling constraints was submitted (Case D), as we agreed last October.
- The greatest effect improving the results over “C” was (as expected) the inclusion of 1-per revolution along-track & cross-track empirical accelerations



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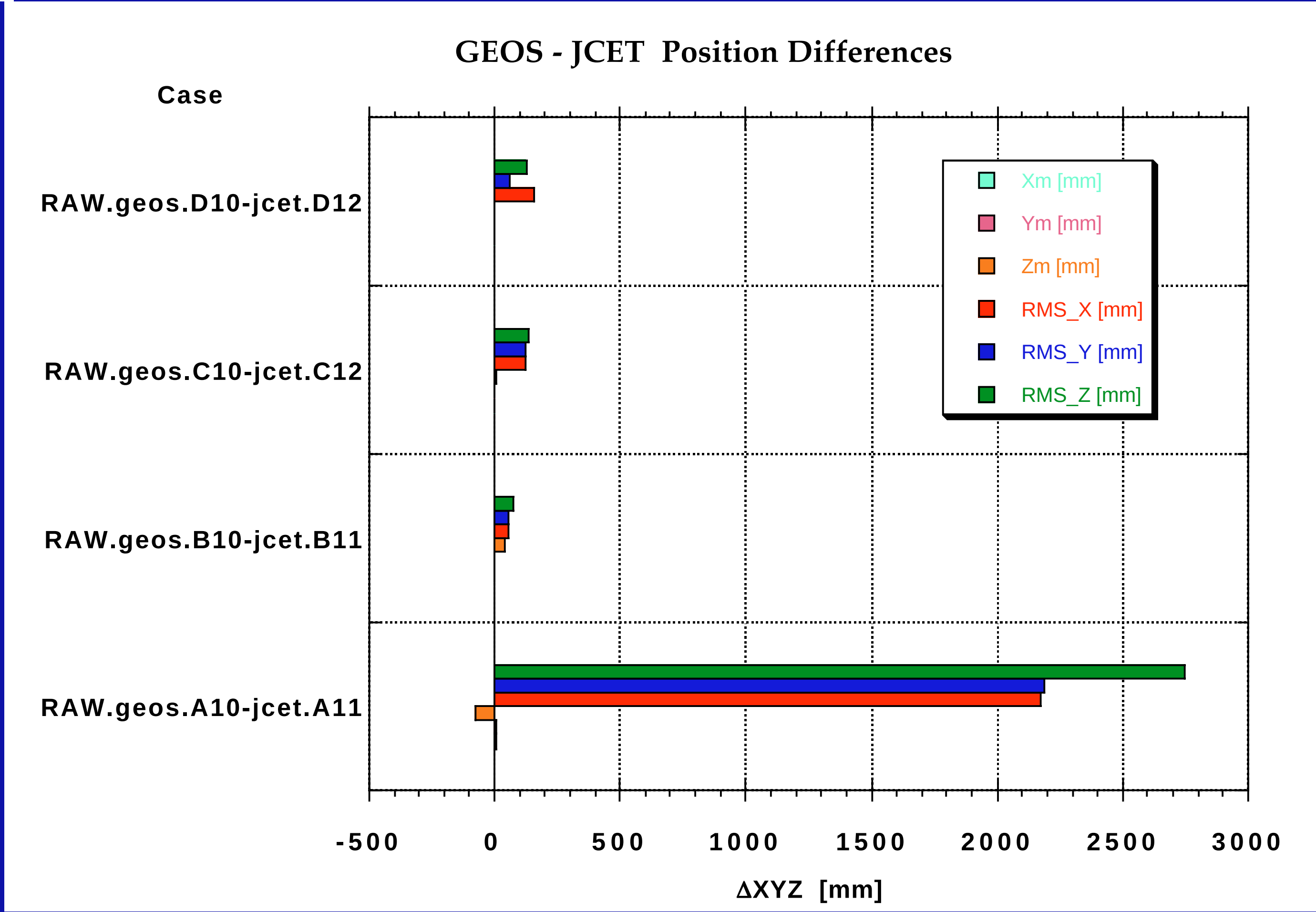
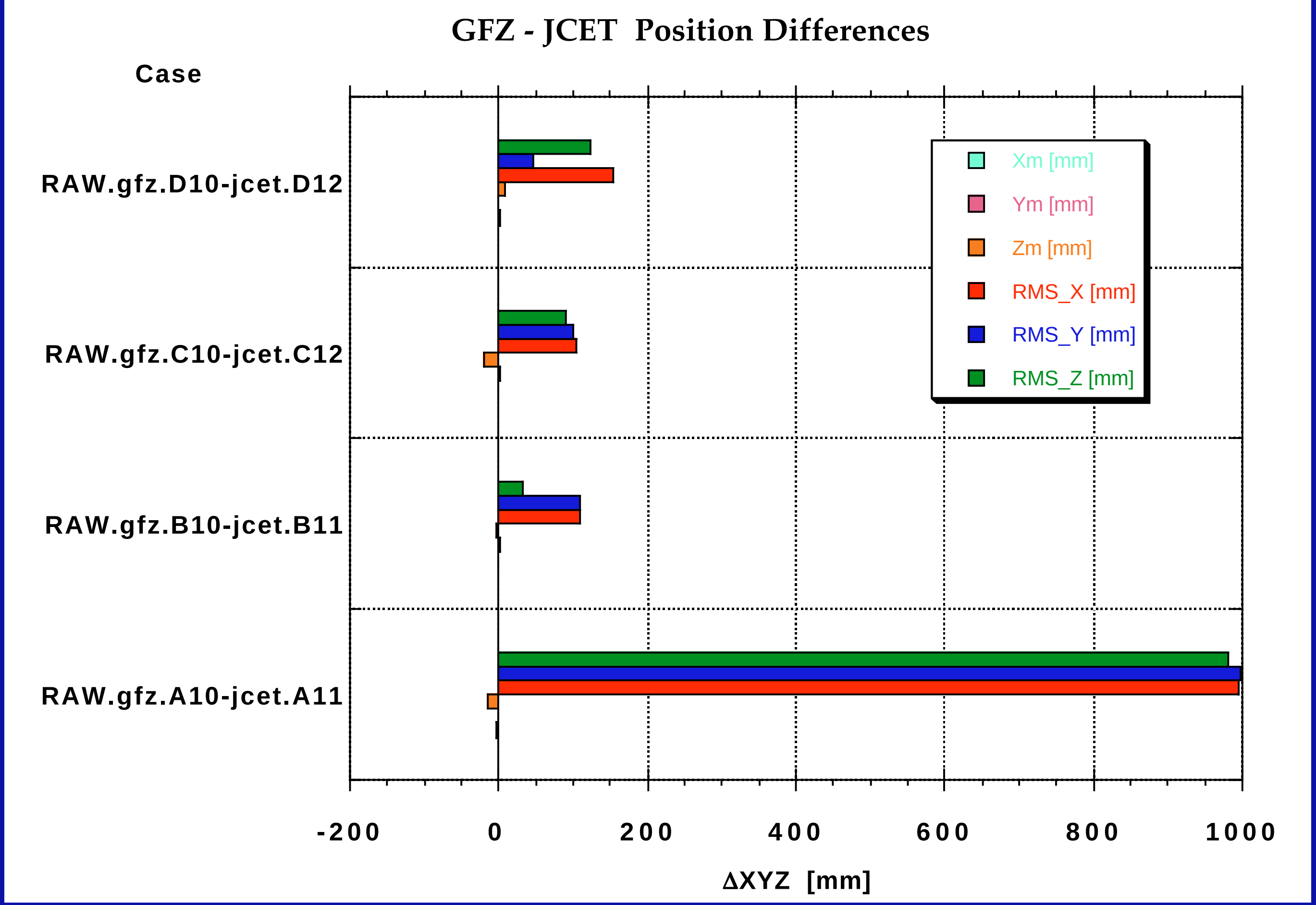
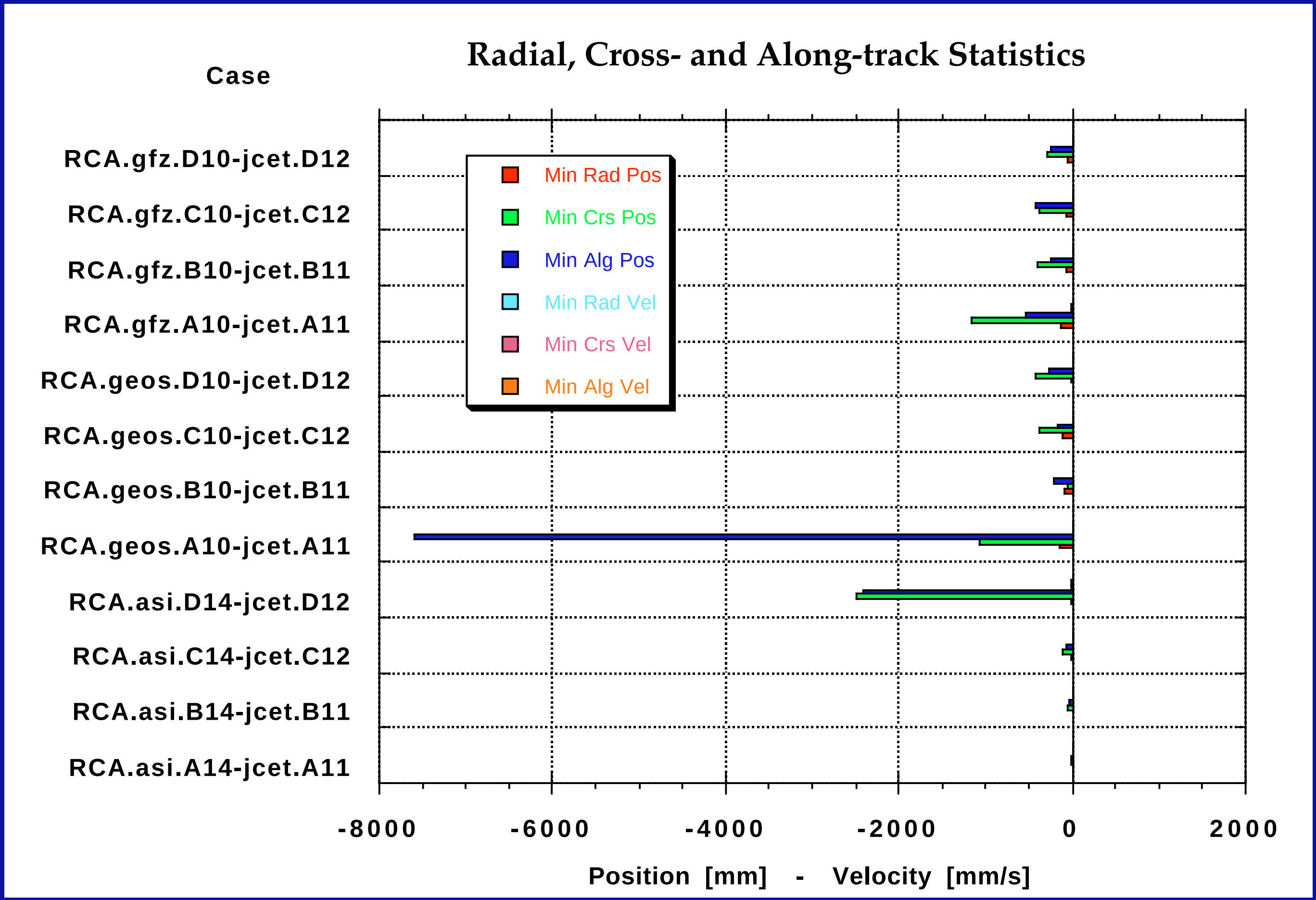
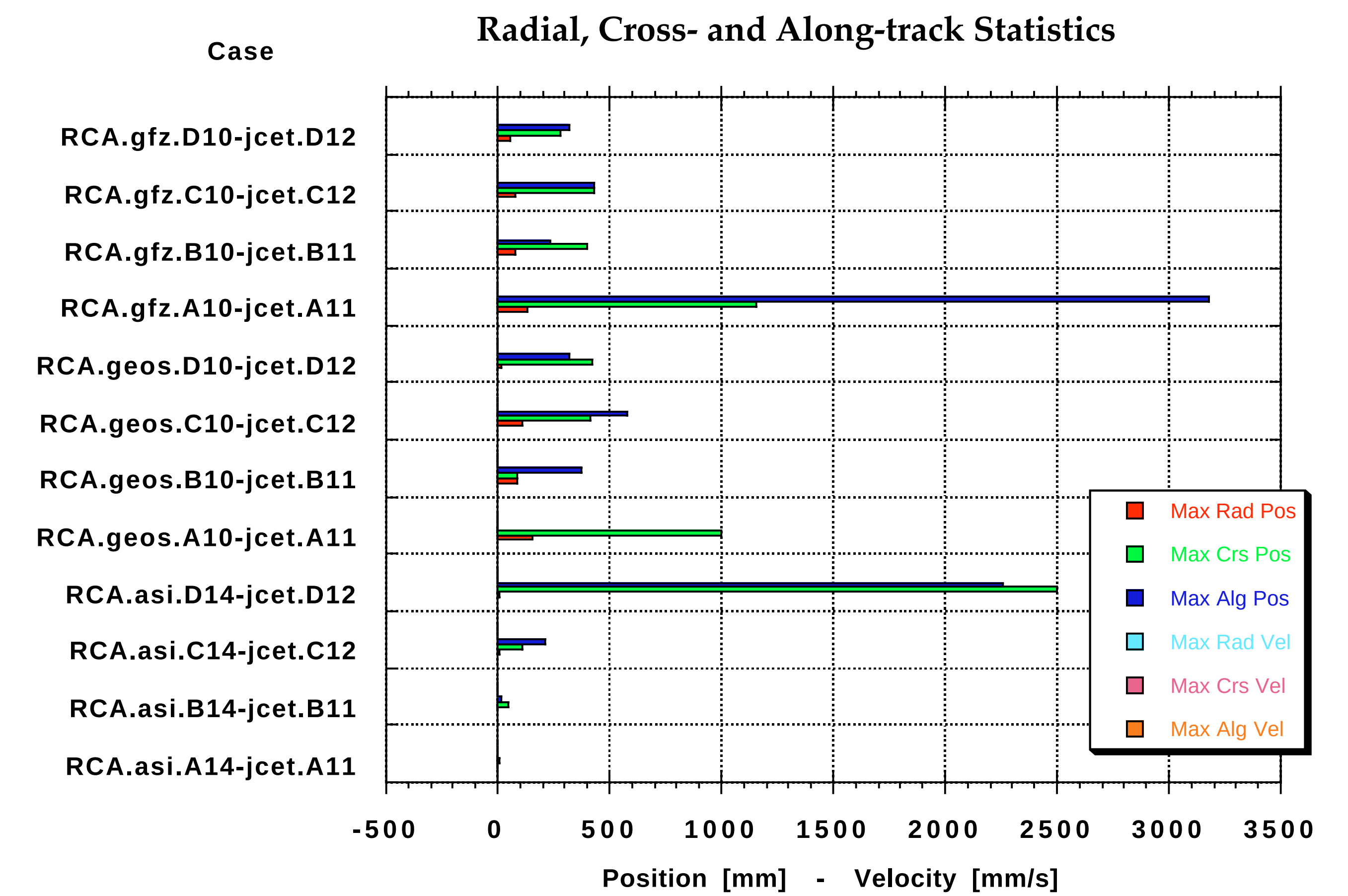

GEOS - JCET Position Differences
Case
RAW.geos.D10-jcet.D12
RAW.geos.C10-jcet.C12
RAW.geos.B10-jcet.B11
RAW.geos.A10-jcet.A11
Xm [mm]
Ym [mm]
Zm [mm]
RMS_X [mm]
RMS_Y [mm]
RMS_Z [mm]
-500
0
500
1000
1500
2000
2500
3000
ΔXYZ [mm]


GFZ - JCET Position Differences
Case
RAW.gfz.D10-jcet.D12
RAW.gfz.C10-jcet.C12
RAW.gfz.B10-jcet.B11
RAW.gfz.A10-jcet.A11
Xm [mm]
Ym [mm]
Zm [mm]
RMS_X [mm]
RMS_Y [mm]
RMS_Z [mm]
-200
0
200
400
600
800
1000
ΔXYZ [mm]



Radial, Cross- and Along-track Statistics
Case
RCA.gfz.D10-jcet.D12
RCA.gfz.C10-jcet.C12
RCA.gfz.B10-jcet.B11
RCA.gfz.A10-jcet.A11
RCA.geos.D10-jcet.D12
RCA.geos.C10-jcet.C12
RCA.geos.B10-jcet.B11
RCA.geos.A10-jcet.A11
RCA.asi.D14-jcet.D12
RCA.asi.C14-jcet.C12
RCA.asi.B14-jcet.B11
RCA.asi.A14-jcet.A11
Min Rad Pos
Min Crs Pos
Min Alg Pos
Min Rad Vel
Min Crs Vel
Min Alg Vel
-8000
-6000
-4000
-2000
0
2000
Position [mm] - Velocity [mm/s]



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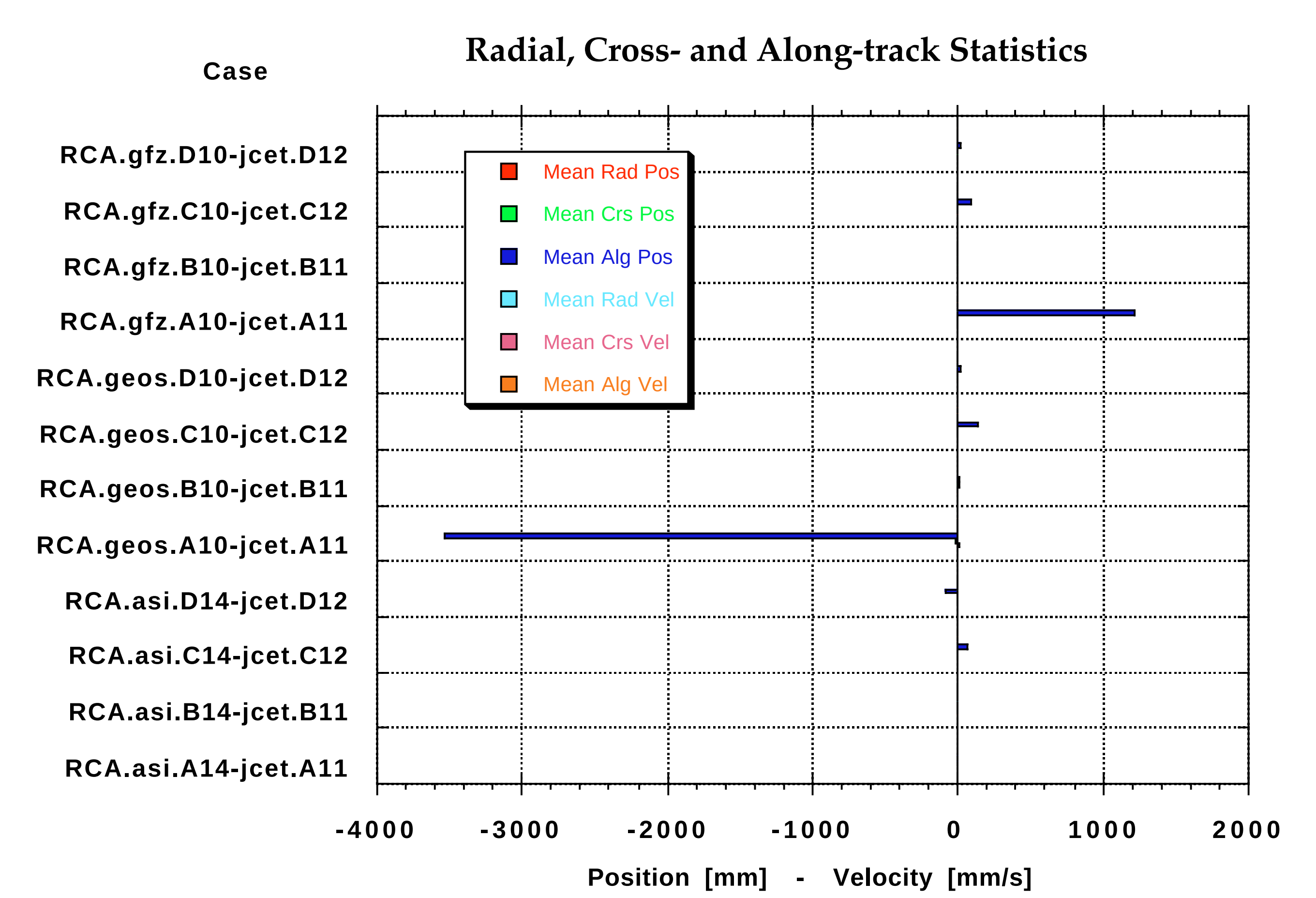
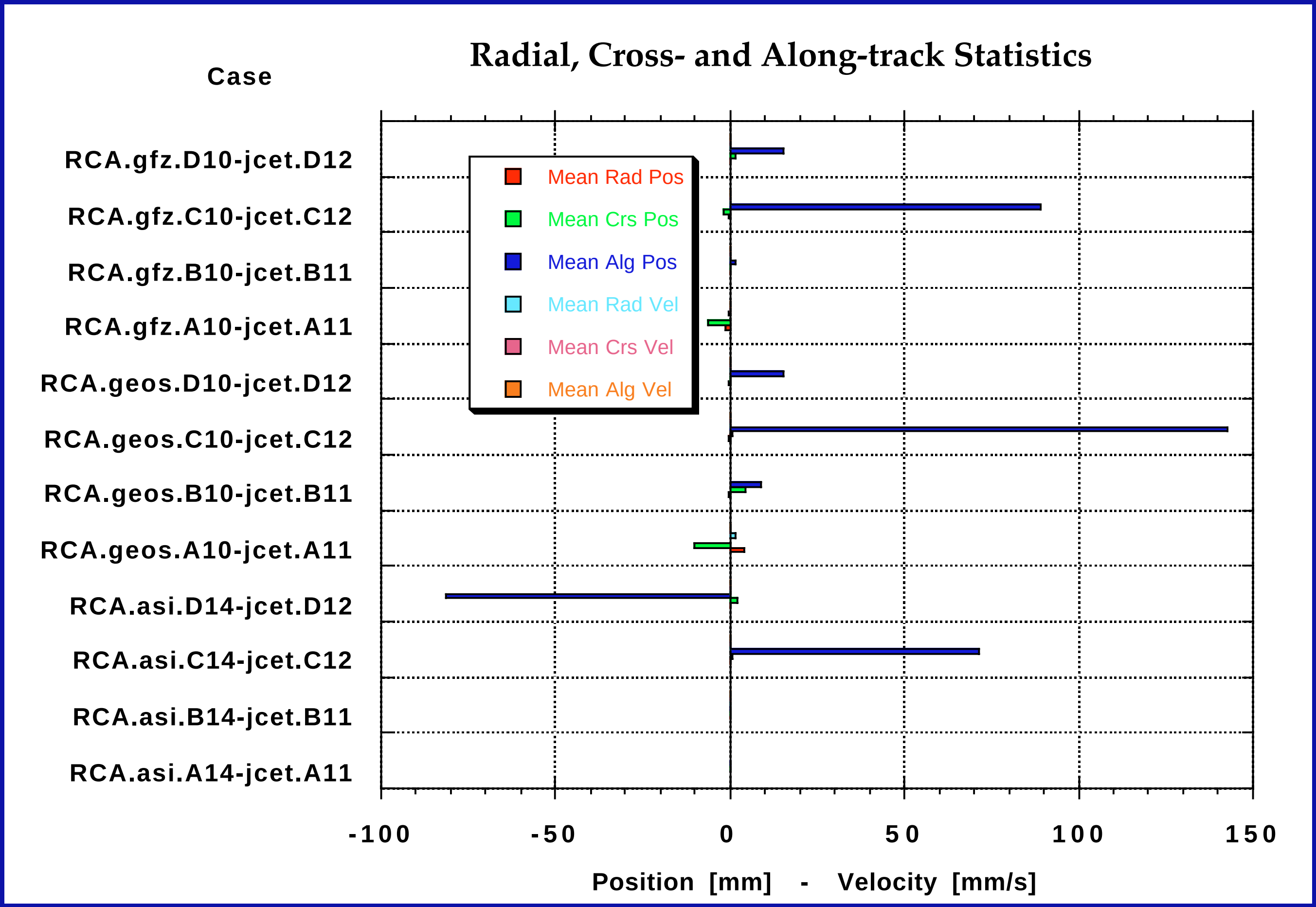
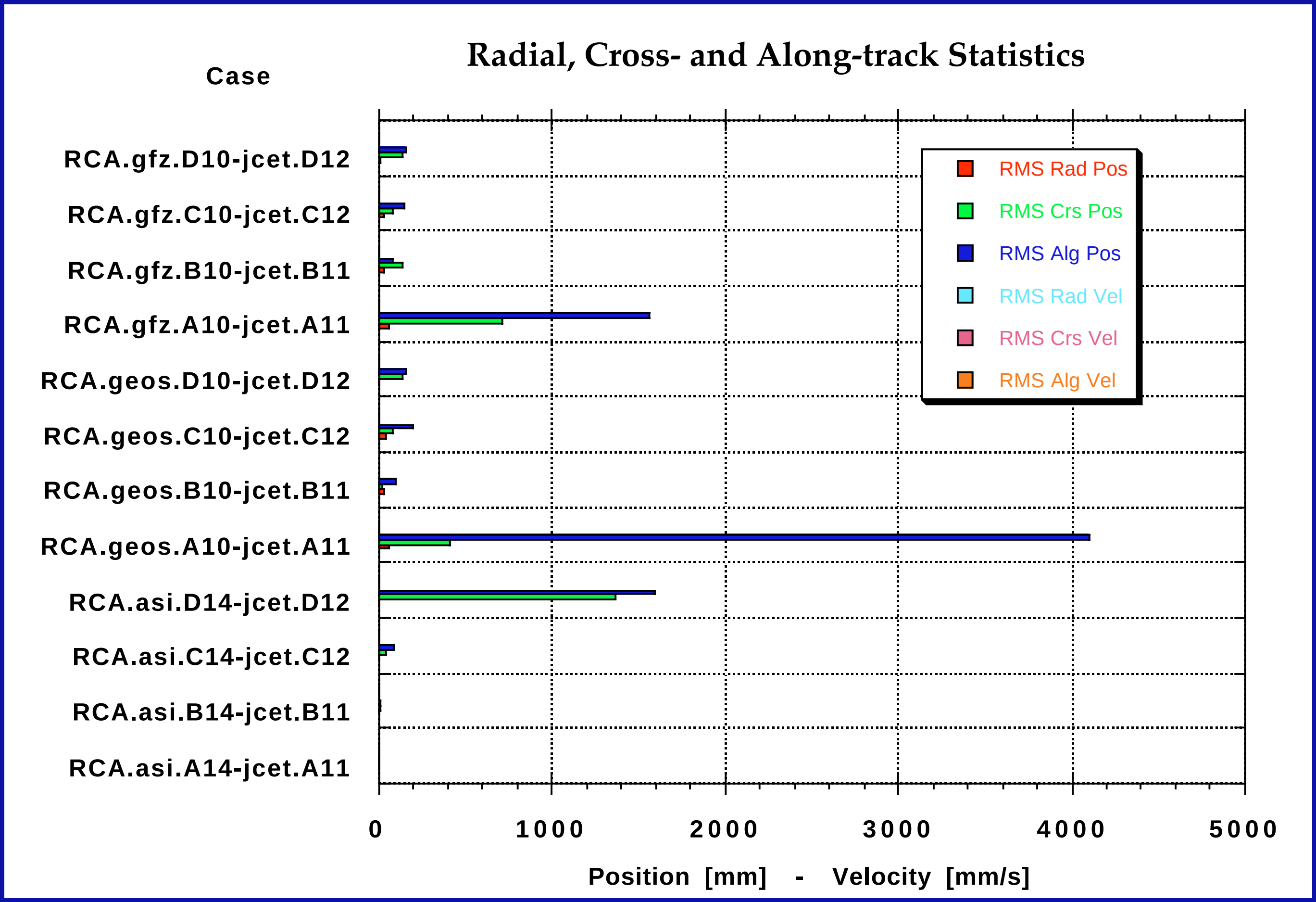

Radial, Cross- and Along-track Statistics
Case
RCA.gfz.D10-jcet.D12
RCA.gfz.C10-jcet.C12
RCA.gfz.B10-jcet.B11
RCA.gfz.A10-jcet.A11
RCA.geos.D10-jcet.D12
RCA.geos.C10-jcet.C12
RCA.geos.B10-jcet.B11
RCA.geos.A10-jcet.A11
RCA.asi.D14-jcet.D12
RCA.asi.C14-jcet.C12
RCA.asi.B14-jcet.B11
RCA.asi.A14-jcet.A11
Mean Rad Pos
Mean Crs Pos
Mean Alg Pos
Mean Rad Vel
Mean Crs Vel
Mean Alg Vel
-4000
-3000
-2000
-1000
0
1000
2000
Position [mm] - Velocity [mm/s]



Radial, Cross- and Along-track Statistics
Case
RCA.gfz.D10-jcet.D12
RCA.gfz.C10-jcet.C12
RCA.gfz.B10-jcet.B11
RCA.gfz.A10-jcet.A11
RCA.geos.D10-jcet.D12
RCA.geos.C10-jcet.C12
RCA.geos.B10-jcet.B11
RCA.geos.A10-jcet.A11
RCA.asi.D14-jcet.D12
RCA.asi.C14-jcet.C12
RCA.asi.B14-jcet.B11
RCA.asi.A14-jcet.A11
Mean Rad Pos
Mean Crs Pos
Mean Alg Pos
Mean Rad Vel
Mean Crs Vel
Mean Alg Vel
-100
-50
0
50
100
150
Position [mm] - Velocity [mm/s]



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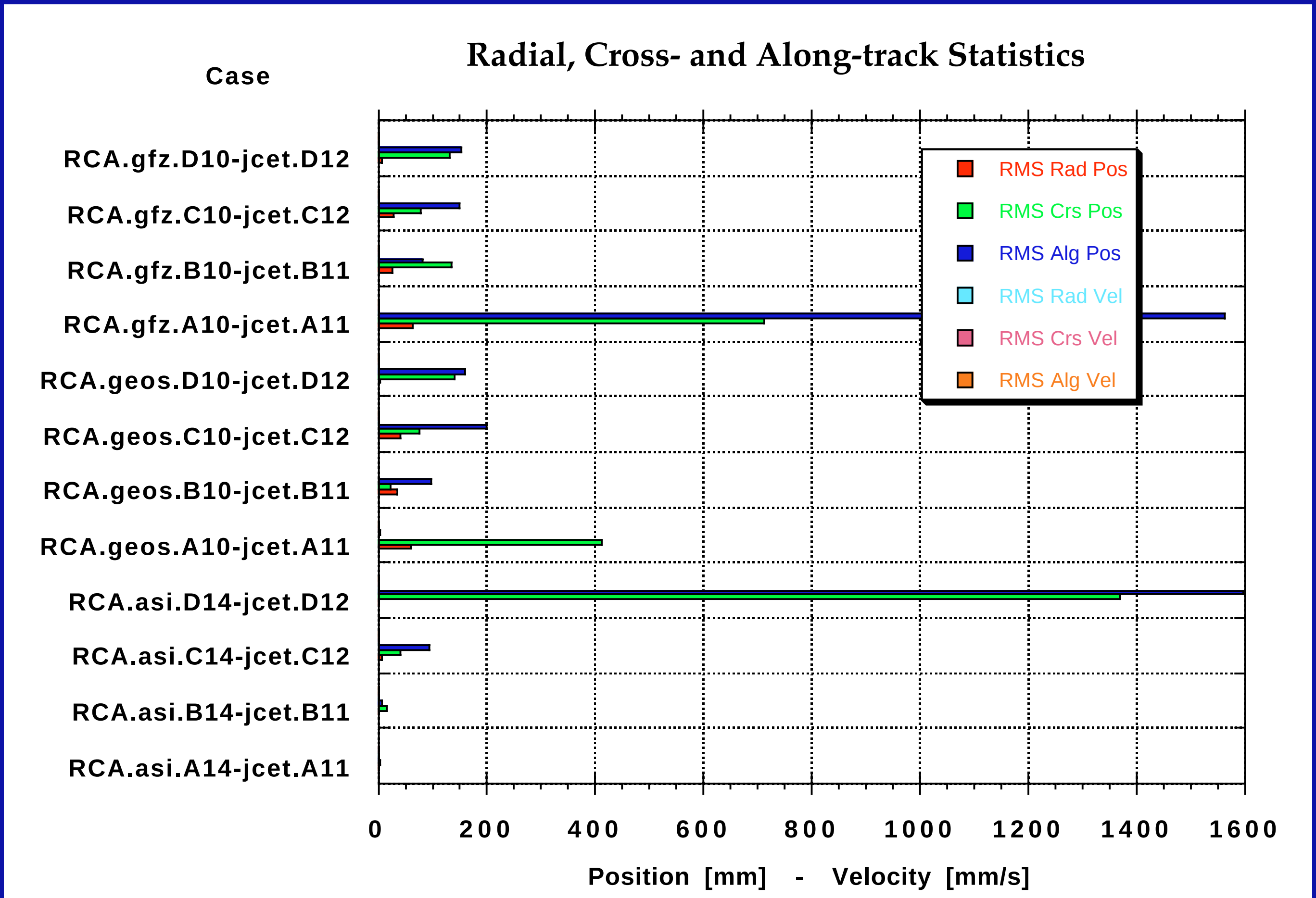
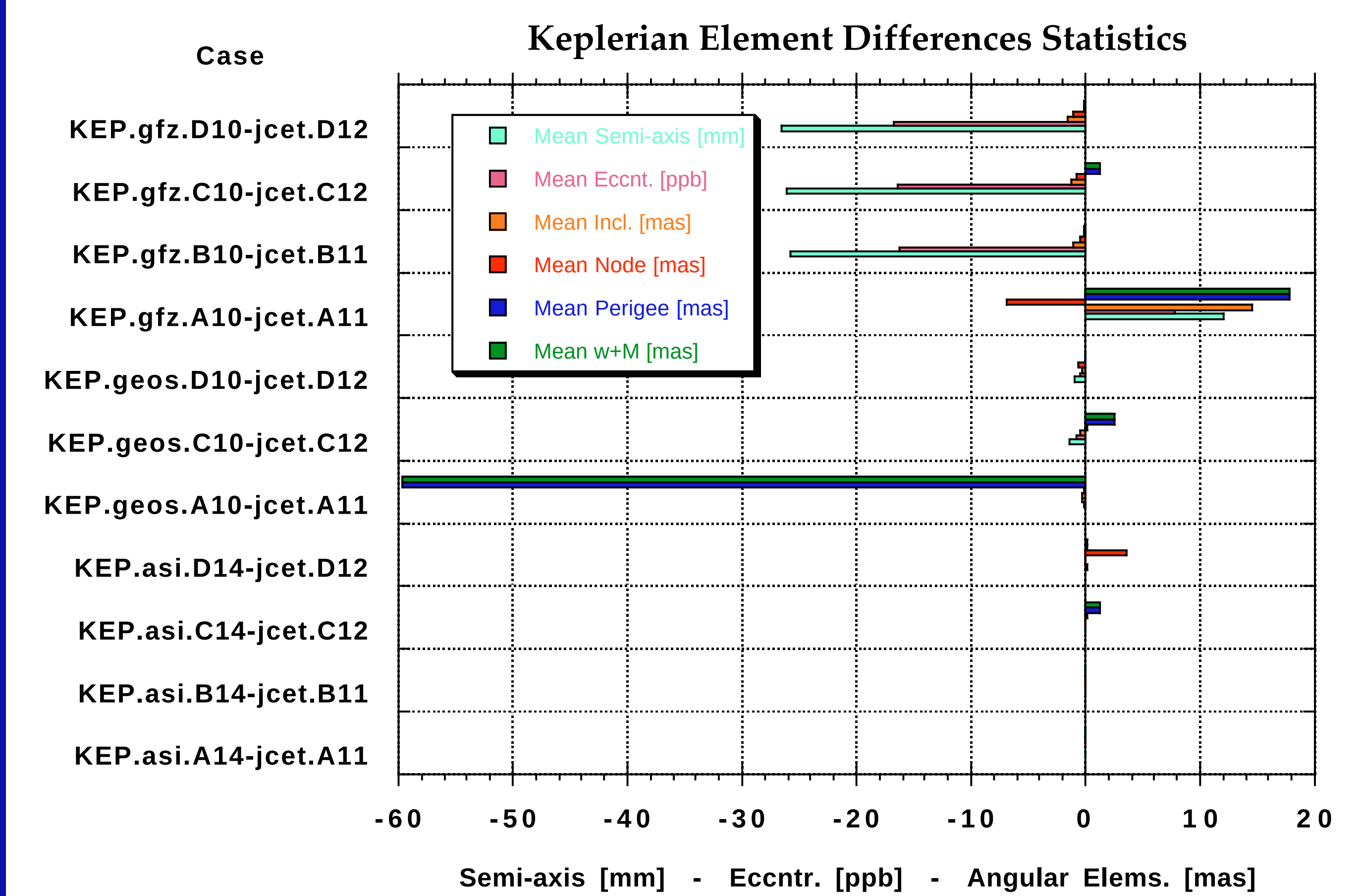
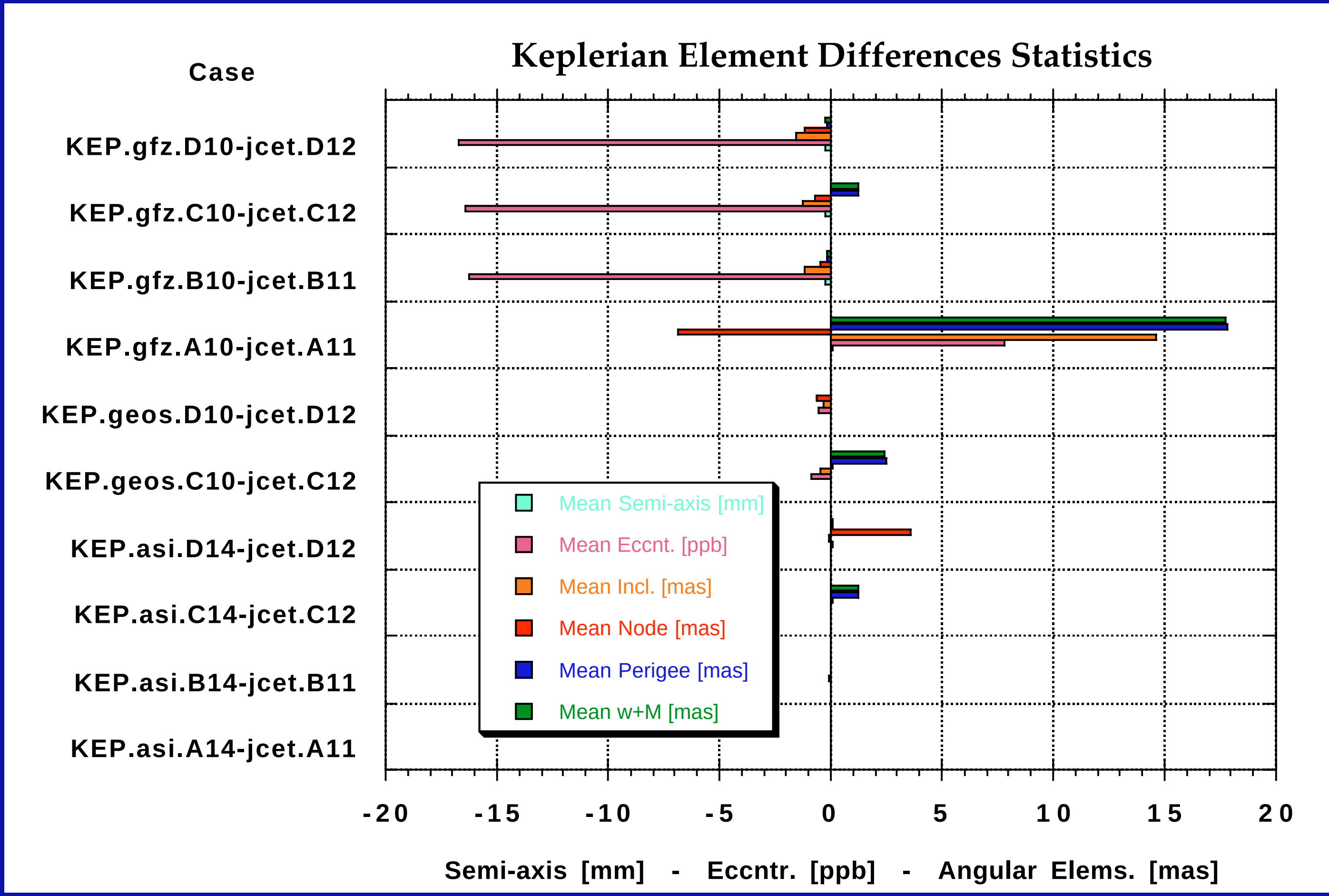

Radial, Cross- and Along-track Statistics
Case
RCA.gfz.D10-jcet.D12
RCA.gfz.C10-jcet.C12
RCA.gfz.B10-jcet.B11
RCA.gfz.A10-jcet.A11
RCA.geos.D10-jcet.D12
RCA.geos.C10-jcet.C12
RCA.geos.B10-jcet.B11
RCA.geos.A10-jcet.A11
RCA.asi.D14-jcet.D12
RCA.asi.C14-jcet.C12
RCA.asi.B14-jcet.B11
RCA.asi.A14-jcet.A11
RMS Rad Pos
RMS Crs Pos
RMS Alg Pos
RMS Rad Vel
RMS Crs Vel
RMS Alg Vel
0 200 400 600 800 1000 1200 1400 1600
Position [mm] - Velocity [mm/s]


Keplerian Element Differences Statistics
Case
KEP.gfz.D10-jcet.D12
KEP.gfz.C10-jcet.C12
KEP.gfz.B10-jcet.B11
KEP.gfz.A10-jcet.A11
KEP.geos.D10-jcet.D12
KEP.geos.C10-jcet.C12
KEP.geos.A10-jcet.A11
KEP.asi.D14-jcet.D12
KEP.asi.C14-jcet.C12
KEP.asi.B14-jcet.B11
KEP.asi.A14-jcet.A11
Mean Semi-axis [mm]
Mean Eccnt. [ppb]
Mean Incl. [mas]
Mean Node [mas]
Mean Perigee [mas]
Mean w+M [mas]
-60
-50
-40
-30
-20
-10
0
10
20
Semi-axis [mm] - Eccntr. [ppb] - Angular Elems. [mas]



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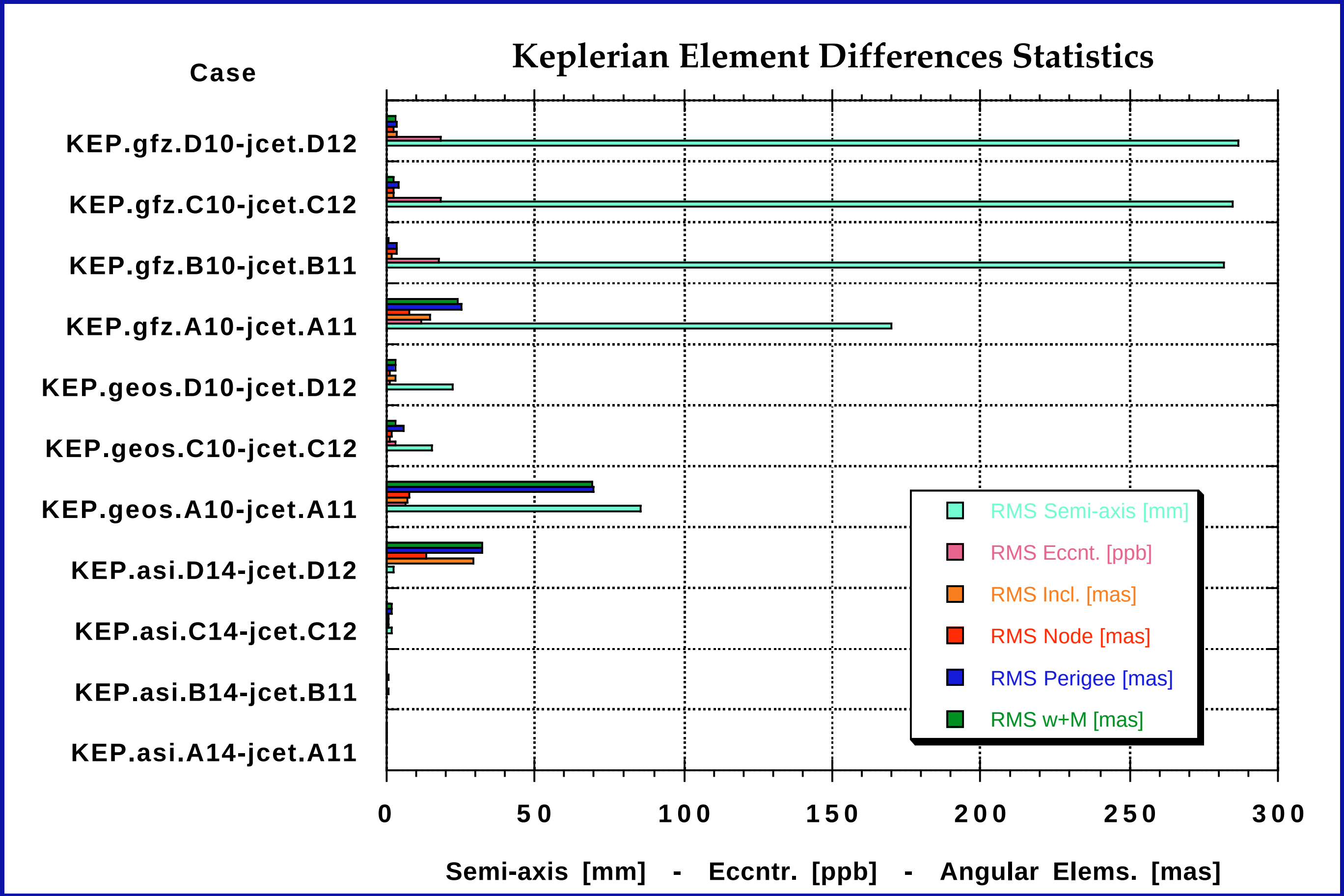

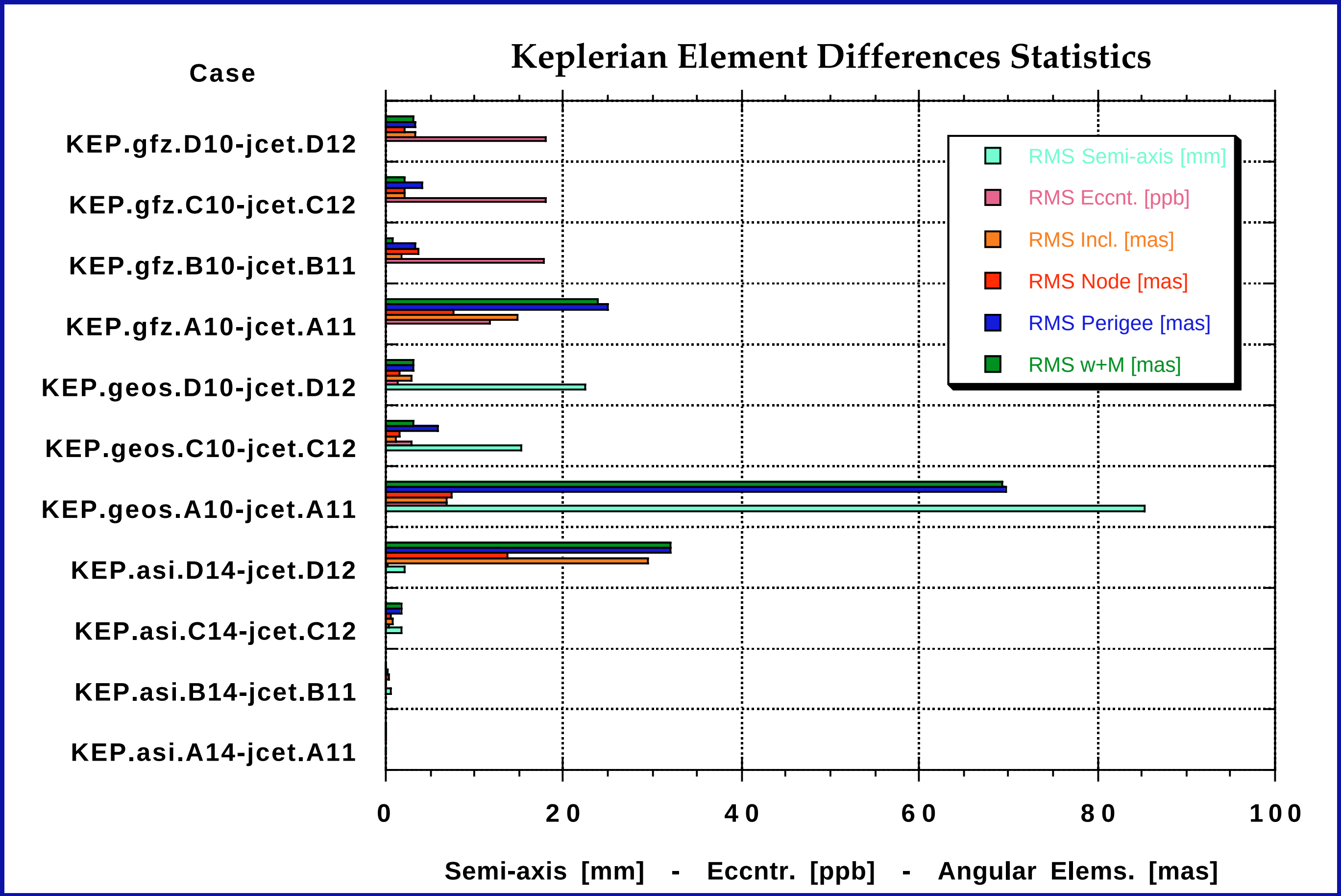
Keplerian Element Differences Statistics
Case
KEP.gfz.D10-jcet.D12
KEP.gfz.C10-jcet.C12
KEP.gfz.B10-jcet.B11
KEP.gfz.A10-jcet.A11
KEP.geos.D10-jcet.D12
KEP.geos.C10-jcet.C12
KEP.geos.A10-jcet.A11
KEP.asi.D14-jcet.D12
KEP.asi.C14-jcet.C12
KEP.asi.B14-jcet.B11
KEP.asi.A14-jcet.A11
RMS Semi-axis [mm]
RMS Eccnt. [ppb]
RMS Incl. [mas]
RMS Node [mas]
RMS Perigee [mas]
RMS w+M [mas]
0
20
40
60
80
100
Semi-axis [mm] - Eccntr. [ppb] - Angular Elems. [mas]

S/W Benchmark Summary I

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- The submitted orbits A - D were compared for ASI, GEOS, GFZ and JCET.
- Other submissions were not included because they were primarily in wrong format (or too incomplete)
- All orbits were compared to JCET orbits
- Comparison was done in various “spaces”:
  - Straight Cartesian position differences
  - Radial, Cross- and Along-Track differences
  - Keplerian Elements
- We computed Min, Max, Mean and RMS statistics

S/W Benchmark Summary II

Goddard Space Flight Center

- The comparisons indicate a good agreement for most of the A-C cases.
- In the case of ASI and JCET, the close coordination in modeling the orbit resulted in practically null differences
- The observed differences in the ASI-JCET case D can be considered the "observer's equation" for SLR
- It seems that there is some typo in the GEOS case A, resulting in large differences, although they too use GEODYN, like ASI and JCET
- We observe this also in the totally independent case of GFZ-JCET, the difference here though is **3 times smaller**!
- There are some errors also in the case B orbit of GEOS (incomplete?)
- There is really no excuse for such differences when the same s/w is used and the modeling and reduction procedure are so rigidly prescribed

S/W Benchmark Summary III

Goddard Space Flight Center

- The good comparisons with GFZ indicate that we have two independent s/w that perform comparably
- The large differences in case A though needs to be resolved, is it the use of slightly different initial conditions, a typo, or a fundamental difference between the two s/w packages?
- The large semi-axis major and eccentricity, mean and RMS differences of GFZ-JCET for cases B, C and D, indicate that there is some error or some modeling difference:
  - did they use EGM96 and comparable tides?
  - why are they much smaller in case A?
  - why do cases B, C, D behave so similarly in Keplerian space, while case A is so different from all three?
- **The other ACs must submit their contributions soon, so that we can have a meaningful comparison of diverse s/w and analysis groups.**
- **PLEASE follow the instructions to avoid having your contributions IGNORED.**