

IADC SG Meeting

IADC Re-Entry Prediction Campaigns for UARS, ROSAT and Phobos-Grunt

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Campaign 2011-1 Test Object Description: UARS

- US satellite of dry mass $\sim 5,668$ kg, diameter 4.6 m, and length 9.7 m; registration under COSPAR ID 1991-063B and US SSN catalog #21701; launched from KSC on STS-48 (Discovery) on 12-Sep-1991
- initial deployment orbit: $575 \text{ km} \times 580 \text{ km}$ at 57.0° inclination; orbit at start of campaign: $233 \text{ km} \times 266 \text{ km}$ at 56.9° inclination



Chronology of UARS Re-Entry Test Campaign 2011-1

- campaign opening: 2011/09/13 12:00 UTC (notification of points of contact);
campaign closure: 2011/09/24 06:18 UTC (no pass of SSN after 04:00 UTC);
re-entry assessment SSN: 2011/09/24 04:00 UTC (80 km altitude pass);
re-entry epoch: 2011/09/24 04:07 UTC (at 10 km, ~7 min after 80 km pass)
- final predictions by participants (epoch on previous day marked by *):
 - ASI (Pardini): 2011/09/24 04:38 UTC (last orbit data: 22:15*)
 - CNES (Laporte): 2011/09/24 04:05 UTC (last orbit data: 22:15*)
 - CNSA (Xiong): 2011/09/24 04:20 UTC (last orbit data: 22:15*)
 - DLR (Wiedemann): 2011/09/24 04:18 UTC (last orbit data: 10:34*)
 - ESA (Klinkrad): 2011/09/24 04:09 UTC (last orbit data: 01:39)
 - ISRO (Anilkumar): 2011/09/24 04:35 UTC (last orbit data: 01:09)
 - JAXA (Hirose): 2011/09/24 04:13 UTC (last orbit data: 01:09)
 - NASA (Johnson): 2011/09/24 04:16 UTC (last orbit data: 01:09)
 - ROSCOSMOS (Ivanov): 2011/09/24 04:53 UTC (last orbit data: 02:37)
 - UKSA (Herridge): 2011/09/24 04:03 UTC (last orbit data: 01:09)

Summary of Activities – Entire UARS Campaign

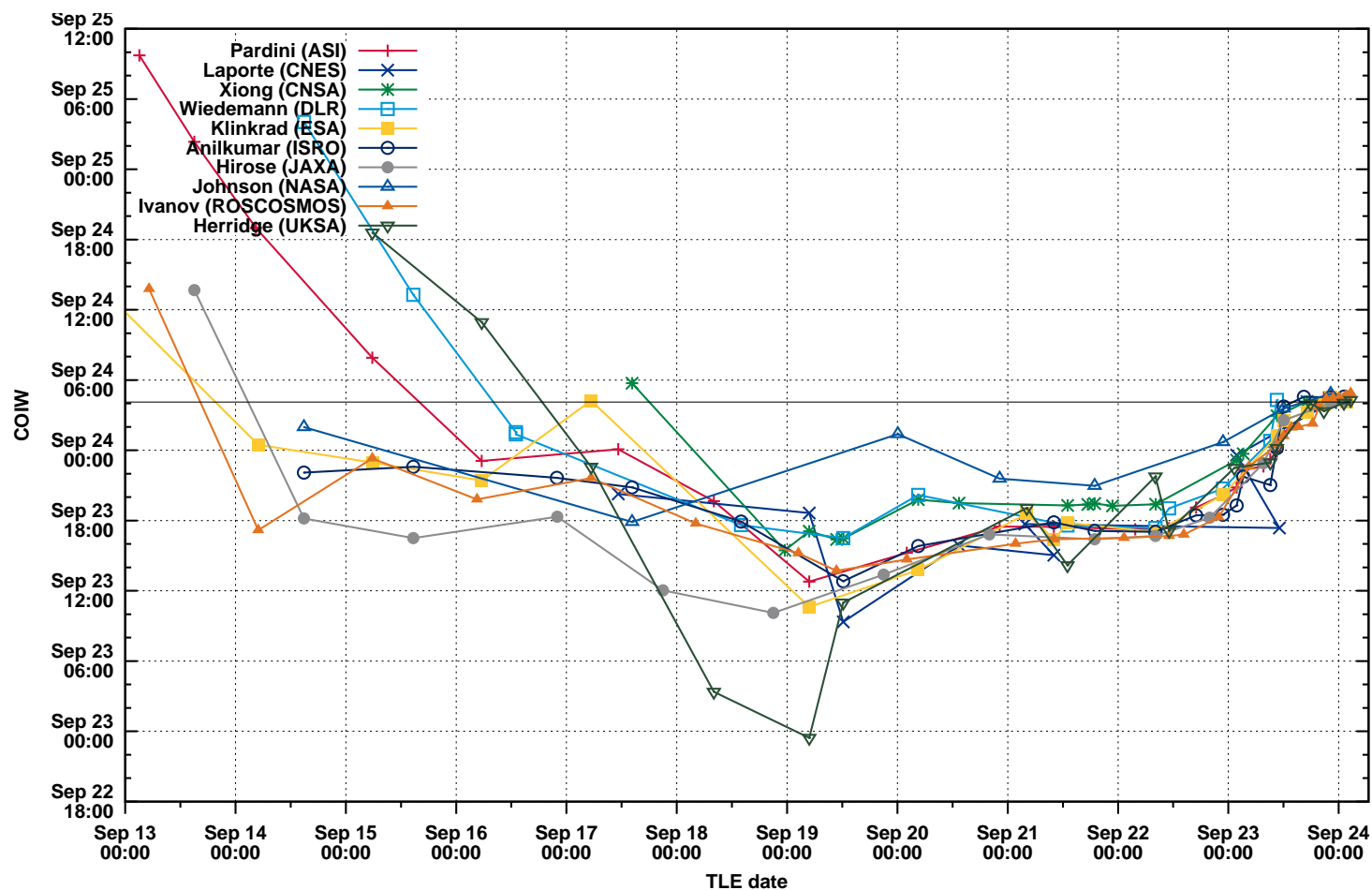
		Predictions		TLE Data Access		Osc. Elem. Access	
P.o.C.		Inputs	Err (%)	Retrievals	Inputs	Retrievals	Inputs
Pardini	(ASI)	25	14.70	48	0	0	0
Laporte	(CNES)	9	17.65	3	0	3	3
Xiong	(CNSA)	17	11.05	1	0	0	0
Wiedemann	(DLR)	13	11.64	101	10	0	0
Klinkrad	(ESA)	20	9.94	23	6	0	0
Anilkumar	(ISRO)	20	15.79	108	0	2	0
Hirose	(JAXA)	15	12.64	77	0	3	5
Johnson	(NASA)	9	7.02	48	153	0	0
Ivanov	(ROSCOSMOS)	27	15.53	43	37	3	0
Herridge	(UKSA)	17	14.24	109	0	3	0
		172		561	206	14	8

UARS Predictions During the Last 48 Hours

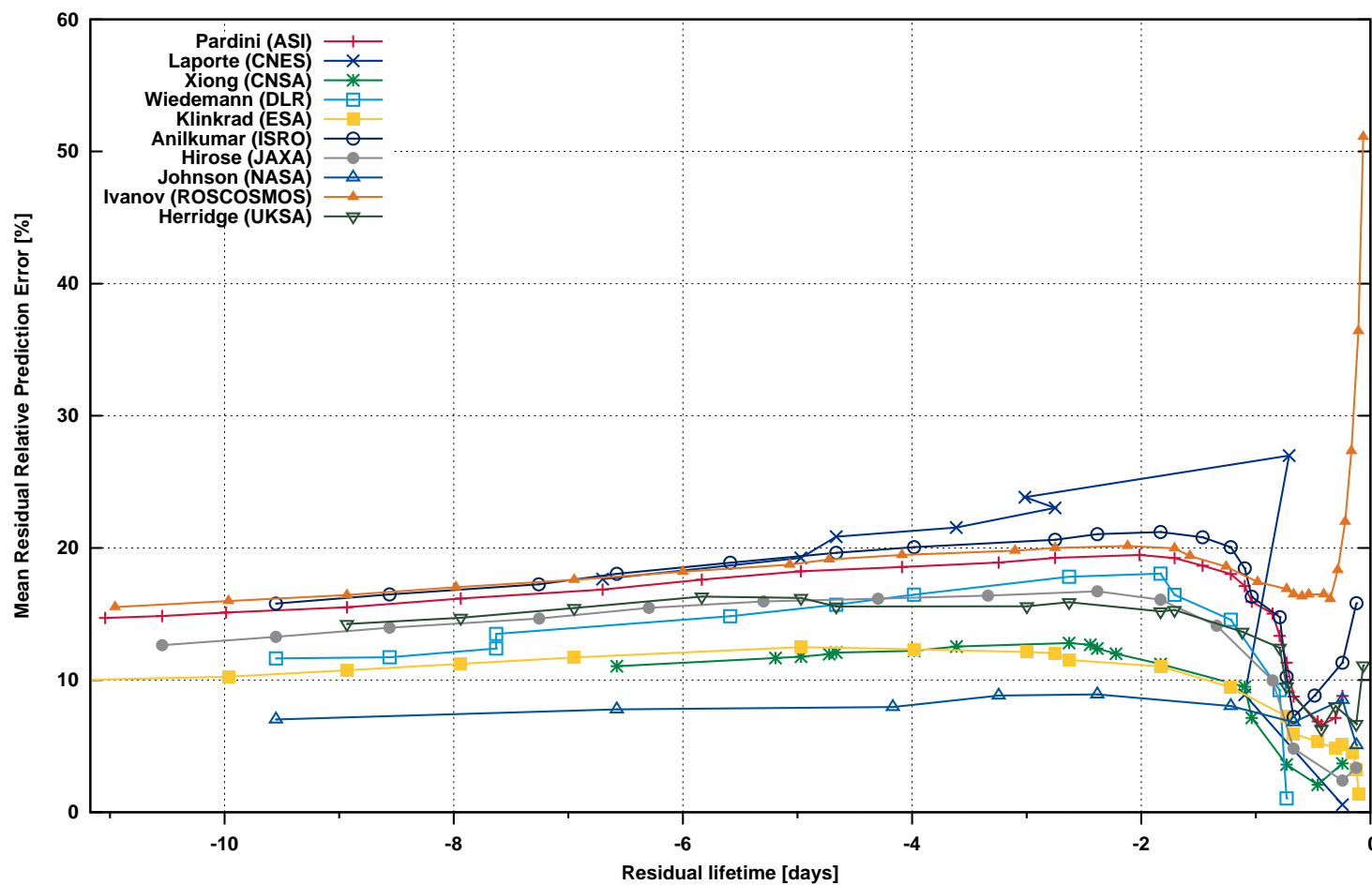
		Predictions		Time Delay (hrs)	
P.o.C.	(IADC Member)	Inputs	Err (%)	Minimum	Average
Pardini	(ASI)	14	19.47	0.89	4.18
Laporte	(CNES)	4	23.84	2.41	3.65
Xiong	(CNSA)	6	11.22	2.08	4.32
Wiedemann	(DLR)	5	18.05	3.26	4.96
Klinkrad	(ESA)	10	11.04	1.11	2.11
Anilkumar	(ISRO)	12	21.04	2.26	6.60
Hirose	(JAXA)	7	16.72	1.48	4.44
Johnson	(NASA)	4	8.03	1.46	2.36
Ivanov	(ROSCOSMOS)	16	20.14	1.16	3.13
Herridge	(UKSA)	9	15.21	0.84	2.11

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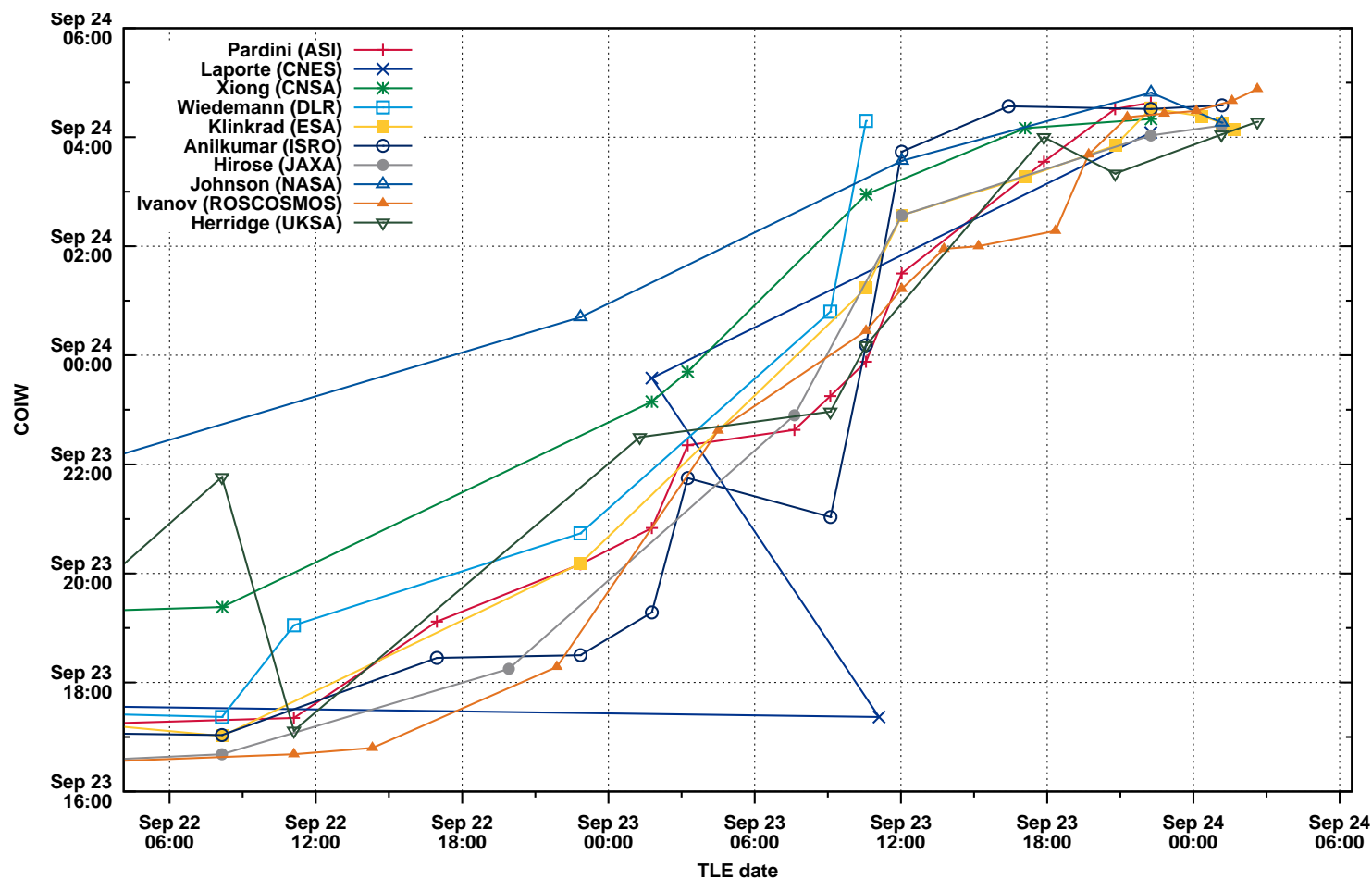
UARS Absolute Prediction Errors (Entire Campaign)



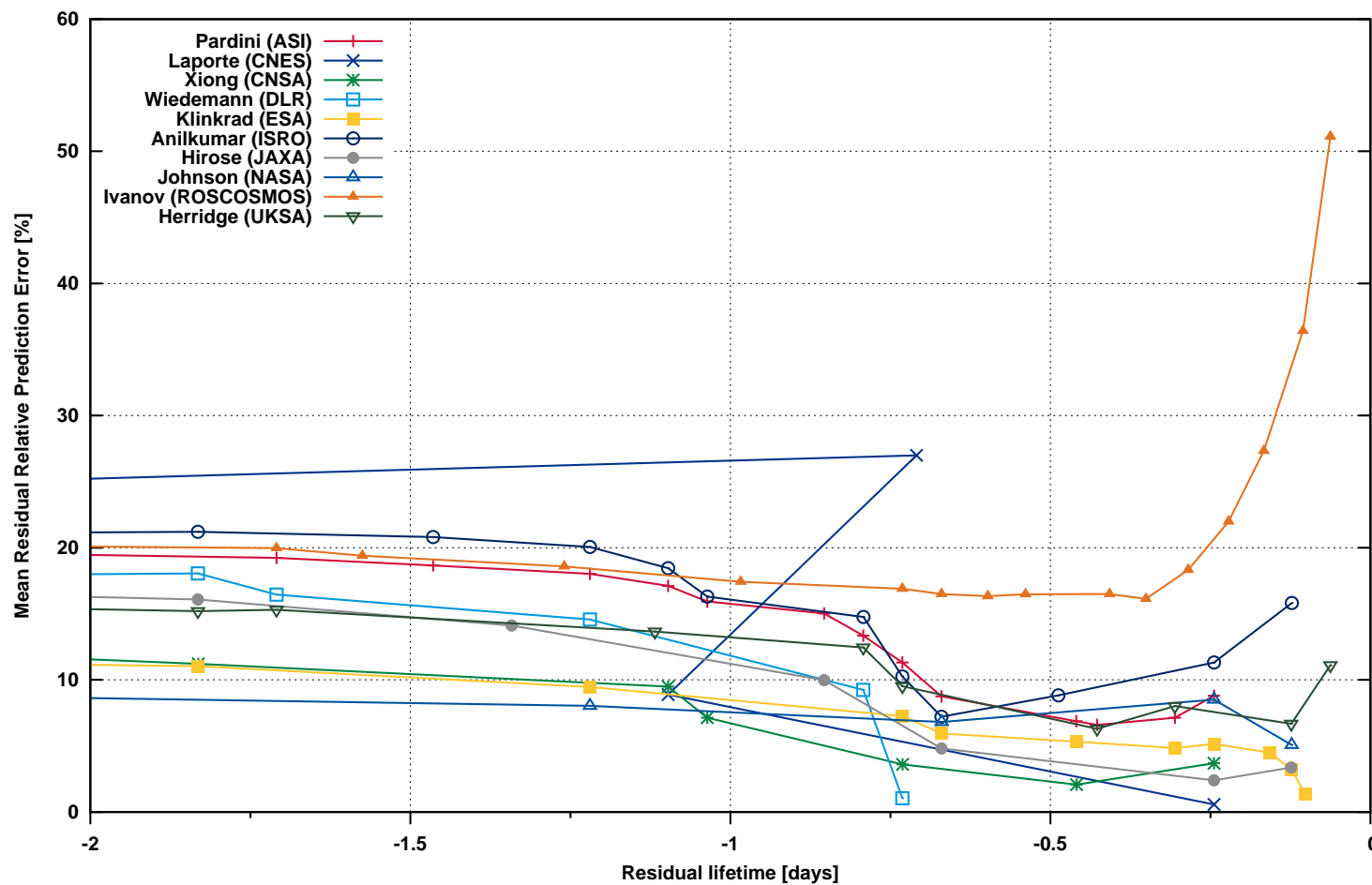
UARS Relative Prediction Errors (Entire Campaign)



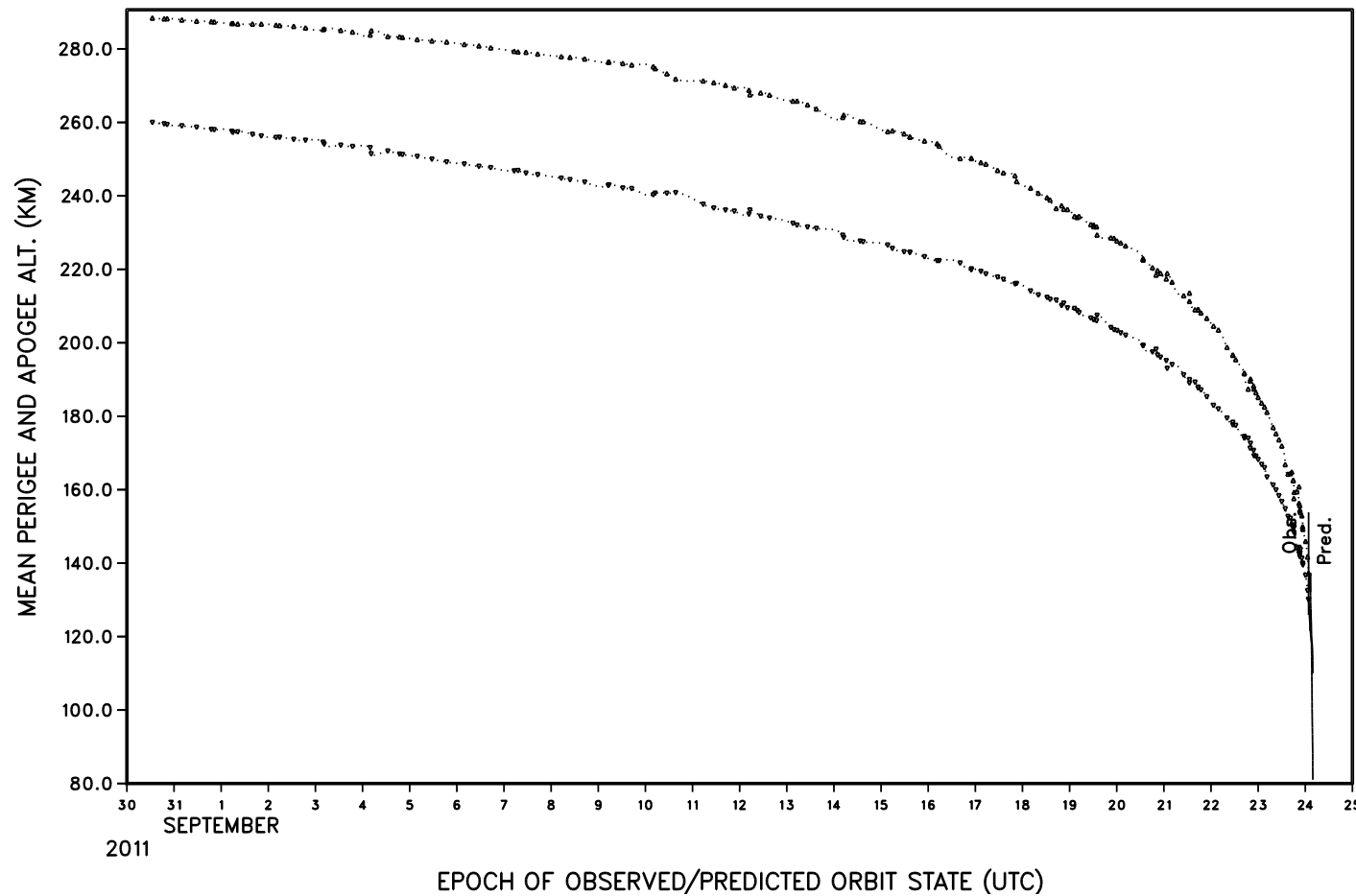
UARS Absolute Prediction Errors (Last 48h)



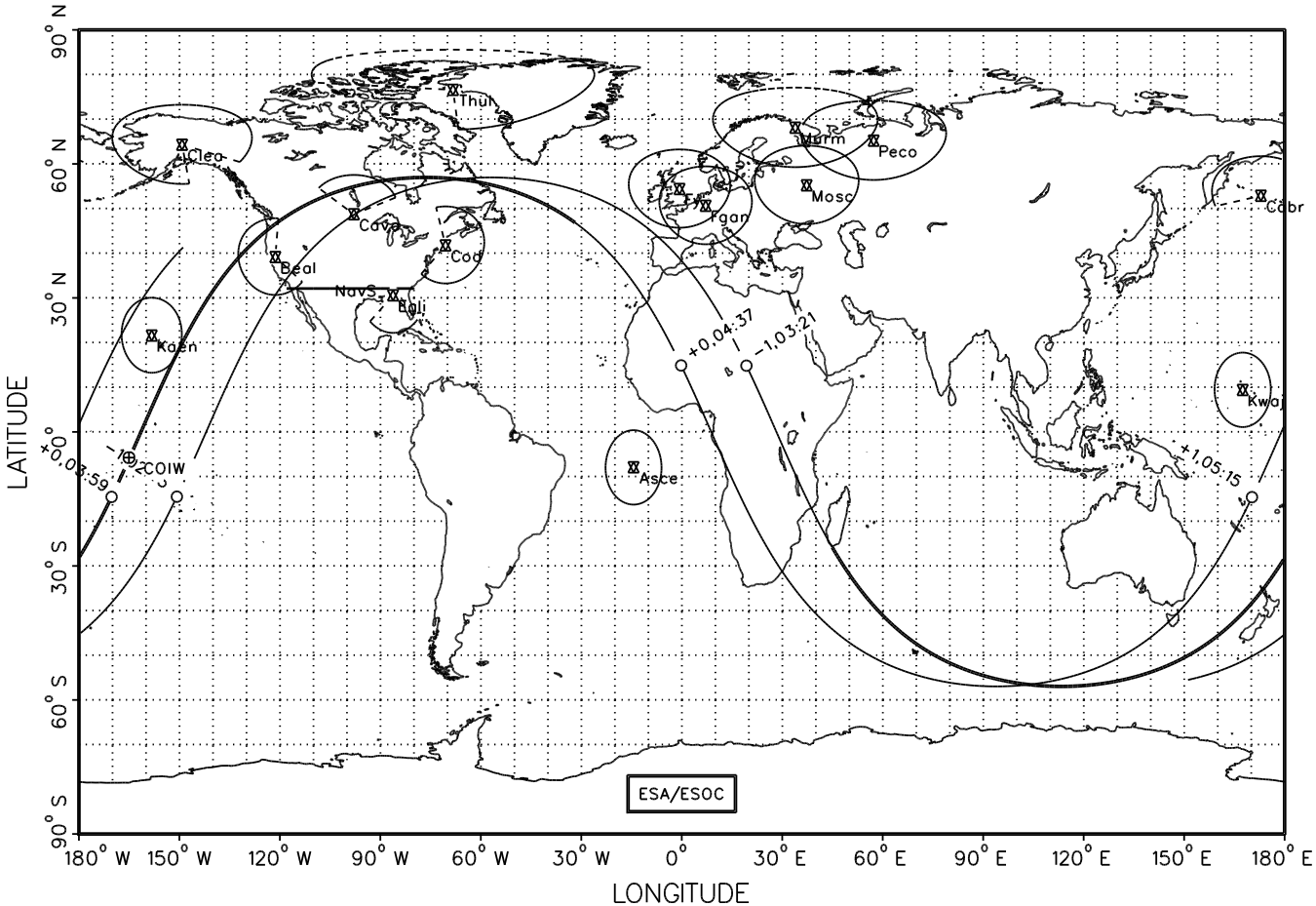
UARS Relative Prediction Errors (Last 48h)



UARS Altitude Decay

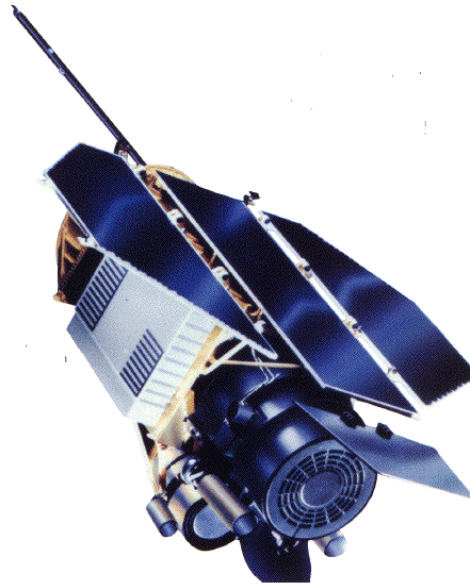


UARS Re-Entry Groundtrack



Campaign 2011-2 Test Object Description: ROSAT

- German satellite of dry mass $\sim 2,400$ kg, size $2.2 \text{ m} \times 4.7 \text{ m} \times 8.9 \text{ m}$; registration under COSPAR ID 1990-049A and US SSN catalog #20638; launched from KSC on a Delta-2 rocket on 01-Jun-1990
- initial deployment orbit: $565 \text{ km} \times 584 \text{ km}$ at 53.0° inclination; orbit at start of campaign: $240 \text{ km} \times 256 \text{ km}$ at 52.95° inclination



Chronology of ROSAT Re-Entry Test Campaign 2011-2

- campaign opening: 2011/10/10 12:00 UTC (notification of points of contact);
campaign closure: 2011/10/23 04:29 UTC (after JSpOC re-entry notification);
re-entry assessment SSN: 2011/10/23 01:50 UTC (80 km altitude pass);
re-entry epoch: 2011/10/23 01:57 UTC (at 10 km, ~7 min after 80 km pass)
- final predictions by participants (epoch on previous day marked by *):
 - ASI (Pardini): 2011/10/23 02:33 UTC (last orbit data: 22:54*)
 - CNES (Laporte): 2011/10/23 01:41 UTC (last orbit data: 13:30*)
 - CNSA (Xiong): 2011/10/23 01:32 UTC (last orbit data: 11:43*)
 - DLR (Wiedemann): 2011/10/23 07:35 UTC (last orbit data: 11:29*)
 - ESA (Klinkrad): 2011/10/23 02:06 UTC (last orbit data: 22:54*)
 - ISRO (Anilkumar): 2011/10/23 02:11 UTC (last orbit data: 22:54*)
 - JAXA (Hirose): 2011/10/23 01:41 UTC (last orbit data: 16:07*)
 - NASA (Johnson): 2011/10/23 02:04 UTC (last orbit data: 20:00*)
 - ROSCOSMOS (Ivanov): 2011/10/23 01:56 UTC (last orbit data: 22:55*)
 - UKSA (Herridge): 2011/10/22 23:58 UTC (last orbit data: 20:36**)

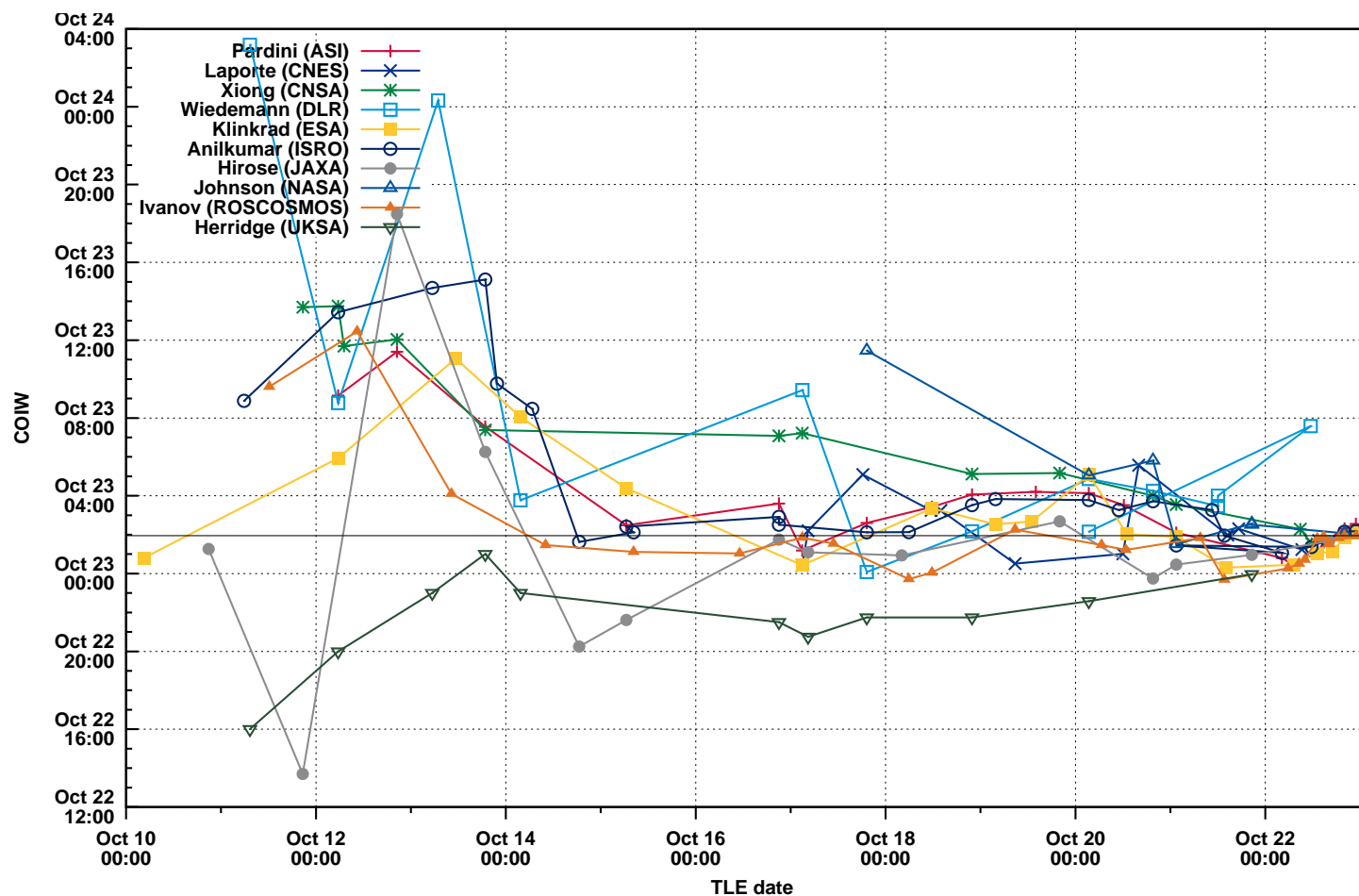
Summary of Activities – Entire ROSAT Campaign

		Predictions		TLE Data Access		Osc. Elem. Access	
P.o.C.		Inputs	Err (%)	Retrievals	Inputs	Retrievals	Inputs
Pardini	(ASI)	19	3.83	49	0	2	0
Laporte	(CNES)	12	1.91	9	0	9	9
Xiong	(CNSA)	13	3.51	4	0	0	0
Wiedemann	(DLR)	13	6.60	103	15	0	0
Klinkrad	(ESA)	18	2.99	2	11	0	0
Anilkumar	(ISRO)	25	2.46	92	0	0	0
Hirose	(JAXA)	14	2.45	59	0	2	0
Johnson	(NASA)	7	3.70	1	152	0	0
Ivanov	(ROSCOSMOS)	25	2.35	42	37	8	0
Herridge	(UKSA)	11	3.14	104	0	9	0
		157		465	215	30	9

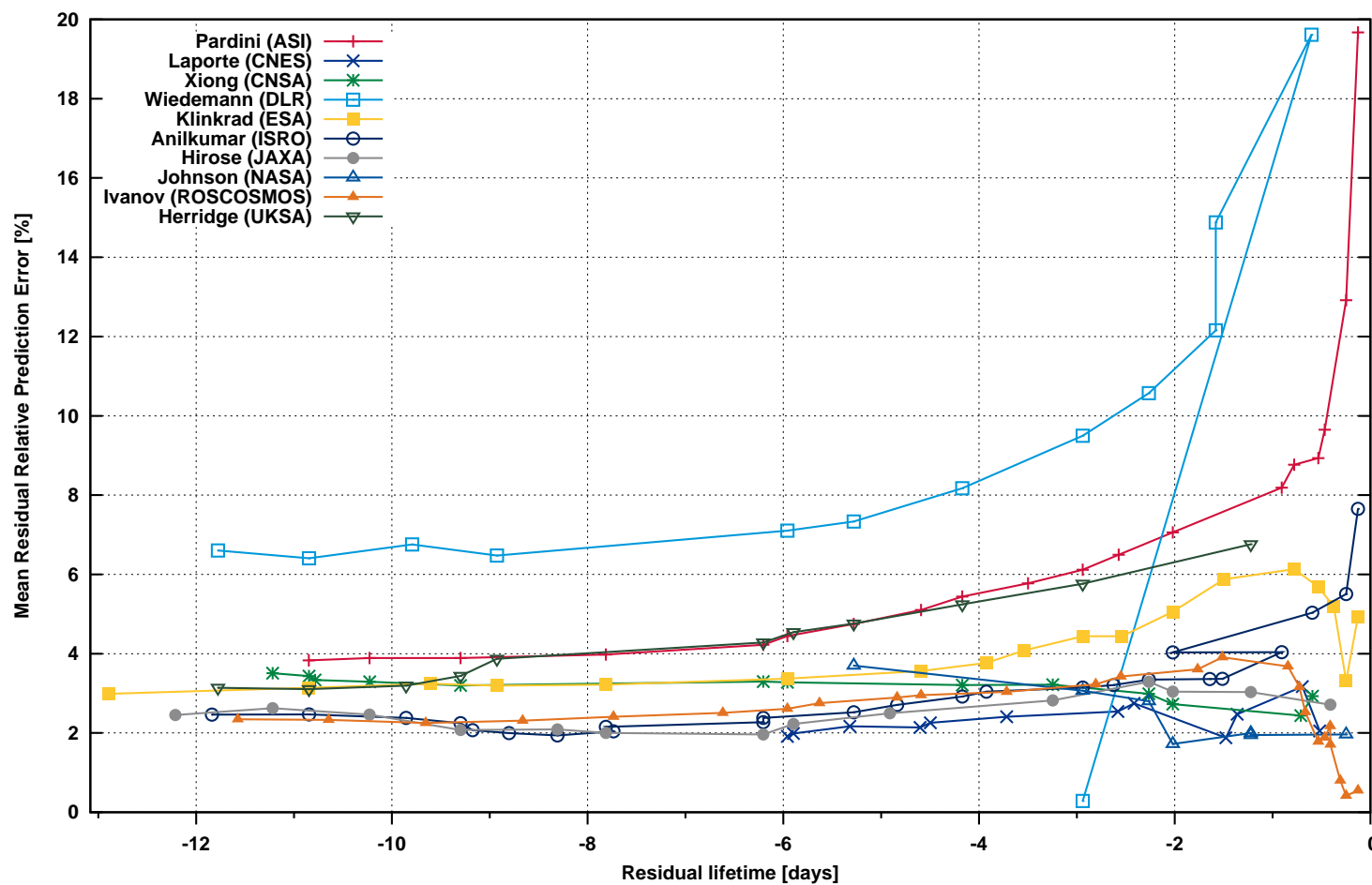
ROSAT Predictions During the Last 48 Hours

P.o.C.	(IADC Member)	Predictions		Time Delay (hrs)	
		Inputs	Err (%)	Minimum	Average
Pardini	(ASI)	7	7.06	1.68	3.41
Laporte	(CNES)	5	2.75	2.93	9.29
Xiong	(CNSA)	4	2.99	0.93	4.44
Wiedemann	(DLR)	5	10.57	0.90	20.18
Klinkrad	(ESA)	7	5.06	2.16	4.63
Anilkumar	(ISRO)	8	3.35	0.90	9.38
Hirose	(JAXA)	4	3.29	9.63	15.82
Johnson	(NASA)	5	2.80	4.24	17.03
Ivanov	(ROSCOSMOS)	12	3.61	1.62	3.24
Herridge	(UKSA)	1	6.76	19.88	19.88
		58			

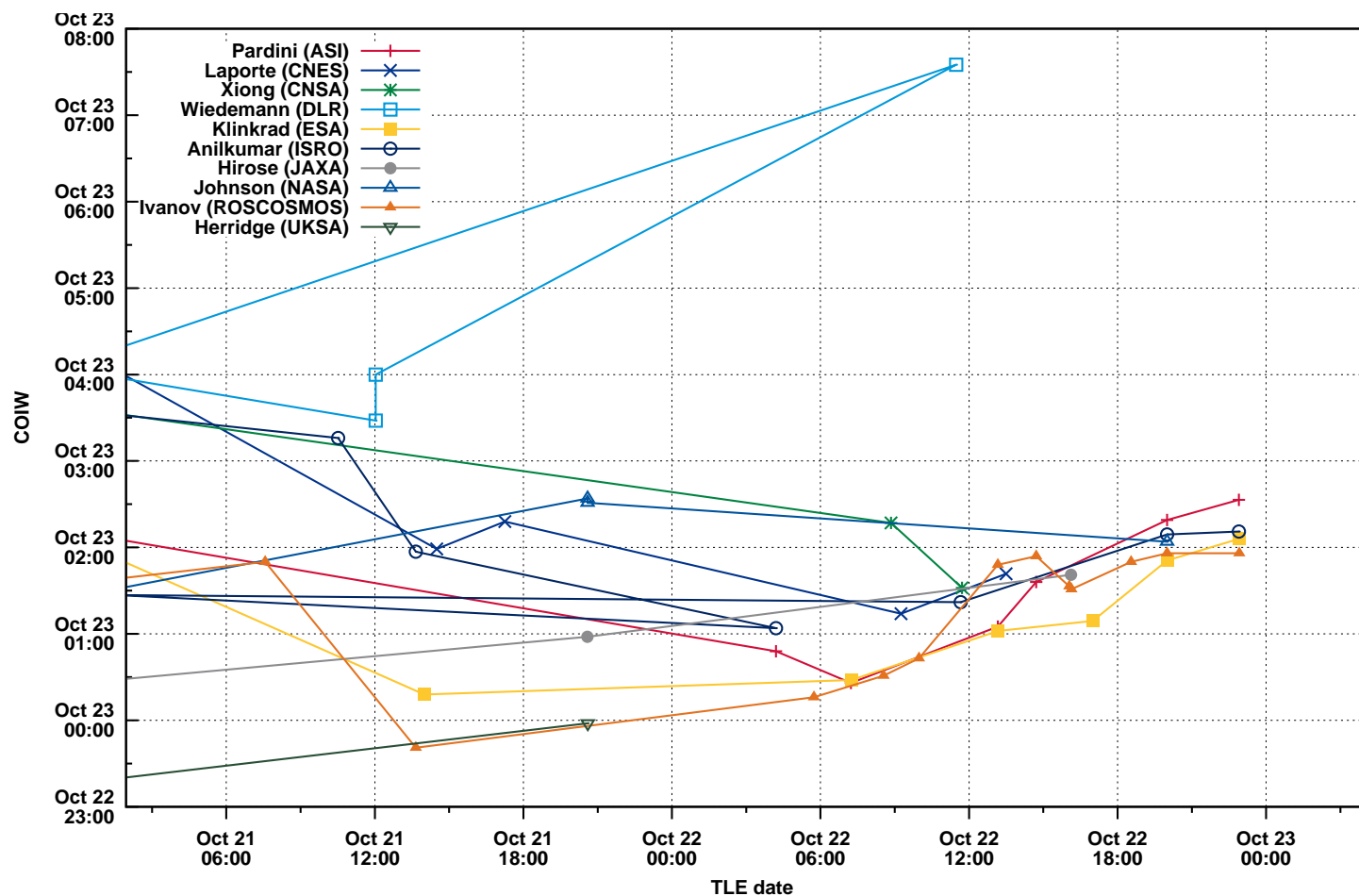
ROSAT Absolute Prediction Errors (Entire Campaign)



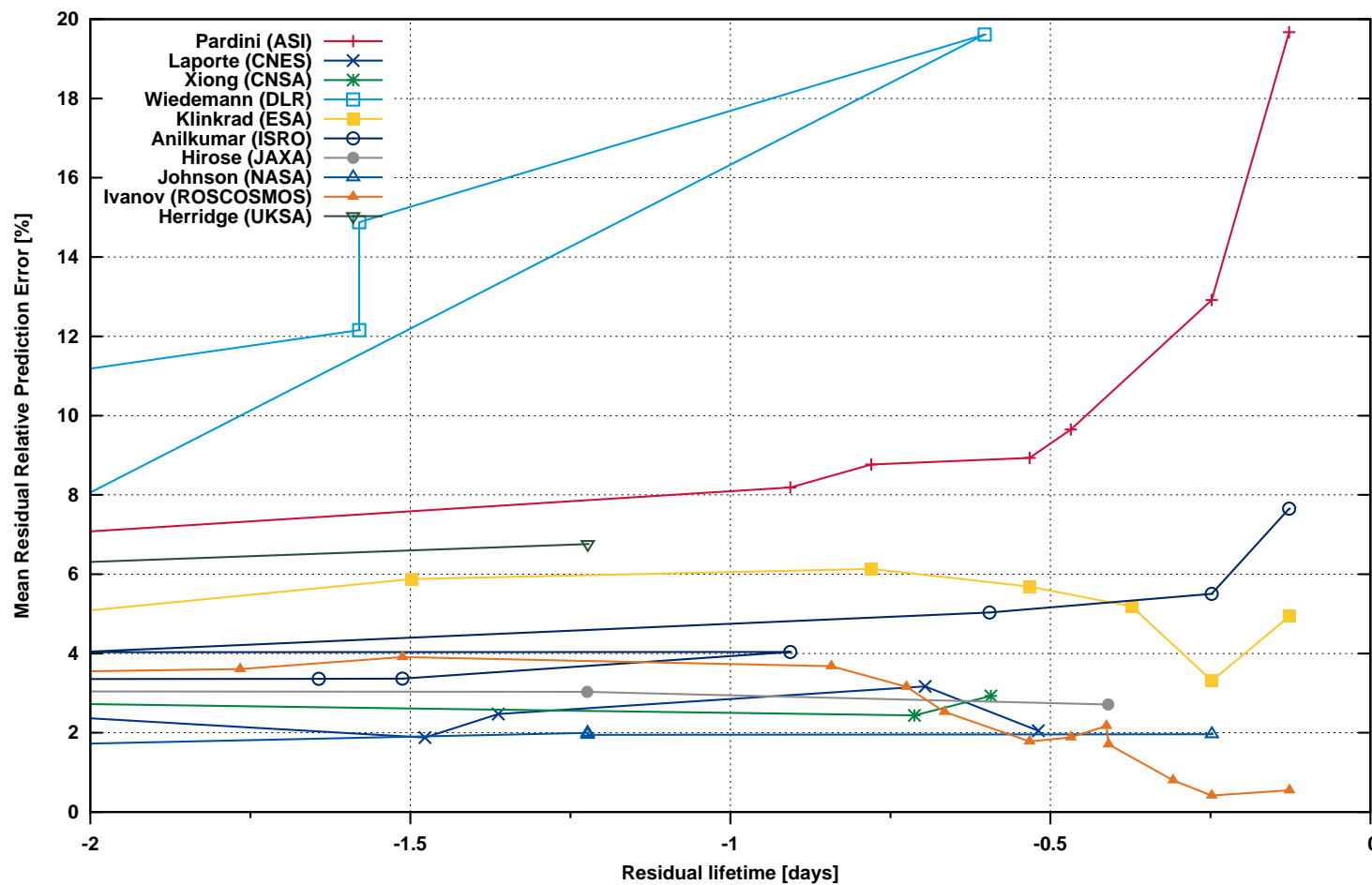
ROSAT Relative Prediction Errors (Entire Campaign)



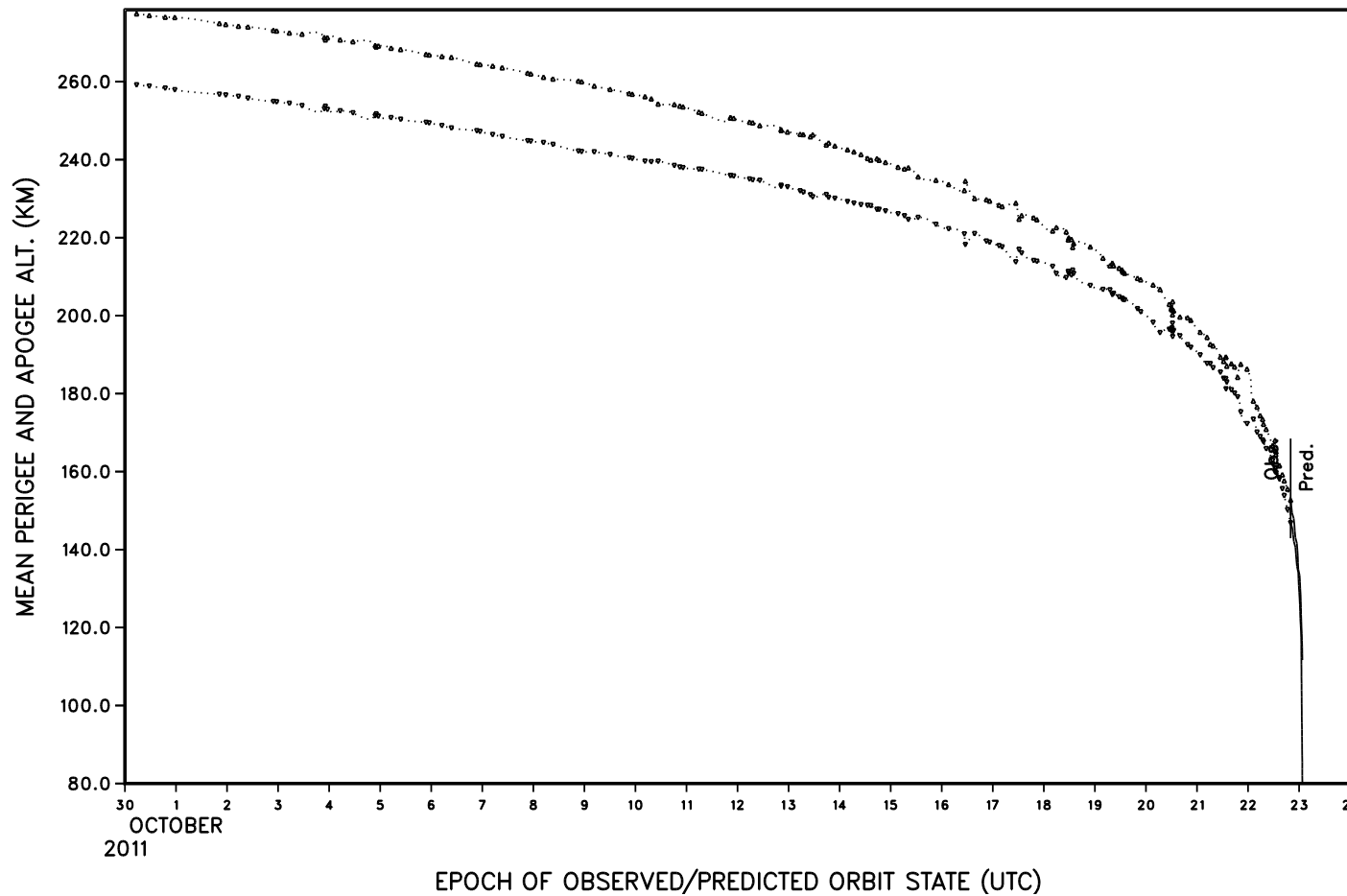
ROSAT Absolute Prediction Errors (Last 48h)



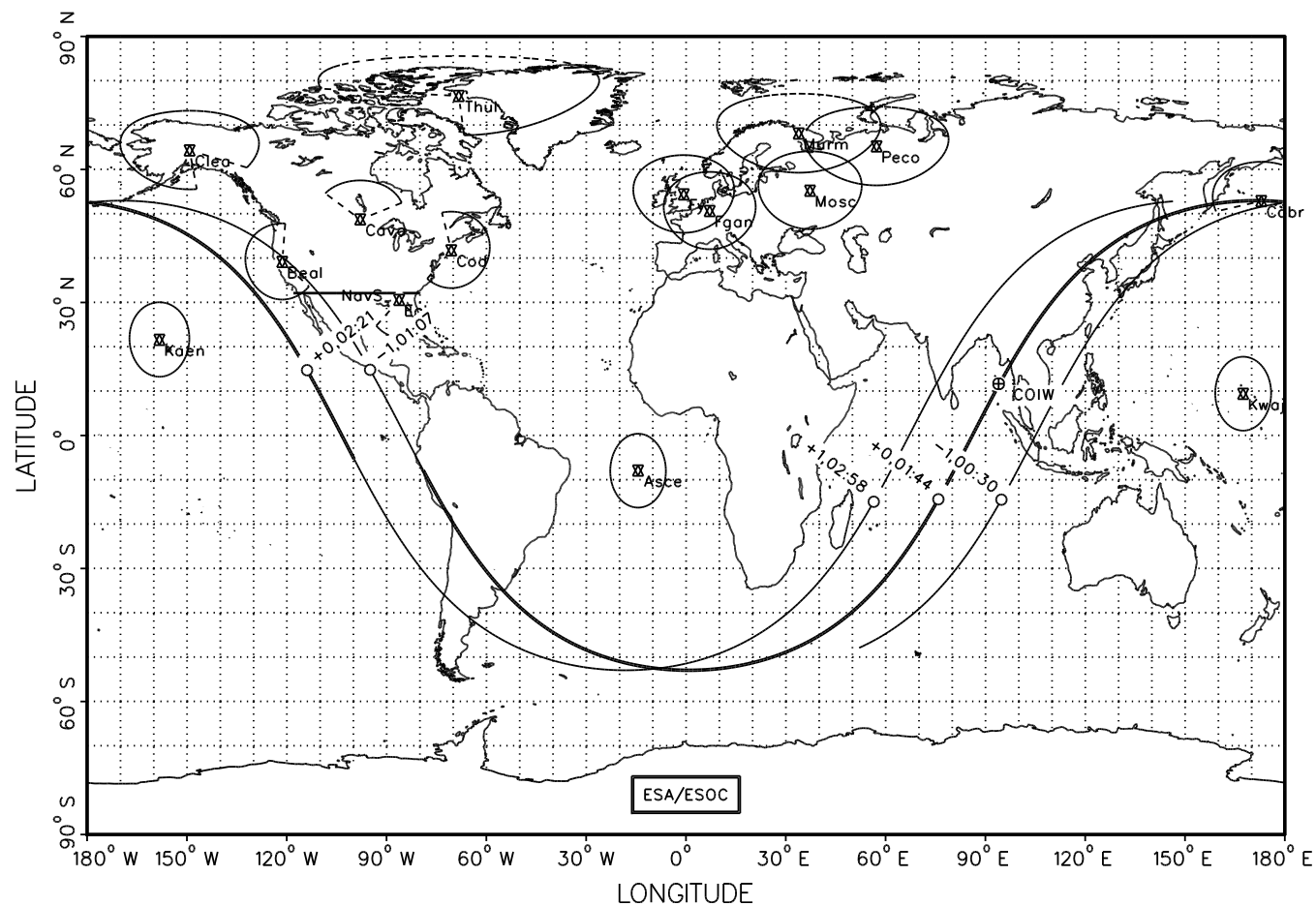
ROSAT Relative Prediction Errors (Last 48h)



ROSAT Altitude Decay

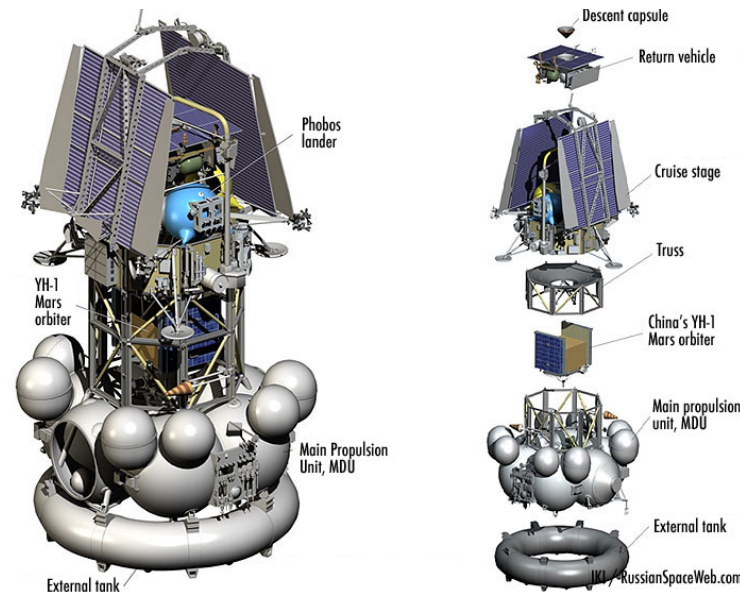


ROSAT Re-Entry Groundtrack



Campaign 2012-1 Test Object Description: Phobos-Grunt

- Russian compound of wet mass $\sim 13,525$ kg, size $3.76 \text{ m} \times 7.97 \text{ m} \times 6.32 \text{ m}$; registration under COSPAR ID 2011-065A and US SSN catalog #37872; launched from Baikonur on a Zenith-2 rocket on 08-Nov-2011
- initial deployment orbit: $206 \text{ km} \times 343 \text{ km}$ at 51.43° inclination; orbit at start of campaign: $188 \text{ km} \times 228 \text{ km}$ at 51.42° inclination



Chronology of Phobos-Grunt Re-Entry Test Campaign 2012-1

- campaign opening: 2012/01/02 12:00 UTC (notification of points of contact);
campaign closure: 2012/01/15 19:00 UTC (after SSS non-acquisitions);
re-entry assessment SSN: 2012/01/23 17:46 UTC (80 km altitude pass);
re-entry epoch: 2012/01/23 17:53 UTC (at 10 km, ~7 min after 80 km pass)
- final predictions by participants (epoch on previous day marked by *):
 - ASI (Pardini): 2012/01/15 17:50 UTC (last orbit data: 17:03)
 - CNES (Laporte): 2012/01/15 17:10 UTC (last orbit data: 09:10*)
 - CNSA (Xiong): 2012/01/15 17:27 UTC (last orbit data: 12:30)
 - DLR (Wiedemann): 2012/01/15 17:43 UTC (last orbit data: 15:33)
 - ESA (Klinkrad): 2012/01/15 17:45 UTC (last orbit data: 17:03)
 - ISRO (Anilkumar): 2012/01/15 17:37 UTC (last orbit data: 09:21)
 - JAXA (Hirose): 2012/01/15 16:30 UTC (last orbit data: 09:21)
 - NASA (Johnson): 2012/01/15 17:23 UTC (last orbit data: 09:21)
 - ROSCOSMOS (Ivanov): 2012/01/15 17:59 UTC (last orbit data: 16:54)
 - SSAU (Alpatov): 2012/01/15 17:26 UTC (last orbit data: 06:27)
 - UKSA (Herridge): 2012/01/15 17:36 UTC (last orbit data: 09:21)

Summary of Activities – Entire Phobos-Grunt Campaign

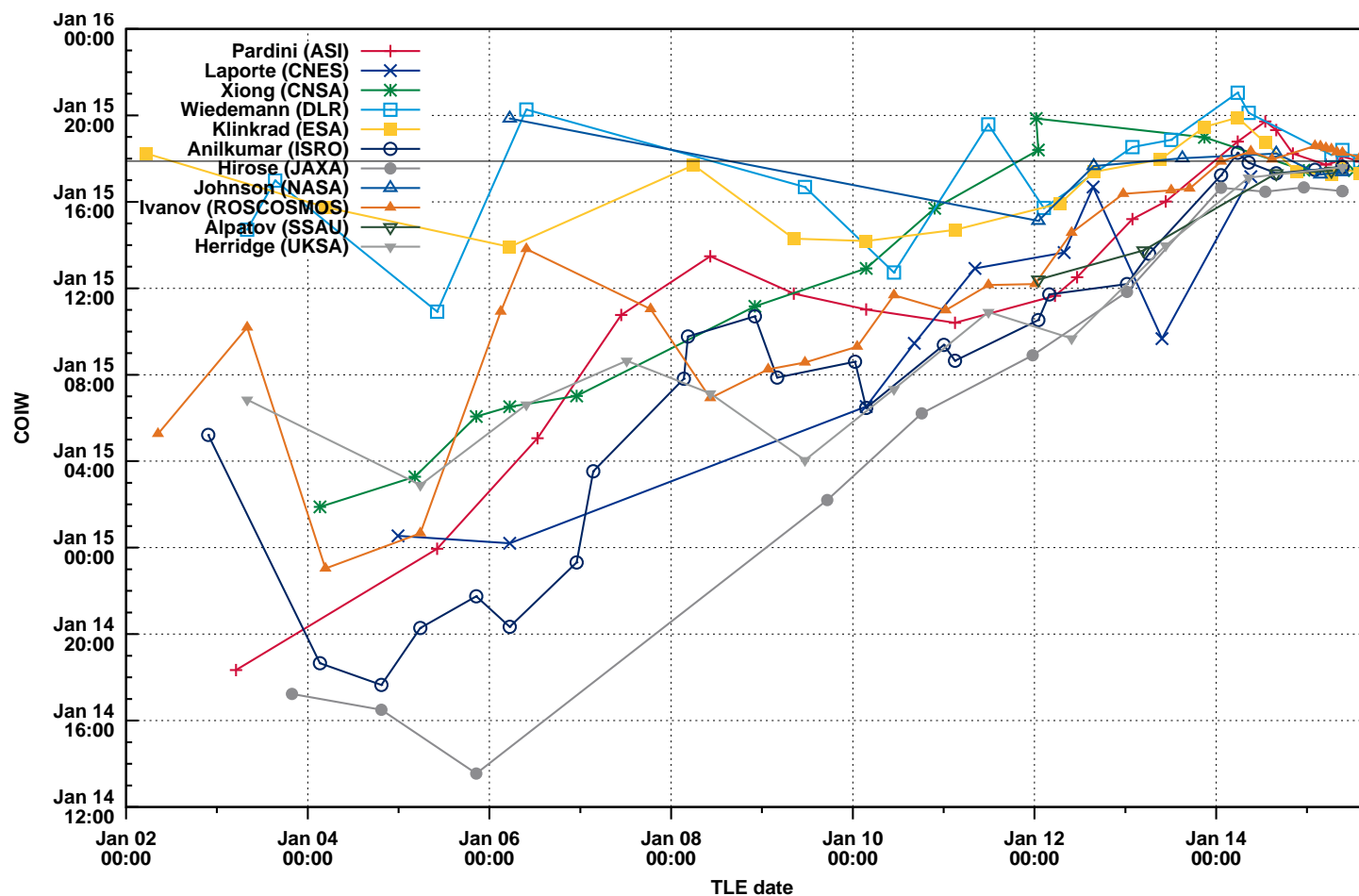
		Predictions		TLE Data Access		Osc. Elem. Access	
P.o.C.		Inputs	Err (%)	Retrievals	Inputs	Retrievals	Inputs
Pardini	(ASI)	21	4.33	32	0	0	0
Laporte	(CNES)	9	6.46	7	0	7	7
Xiong	(CNSA)	13	3.98	0	0	0	0
Wiedemann	(DLR)	16	3.01	131	8	0	0
Klinkrad	(ESA)	19	4.54	1	4	0	0
Anilkumar	(ISRO)	27	5.96	132	0	0	0
Hirose	(JAXA)	12	9.74	0	0	0	0
Johnson	(NASA)	8	2.74	33	249	7	0
Ivanov	(ROSCOSMOS)	30	4.39	16	73	7	0
Alpatov	(SSAU)	4	4.76	0	0	0	0
Herridge	(UKSA)	12	6.06	128	0	0	0
		157		480	334	21	7

Phobos-Grunt Predictions During the Last 48 Hours

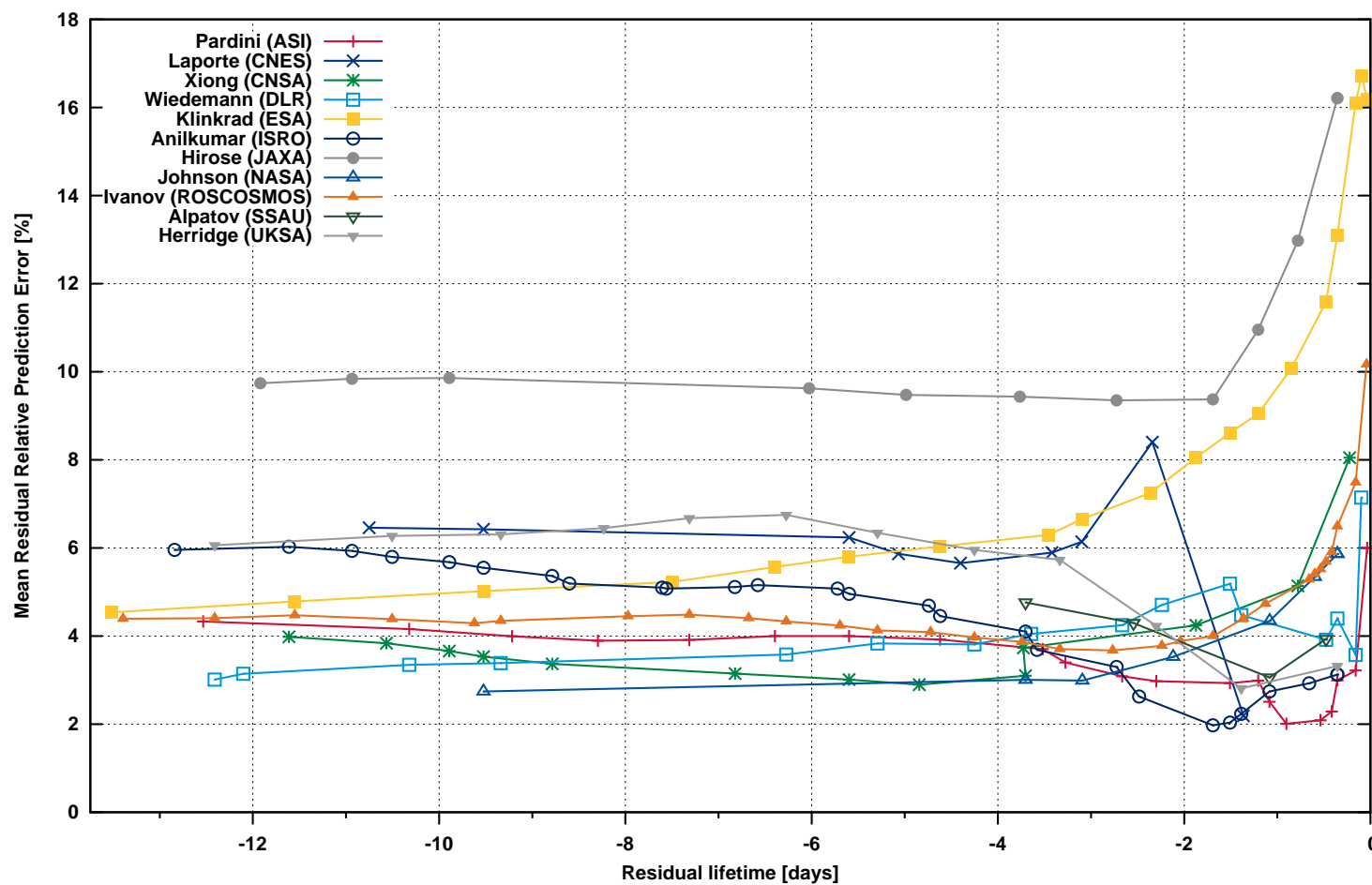
P.o.C.	(IADC Member)	Predictions		Time Delay (hrs)	
		Inputs	Err (%)	Minimum	Average
Pardini	(ASI)	9	2.93	1.04	2.38
Laporte	(CNES)	2	8.40	16.61	20.11
Xiong	(CNSA)	3	4.24	2.09	3.48
Wiedemann	(DLR)	6	5.19	1.33	3.73
Klinkrad	(ESA)	9	8.05	0.77	2.02
Anilkumar	(ISRO)	7	1.97	4.96	10.07
Hirose	(JAXA)	5	9.37	3.86	4.90
Johnson	(NASA)	5	3.53	1.68	3.28
Ivanov	(ROSCOSMOS)	12	3.88	0.72	3.21
Alpatov	(SSAU)	2	3.06	4.36	5.79
Herridge	(UKSA)	2	2.81	3.17	3.58

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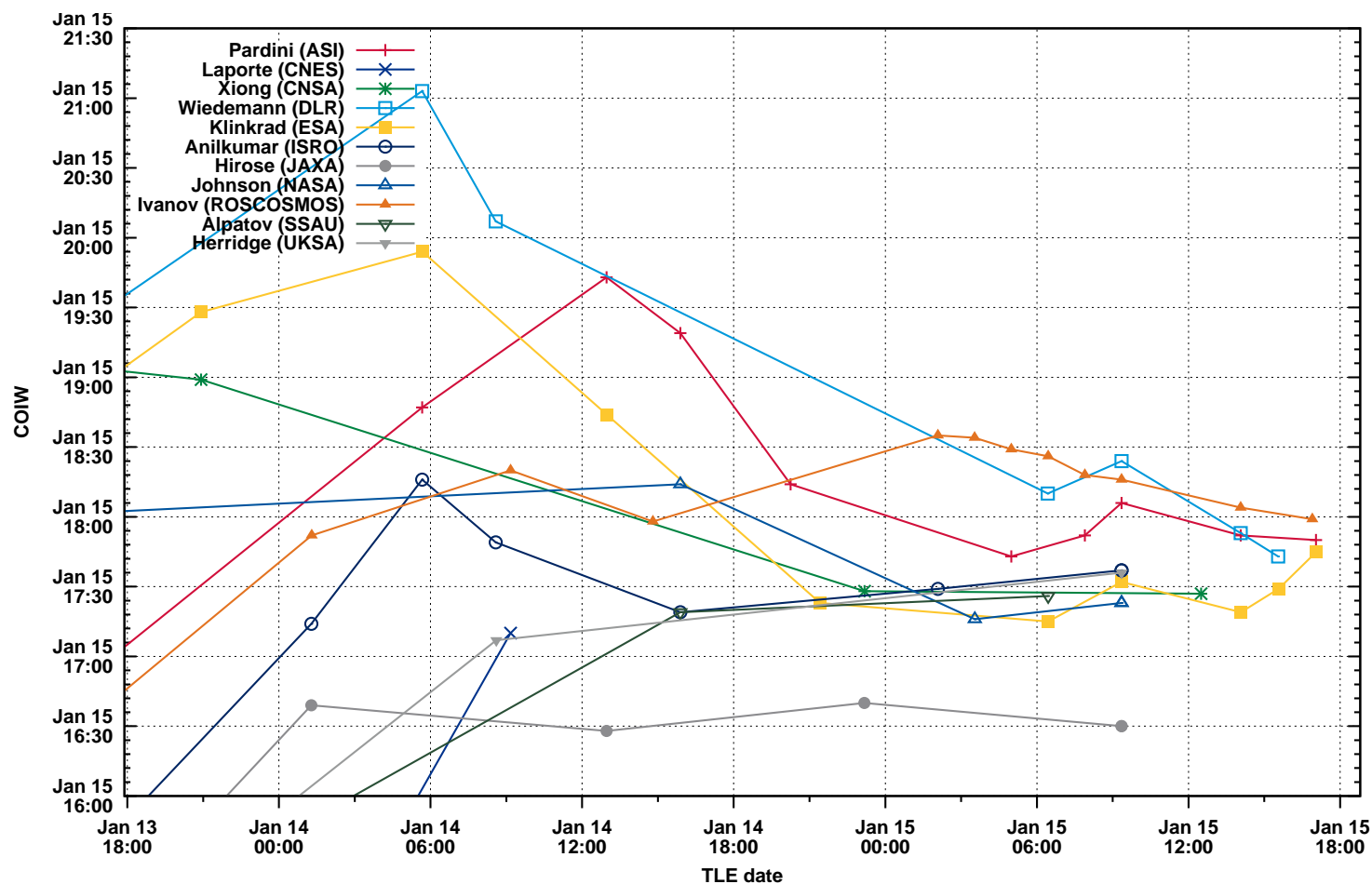
Phobos-Grunt Absolute Prediction Errors (Entire Campaign)



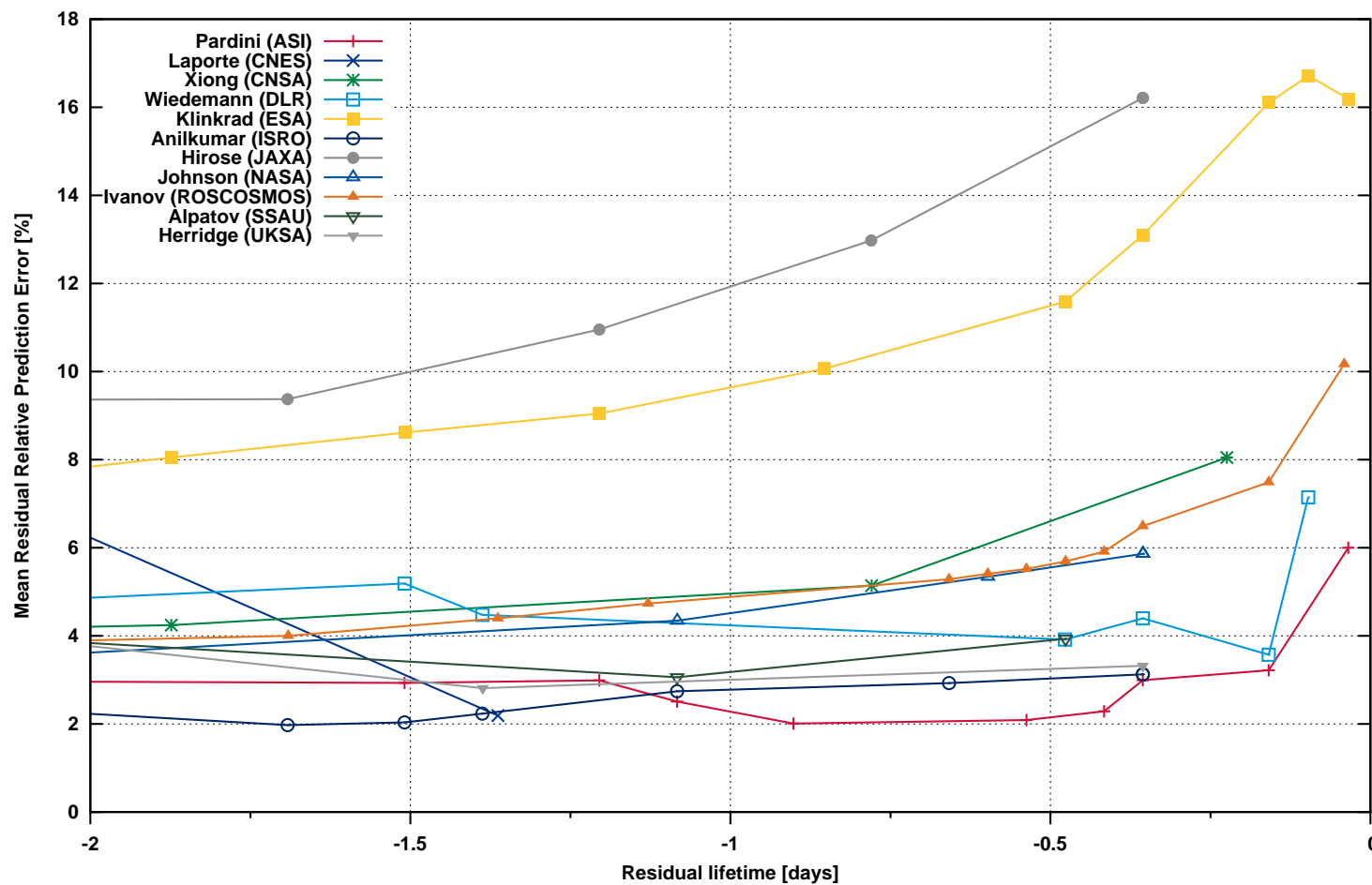
Phobos-Grunt Relative Prediction Errors (Entire Campaign)



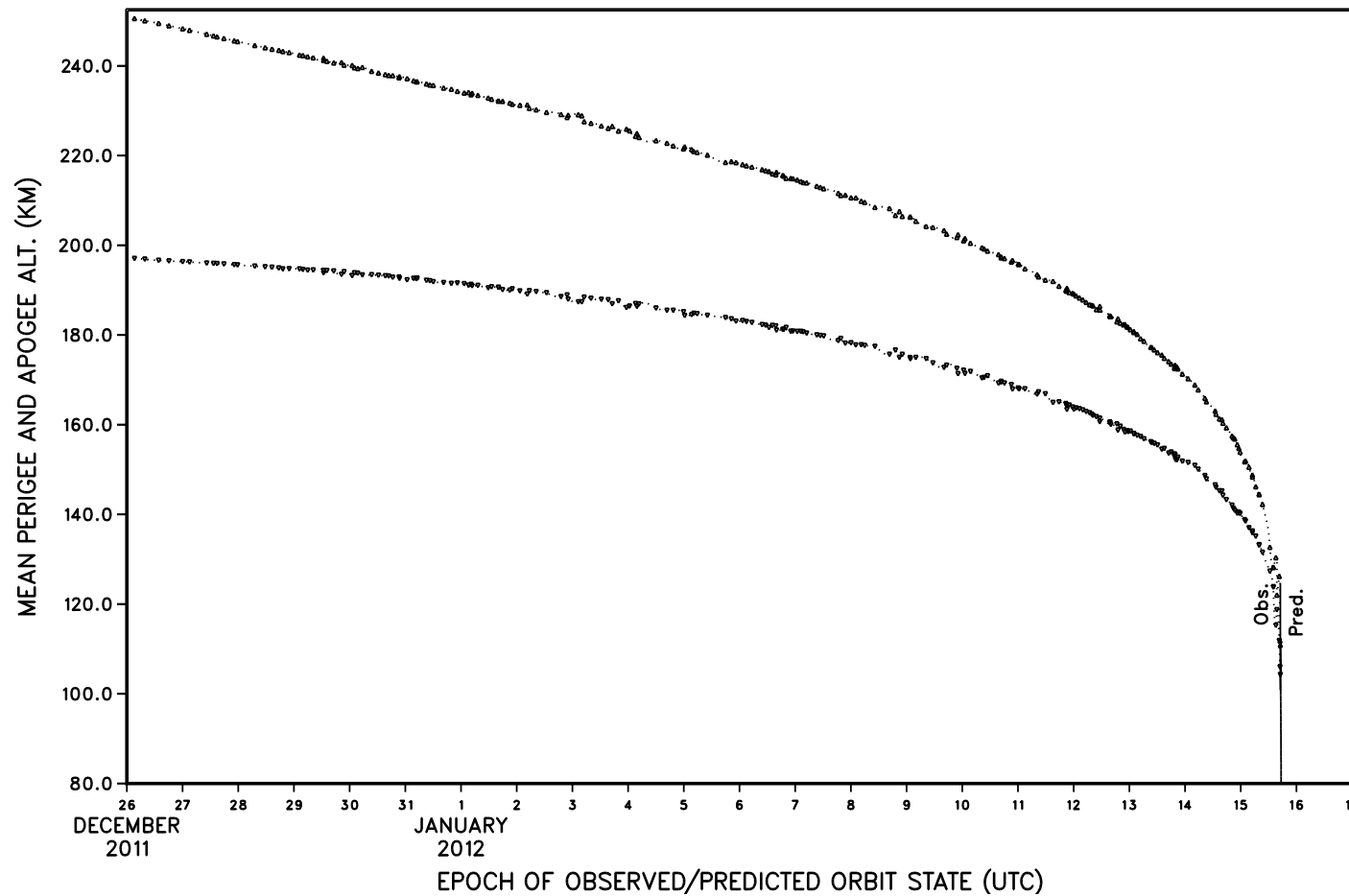
Phobos-Grunt Absolute Prediction Errors (Last 48h)



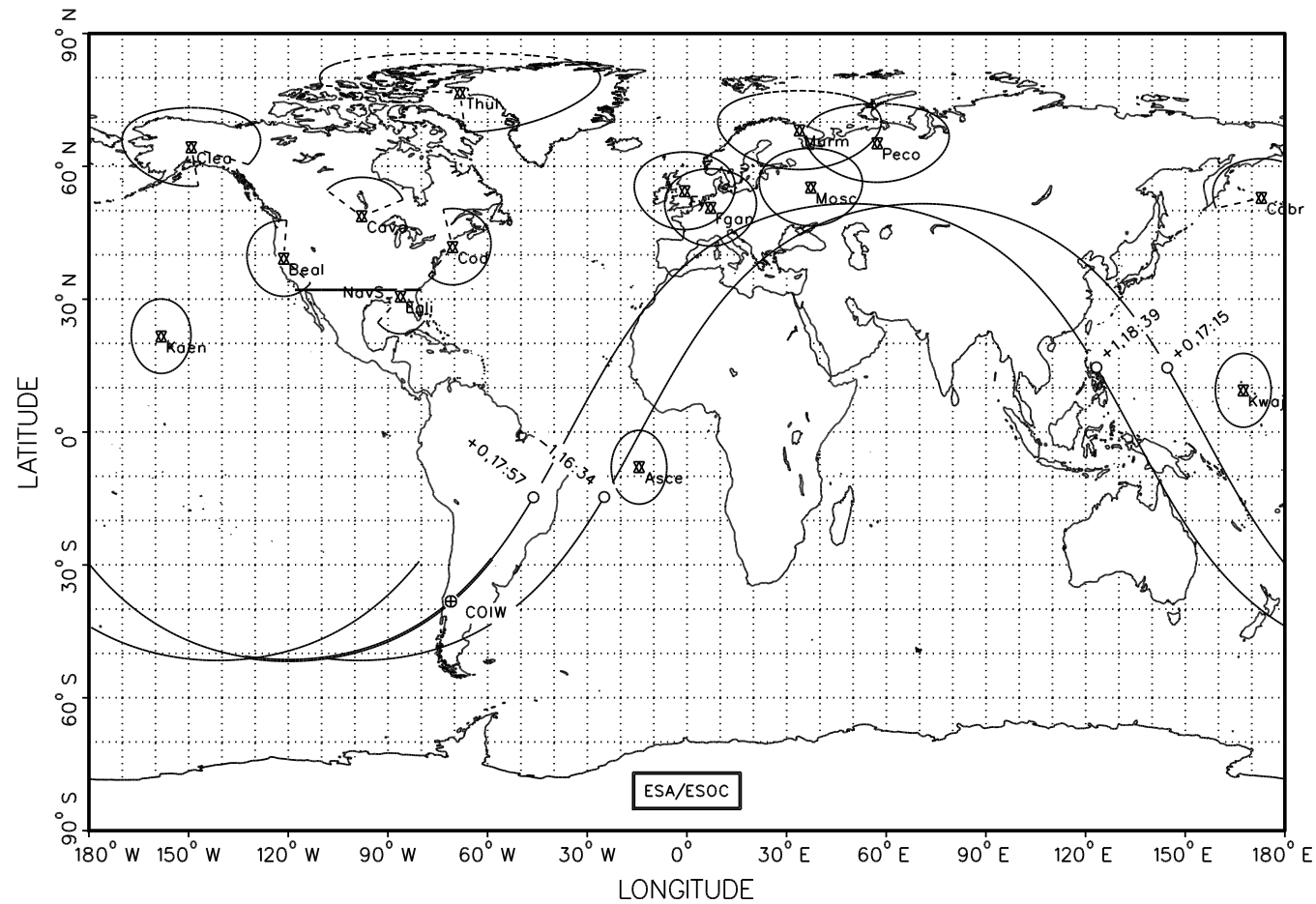
Phobos-Grunt Relative Prediction Errors (Last 48h)



Phobos-Grunt Altitude Decay



Phobos-Grunt Re-Entry Groundtrack



Concluding Remarks

- the IADC re-entry prediction test campaigns 2011-1 (UARS), 2011-2 (ROSAT) and 2012-1 (Phobos-Grunt) validated the functionality of the IADC REDB.
- UARS: the final assessment of the 80 km altitude interface pass of UARS was published by US JSpOC five days after the re-entry, on 29-Sep-2011. - Some REDB users questioned the currently applied IADC procedure for adopting the US JSpOC 80 km atmospheric interface data as reference.
- ROSAT: there was a 32-hours gap with regard to US-provided TLE data on Oct. 21/22. - This was subsequently identified by the SSN as being part of a more general problem in the data delivery chain (could then be resolved prior to the critical phase of the re-entry campaign).
- Phobos-Grunt: several users reported excessive wait times when uploading or downloading TLE data sets from the IADC REDB. - The problems were related with an excessive growth of a DB roll-back register (could be resolved by a system re-start, which was only possible after the end of the campaign).