An ESA View of the IADC

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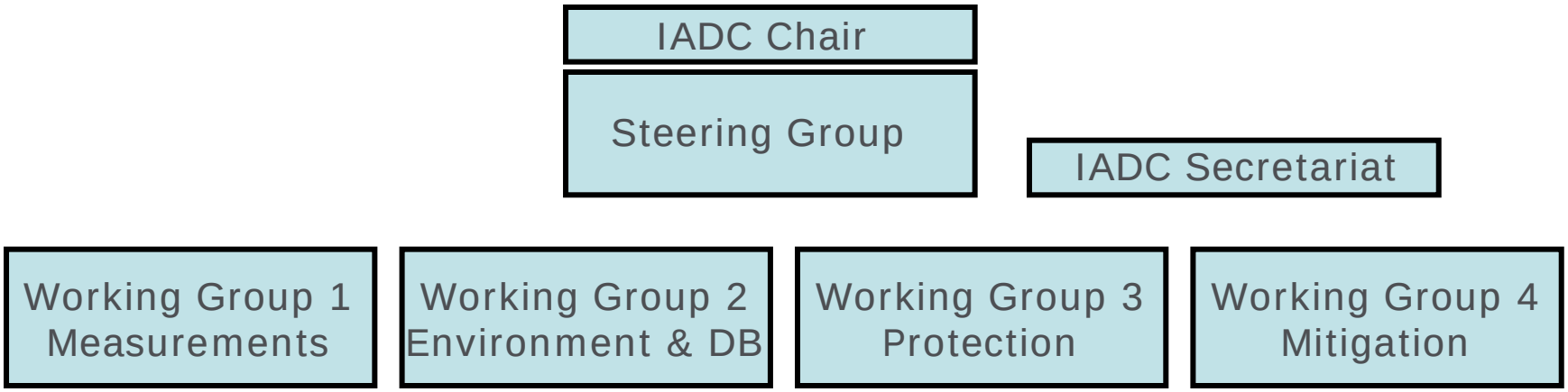
IADC Background Information

- IADC history:
  - 1989: position paper on orbital debris by the US Interagency Group Space
  - 1989: directive to NASA by the US Security Council to talk to all spacefaring nations on common steps towards space debris mitigation
  - IADC#1: bi-lateral NASA-ESA meeting at Rolleboise/France, Oct. 1987
  - IADC#9: IADC inauguration meeting with NASA, NASDA, RSA and ESA, at Darmstadt/Germany, Apr. 1993
  - IADC#29: hosted by DLR in Berlin/Germany, Apr. 2011
- IADC purpose:
  - exchange information on space debris research activities between members, to facilitate opportunities for cooperation in space debris research
  - review progress of cooperative activities
  - identify space debris mitigation options
- IADC membership:
  - ASI, CNES, CNSA, DLR, ESA, ISRO, JAXA, NASA, NSAU, ROSCOSMOS, UK Space Agency, [CSA] 

IADC Organization



- key facts:
  - members are national or international space agencies that perform space activities and actively contribute to space debris research; new members may be included upon unanimous decision
  - the work program is governed by a steering group (SG) and performed in 4 working groups (WG); membership in SG and WG 4 is mandatory
  - IADC technical meetings are held annually (SG meetings semi-annually); they are chaired by the head of delegation of the hosting member
  - the IADC Chair is the head of delegation of the hosting member; s/he is supported by a secretariat (function provided by a SG member)

IADC Terms of Reference (1)

- SG terms of reference:
  - the SG is chaired by the head of delegation of the hosting member
  - mandatory representation in the SG by all member delegations
  - acceptance of new IADC members (unanimous decision required)
  - the SG coordinates IADC WG's and may assign action items
  - the SG organizes IADC meetings, defines new work areas, and represents IADC in other organizations
- WG-1 terms of reference (measurements)
  - review research efforts in measurement techniques for space debris & meteoroids (ground- and space-based)
  - identify opportunities for cooperation (e.g. beam-park experiments)
  - serve as platform for information exchange and observation planning
- WG-2 terms of reference (environment & database)
  - review research efforts in environment modelling and related databases
  - identify opportunities for cooperation (e.g. re-entry prediction campaigns)
  - serve as means of information exchange on environment modelling

IADC Terms of Reference (2)

- WG-3 terms of reference (protection)
  - review efforts in HVI research and protection (HVI testing, hydro-code simulations, damage characterization & prediction, shield designs)
  - identify opportunities for cooperation (e.g. common test procedures)
  - serve as platform for information exchange (e.g. protection manual)
- WG-4 terms of reference (mitigation)
  - review research efforts in space debris mitigation (debris sources, mitigation & remediation techniques, collision & re-entry risk reduction)
  - identify opportunities for cooperation (e.g. IADC mitigation guidelines)
  - serve as means of information exchange on debris mitigation
- common issues:
  - SG chairs have 1 year term (with no formal deputy chair)
  - WG chairs have a 2 year term (with a prior 2 year deputy chair function); new WG deputy chairs are assigned by the SG every 2 years
  - the IADC host prepares the SG MoM and the overall MoM, based in inputs by the WG chairs

IADC Terms of Reference (3)

- annexes of the IADC Terms of Reference
  - Annex 1: criteria for membership in IADC
  - Annex 2: points of contact of IADC members
  - Annex 3: format of IADC meetings and procedures for WG's
  - Annex 4: WG chair persons and deputies
  - Annex 5: membership in IADC SG and WG's
  - Annex 6: IADC data exchange on re-entry risk objects
  - Annex 7: role of the IADC secretariat
  - Annex 8: IADC Web site (and Web master)
- case study "IADC re-entry prediction campaigns"
  - purpose: test re-entry prediction tools & procedures of IADC members for potential risk objects, at least once every year
  - procedure: test articles, agreed within the IADC SG, are selected from the US SSN Catalog and predicted/observed up to their re-entry
  - output: the SG issues a campaign summary report in a prescribed format

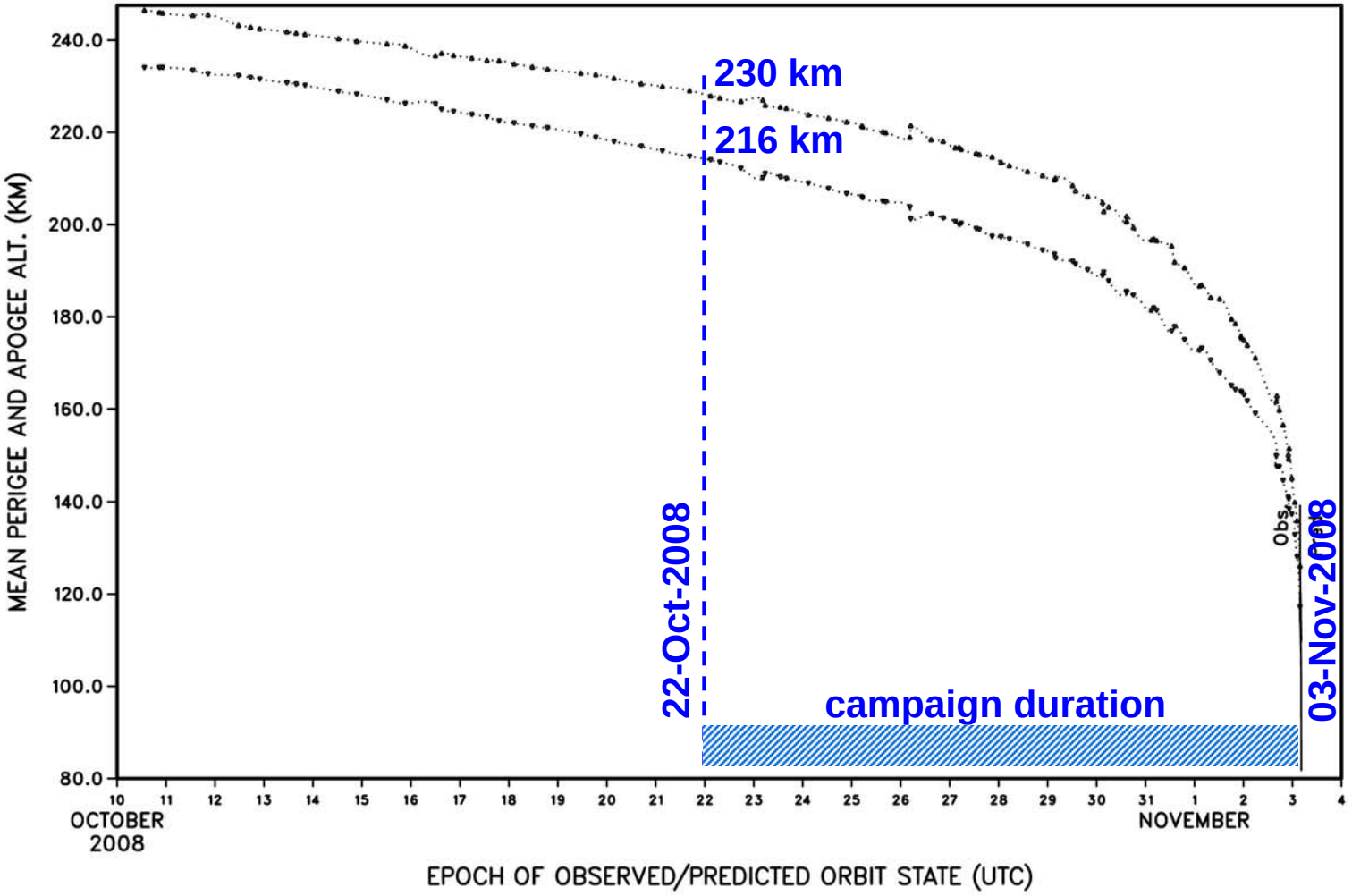
IADC Re-Entry Predictions (1)

- scope:
  - as part of their terms of reference (Annex 6), IADC fosters the exchange of data on potentially hazardous re-entry objects
- history:
  - the risk potential of re-entries was recognized at the occasion of Cosmos 954 (Jan. 1978), Skylab (July 1979), and Salyut 7 (Feb. 1991)
  - an initial, limited IADC data exchange was realized for the Cosmos 398 re-entry (Dec. 1995); a more formalized data exchange was later implemented for the re-entry of the Chinese FSW-1-5 capsule (March 1996)
  - in 1997 plans were adopted to develop a web-based IADC Re-Entry Events Database to facilitate the exchange of information on a re-entry object, on its orbit, and on its predicted re-entry time and location
- implementation:
  - the IADC Re-Entry Events Database is hosted by the European Space Operations Centre of ESA; it is operational since 1998
  - all data exchange through a Web interface of the IADC Re-Entry Events Database (⇨ orbits states and re-entry predictions)
  - opening & closing of a campaign via DBA (based on SSN/SSS re-entry data)

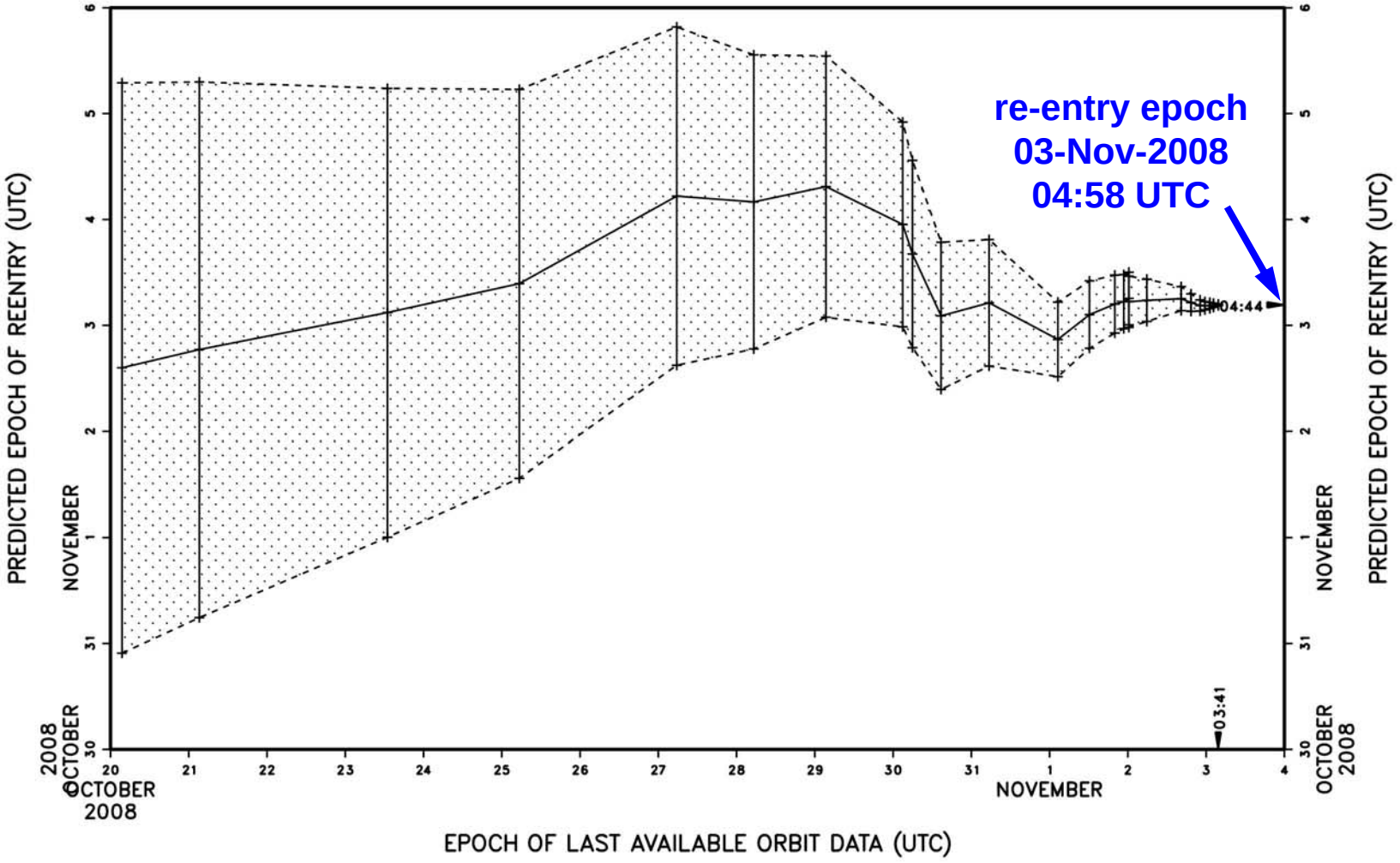
IADC Re-Entry Prediction (2)

- re-entry risk object qualification criteria:
  - the object or parts of it may survive to cause potential damage, or
  - the entry event may cause radioactive contamination
- past IADC re-entry prediction campaigns (12 in total):
  - Inspektor (D, 1998), GFZ-1 (D, 1999), Soyuz stage (RU, 2000), Vostok stage (RU, 2002), Cosmos 389 (RU, 2003), Cosmos 2332 (RU, 2005), Coronas F (RU, 2005), Cosmos 1025 (RU, 2007), Delta-2 stage (USA, 2007), EAS (USA, 2008), Molniya 3-39 (RU, 2009), Vostok stage (RU, 2010)
- IADC re-entry campaign 2008-1:
  - Early Ammonia Servicer EAS (98-067BA, #31928)
  - launched on STS-105 on Aug. 10, 2001, and installed on ISS truss P-6
  - jettisoned from ISS on July 23, 2007, during EVA
  - mass: 640 kg; dimensions: 2.5m × 1.2m × 1.7m
  - orbit at campaign start on October 22, 2008: 216 km × 230 km at 51.64° inclination

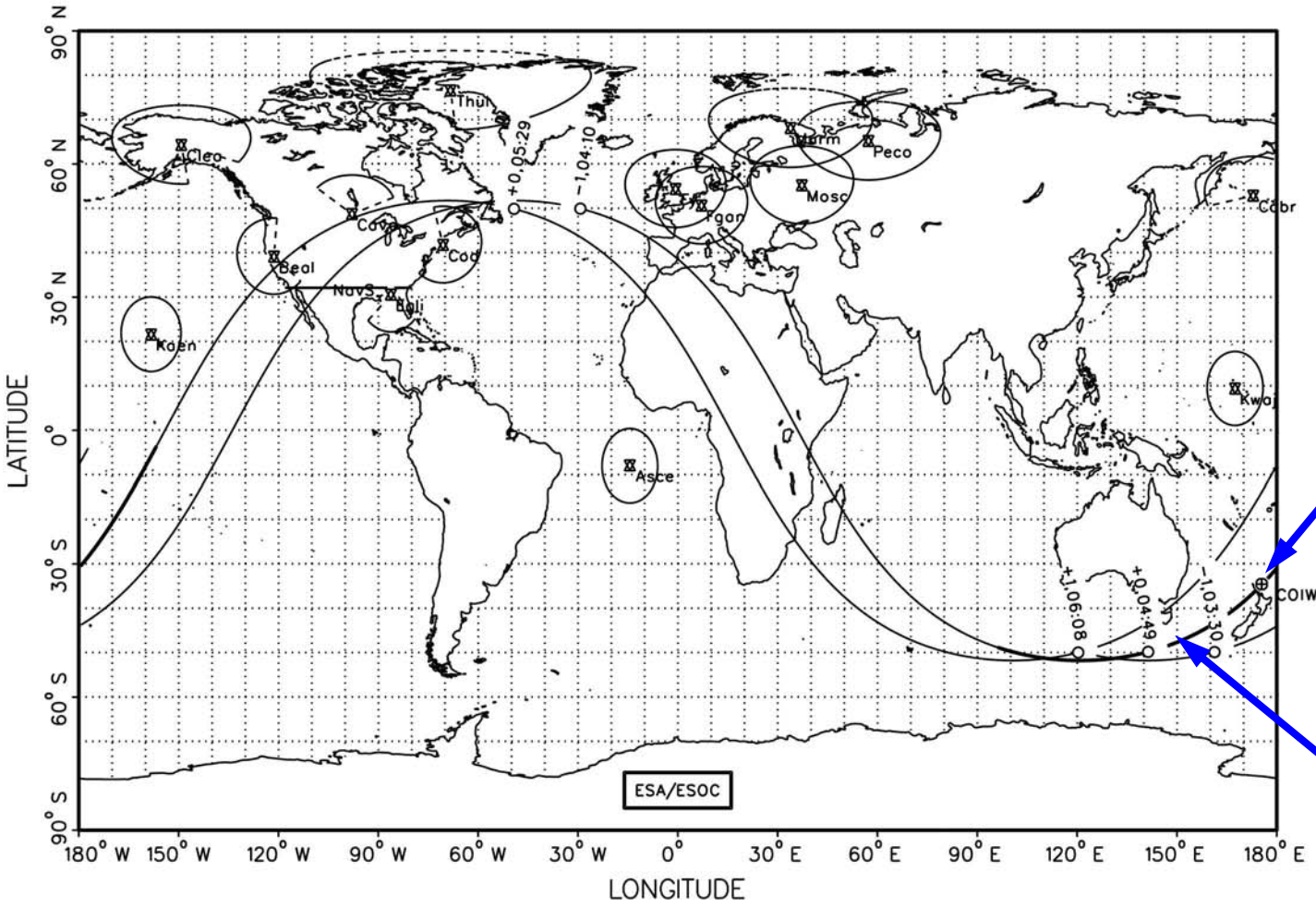
IADC Re-Entry Prediction (3)



IADC Re-Entry Prediction (4)



IADC Re-Entry Prediction (5)



"impact" location 35°S, 176°E

"80 km alt." location 48°S, 151°E

EAS Campaign Summary

	All Predictions		Last 48h Predictions	
Agency	Count	Error Δt (%)	Count	Error Δt (%)
ASI	24	5.76	11	8.53
BNSC	9	18.89	5	9.18
CNES	12	5.96	4	7.92
CNSA	20	7.35	11	4.85
DLR	16	9.06	7	6.79
ESA	20	8.50	12	7.75
ISRO	28	7.30	13	8.20
JAXA	7	4.28	-	-
NASA	7	6.51	4	6.37
ROSCOSMOS	27	5.54	13	5.30
total	170		80	

- pass of 80 km altitude interface at 04:51 UTC on Nov. 3, 2008 (SSN information)
- assessed ground impact at time 04:58 UTC, and location 35°S and 176°E
- IADC re-entry database statistics: $6^{d}13^{h}$ total log-on time of 10 IADC Members; 170 predictions and 160 orbit determinations were entered

Conclusions

- IADC has representatives of all major spacefaring nations (12 members)
- IADC is regarded as *the* international body of technical expertise on space debris mitigation and space debris environment remediation
- the „IADC debris mitgation guidelines“ influenced many national and international guidelines, requirements, and standards (e.g. UN Guidelines on Space Debris Mitigation and ISO 24113 standard)
- the Web-based IADC Re-Entry Events Database has proven to be a valuable tool for the timely exchange of technical information required to perform reliable re-entry predictions of potentially hazardous space objects
- the technically oriented terms of reference of IADC, and the high-quality technical output (e.g. „IADC protection manual“) are part of the IADC success story