



**30th Inter-Agency Debris Committee Meeting  
Montreal, Canada  
May 22-25 2012**

**WORKING GROUP 1 (Measurements) Minutes (final version)**

## **1 Attendees**

Delegation members attending the WG1 meeting:

ASI:	Chantal Cappelletti, Stelio Montebugnoli, Fabrizio Piergentili, Giuseppe Pupillo
CNES:	Patrick Ameline, Jacques Bouchard, Christophe Colliard, Olivier Fleury, Pascal Richard
CNSA:	Yiding Ping, Changyin Zhao, Zou Weiping
CSA:	William Harvey, Martin Lévesque
DLR:	Klemens Letsch
ESA:	Tim Flohrer, Thomas Schildknecht
ISRO:	None
JAXA:	Nobuo Kudoh, Toshifumi Yanagisawa
NASA:	Paul Kervin, Timothy Payne, Patrick Seitzer, Gene Stansbery
ROSCOSMOS:	Vladimir Agapov, Igor Molotov
SSAU:	Leonid Lytvynenko, Oleksandr Vereschak
UK Space Agency:	Phil Herridge

Contact details are listed in the Annex B.

For this meeting, WG1 Chair is Thomas Schildknecht (ESA) and the Deputy Chair is Fabrizio Piergentili (ASI).

## **2 Agenda**

The agenda of this meeting can be found in Annex A.



## 3 Minutes

**Day 1: Tuesday, May 22**

### **3.1 13:30 – 15:00      Session 1.1** **General**

#### **3.1.1 Update and approval of Agenda**

Presentation and update of the Agenda including the joint WG1-WG2 session with a focus on the discussion of the “data exchange format”. The Agenda is agreed by the members.

#### **3.1.2 Meeting overview & objectives; status of Action Items, Summary of SG meeting September 2010**

Report by T. Schildknecht

#### **3.1.3 Agency Status Reports**

Reports on space debris related activities in 2011/2012: all delegation gave a brief description of activities related to measurements carried out during the past year. ISRO was not represented in WG1.

### **CNES**

Radar:

- Monge radar tracking campaign
  - o Collision avoidance experiments for CNES
  - o SSA experiments for ESA
- Reentry campaigns
  - o IADC 2011 exercises : UARS, ROSAT
  - o International exchange of data : Phobos-Grunt

Optical:

- Infrared Observations
  - o Theoretical study, Tarot experiments
- Experimental catalog of GEO and GTO objects
- Image processing
  - o Project of a WG1 processing description form

Tumbling rates measurement experiments:

- Radar : Le Monge
- Optical : Tarot + amateur observations

### **CNSA**

In the past year, we did some preliminary work on photometry of rocket bodies for space debris tumbling research suggested by WG1 and we will give one presentation at this meeting.



We participated in observation and predication of IADC Re-Entry campaign three times, including UARS, ROSAT & Phobos-Grunt.

As usual, using our optical facilities, we continued to track some of rocket upper stages and disabled satellites launched by China in support of mitigation measures. Latest November we observed de-orbit activities of two GEO satellites operated by China Space Agency.

We are now upgrading our 65cm telescope for space debris research, especially the photometry of rocket bodies.

## CSA

Canadian activities on surveillance of space (SofS): Four autonomous Raven class telescopes (40cm) are operated for SofS. Two are fully operational for routinely surveillance tasks, while the two other are for research and training. They are remotely operated and completely autonomous. They are tasked during the day and they execute their programs autonomously by night. Hundreds of acquisitions can be done in a clear night by a single station. These GBOs (ground base optical) are used in support of the US/SSN catalogue maintenance.

The operation of these observatories is fully automatic from the tasking to the detection report. Starting with an observation request, the operator only has to specify the satellite ID to the GBO-control software. Using the satellite TLE, the operating program determines when and where the satellite will be visible and it generates the control command lines that are uploaded into the observatory computer. The observatory computer will timely execute these commands later, controlling the dome, telescope and camera, doing automatic acquisitions.

Once the acquisition is done, image-processing algorithm are automatically applied on the image for satellite detection and reporting. The image processing parameters are set for an automatic processing mode, i.e. for safe detection without false alarms. Even in these conditions, the sensitivity is very high and streaks are detected up to the noise level.

Basically, the processing includes:

- Accurate background estimation and removal,
- Point target detection
- Streak detection (with an iterative matched filter)
- Morphological analysis for false alarm rejection and streak unmerging.
- Algorithms auto adjust detection parameters using the noise level and optical PSF.
- Detection algorithms are developed for images acquired in sidereal tracking mode (SM), track rate mode (TRM) and uncorrected constant track rate mode sequence (UCTRM).

In addition to the GBOs, two satellites, SAPHHIRE and NEOSSat are build and ready for launch. Estimated launch date is December 2012. SAPHHIRE is fully dedicated to SofS for SSN catalogue maintenance. NEOSSat is an experimental satellite with a dual mission: 1) it is a space-based SofS test bench for acquisition method and processing testing and 2) it is also a small space-based telescope used for near-Earth asteroid detection.

## DLR

LEO Measurements campaigns

- 2006 (AI23.3): Data report provided
- 2008 (AI25.1): Data report provided
- 2010 (AI28.1): Data evaluation finished, generation of formatted data report in process



Participation in the reentry campaigns for the satellites UARS (US), ROSAT (GE) and Mars explorer Phobos Grunt (RU)

- Delivery of tracking data and orbital parameters (TLE)
- Processing and delivery of 2D ISAR images

Tracking/Imaging support during the passivation of ESA's ERS-2 satellite

- Delivery of tracking data and ISAR images

Support of ESA's ENVISAT contingency activities

Delivery of tracking data and ISAR images

- Image-based attitude estimation of ENVISAT's solar panel

Possible use of Stockert antenna system (diam. 25 m, gain 49 dB, beam width 0.6 deg) as „guard“ antenna during TIRA Beampark experiments → Identification of „Sidelobe targets“

- Development of plans and concepts for initial tests

## ESA

Optical observations

- Monthly survey campaigns
- 1-m ESA telescope at the OGS, Tenerife
  - o GEO/GTO surveys
  - o Maintenance of catalogue of high AMR GEO objects
    - Session 2.3 presentation (TS)
- Total of 37 nights in 2011
- MEO surveys completed (30 nights) → Session 2.2 (TS)
- Study on observation strategies for eccentric MEO started
- Study on hybrid CMOS detectors started
- Study on streak detection in preparation

Radar Observations

- No 24h ESA beam-park during Summer 2011
- Processing of 2010 beam-park with TIRA → DLR, data ready soon

Instrument upgrades

- OGS: New camera (acceptance testing)

Reports

- Annual GEO classification, and ESA efforts on LEO classification from TLE data
  - Session 3.1 presentation (TF)

Attitude characterisation techniques

- Lightcurves of upper stages acquired at Zimmerwald
- Envisat observations for supporting contingency resolution

SSA Preparatory Program related

- GSTP study of optical/radar data fusion for eccentric orbits, related observation strategies and sensor network architecture
- Various support activities (requirements definition, system architecture, sensor design, federation of assets)
- Council meeting Nov 2012



## **JAXA**

JAXA uses three telescopes, which are Bisei 1m, 50cm, and Nyukasayama 35cm to observe GEO, GTO and MEO space debris.

Main targets of Bisei are space objects that might approach JAXA's three operating geosynchronous satellites. We observed them for a few weeks until the time of closest approach to use the data for conjunction assessment of these satellites.

Nyukasa 35cm telescope carried out survey and chase observation to detect un-cataloged GEO objects and determine their orbits. Determined orbital elements were transferred to Bisei so that it can track them and determine further precise orbits. So far, about 30 un-cataloged GEO objects were detected and their orbits were well determined. Nyukasa 35cm telescope also carried out search observation of the breakup fragments caused by Titan 3C transtage with collaboration of Kyushu University, IHI corporation and National Central University of Taiwan. We succeeded in detecting 40 Titan3C fragments whose size range were from 25cm to 1m. Optical observation system for LEO using a 18cm telescope and the FLI 2K2K CCD camera are being developed. We confirmed orbit improvement of some TLE objects using this system.

JAXA also uses Kamisaibara active phased array radar to observe LEO space debris. Especially, we observed some reentry objects, which are one rocket body whose origin is from Japan and three targets of IADC reentry prediction campaign, those are UARS, ROSAT, and Phobos-Grunt.

To cover the large antenna prediction errors of these objects, we used the advantages of phased array radar that can observe some objects simultaneously.

We also continued to observe ALOS, which was an earth observation satellite of JAXA. Its power generation decreased and the satellite lost contact with us. Eventually, we terminated the operation of this.

## **NASA**

NASA reported on the following activities:

- Haystack/HAX/Goldstone Radars
- Analysis of returned surfaces
- Optical observations with MODEST/Magellan
- Observations of tumbling LEO objects
- Optical Measurement Center
- Meter Class Autonomous Telescope MCAT
- DARPA/Air Force Space Surveillance Telescope SST

For details we refer to the corresponding presentation.

## **SSAU**

SSAU reported on the use of the RT-70 antenna in Evpatoria for multiple purposes. In particular experiments to observe space debris in multistatic mode and the project RadioAstron were mentioned. For details see the corresponding presentation.

## **UK Space Agency**

UK Space Debris Activities - 2011/12



The UK Space Agency does not focus specifically on measurement of debris, it sees its activities being focussed towards the whole population of which debris objects form one part. As such the Agency supports debris measurement activities at the three main UK groups, RAF Fylingdales, Chilbolton Observatory and Starbrook.

At Fylingdales the main thrust of their measurement activities is in support of the US SSN catalogue maintenance.

The radar at Chilbolton is in the final phases of its present upgrade programme adding two new transmitters. The expectation is that the final commissioning of the first transmitter will be complete over the next month bringing a sensitivity improvement of ~22dB allowing debris size objects to be brought within the scope of the observatory. Installation of the second transmitter is due to start shortly. The 25m dish itself has undergone extensive refurbishment.

At the request of ESA, the radar was used to observe Envisat during attempts to re-establish control over the satellite, and will carry out observations of the docking and undocking of ATV-3 with ISS. Experiments into bistatic observations have been carried out between GRAVES and the LOFAR phased array sensor. There have been preliminary discussions on collaboration with an Italian radio astronomy group.

On the optical side, the existing Starbrook sensors have been fully engaged in monitoring UK registered objects and other activities this year. As part of an interest by the Space Agency to see the registry monitoring capability extended, Space Insight is due to install a larger aperture sensor during the coming year. This will improve the limiting brightness available to the UK Space Agency for participation in appropriately defined future studies.

The UK has started to investigate the possibility of using some of the capability in the UK University sector for space debris observations. Whilst most University observatories do not include appropriately configured telescopes there are some that may be able to play a useful role. This remains at a tentative and preliminary stage but there has been initial interest.

Once again in the coming year the most useful development may occur on the political front. The UK National Space Security Policy is due to be completed and released shortly. There have been indications that the policy will highlight the need for greater UK independent SSA capability and with that an improved ability to detect and track debris. It should be stressed that this remains conjecture, there is no immediate prospect of new funding, however a strong recommendation in the NSSP might be reflected in reallocation of existing funding into activities of interest to this working group.

### **3.1.4 Contact information**

The contact information sheet was completed by the WG1 members (see Annex B).



## **3.2 15:30 – 16:45 Session 1.2 General (continue)**

### **3.2.1 Open Action Items**

#### **Final report for AI 23.2 (Investigation of high A/m ratio debris in higher Earth orbits)**

- V. Agapov provides a status report. There is a substantial delay due to illness of the main author. A draft of the report should be circulated in WG1 by end of July and a consolidated draft be submitted to the SG for their meeting in October.

#### **AI 23.4 (International 2007 optical observation campaigns in higher Earth orbits)**

P. Seitzer gives a presentation on the status. The report stimulated a discussion on the magnitude distribution of the observed objects which was emphasizing, once again, the need of cross-calibrations. In addition the need for full orbit determinations was pointed out.

The draft report will be circulated in the WG by May 21 for comments until July 24. A revised draft shall be submitted to the SG by August 1.

#### **AI23.3, AI25.1, AI 28.1 (International 24h LEO space debris measurement campaign 2006, 2008, 2010)**

G. Stansbery reports on the status of these action items.

- The draft Final Report for the 2006 campaign (AI23.3) was submitted to SG in January 2012 (G. Stansbery, NASA)
- The draft Final Report for the 2008 campaign (AI25.1) (including a comparison with the 2008 data) is 50% complete and shall be circulated in the WG by October 2012 (G. Stansbery, NASA)
- The date for the Final Report for the 2010 campaign (AI28.1) is open due to calibration issues with the Haystack data which have to be solved before. The Tira data will be delivered within weeks (T. Flohrer, ESA)

**16:45 – 17:00 Preparation of WG1 report to SG**

**17:00 – 18:00 WG reports to SG**

**Day 2: Wednesday, May 23**

## **3.3 08:30 – 10:00 Session 2.1 Instrumentation/Observations**

Technical Presentations (electronic copies included in the IADC 30 Proceedings):

- Status of TIRA Upgrade Activities (K. Letsch, DLR)
- MCAT Update (G. Stansbery, NASA)
- Satellite Handoff from MCAT (P. Kervin, NASA)
- Study on infrared observation potential (P. Richard, CNES)



- Further results of the spectrometry observations from the Loiano 1,5 meter telescope (A. Rossi, ASI, 15min)

### **3.4 10:15 – 11:30 Session 2.2 Observations**

Technical Presentations (electronic copies included in the IADC 30 Proceedings):

- Detection and orbit determination of un-cataloged GEO objects at Nyukasa Observatory and Bisei Spaceguard Center (Toshifumi Yanagisawa, JAXA)
- Measurement accuracy for orbit determination of GEO close approaching objects (F. Piergentili, ASI)
- Optical Studies of GEO Debris with the 6.5-m Magellan Telescopes (P. Seitzer, NASA)
- Results of Optical Surveys for Space Debris in MEO (T. Schildknecht, ESA)

### **3.5 13:30 – 15:00 Session 2.3 Observations (cont.)**

Technical Presentations (electronic copies included in the IADC 30 Proceedings):

- Catalogue of high AMR GEO-like debris (T. Schildknecht, ESA)
- ISON network development in 2011-2012 (I. Molotov, Roscosmos)
- Updated Results of 8 Years of GEO Region Surveys (V. Agapov, Roscosmos)
- Photometry of Rocket bodies (Yiding Ping, CNSA)

### **3.6 15:30 – 16:45 Session 2.4 Observations (cont.)**

Technical Presentations (electronic copies included in the IADC 30 Proceedings):

- Optical tumbling rate observation experiments on LEO and GTO objects (P. Richard, CNES)

#### **Nomination of new WG1 Deputy Chair (to be submitted to SG)**

WG1 proposes P. Seitzer (NASA) as candidate for the WG1 Deputy Chair

#### **WG1/WG2 Session preparation**

An intense discussion on the data exchange format takes place with many interventions from all delegates. It seems not yet clear which kind of data could be useful for WG2. In particular RA and DEC of the objects could be not enough and misinterpreted without information on the limiting magnitude. Are light curve of objects with unknown orbits useful for WG2?



- 16:45 – 17:00 Preparation of WG1 report to SG**  
**17:00 – 18:00 WG reports to SG**  
**20:00 – 21:00 Public Lecture**

**Day 3: Thursday, May 24**

**3.7 08:30 – 10:00 Joint WG1/WG2 Session 3.1**

Technical Presentations (electronic copies included in the IADC 30 Proceedings):

- WG2: The attitude evolution of conductive objects in magnetic field (from standard radar measurements) (J.C. Dolado Pérez, CNES)
- WG2: Multi-Layer Insulation Debris from GEO Fragmentations (S. Flegel, DLR)

*AI 25.1: Data Exchange Format*

- WG2: WG1-WG2 Data Exchange Document (P. Krisko, NASA)
- WG1 Review of WG2 Proposal for (AI 25.1) Data of Interest to WG2 (T. Schildknecht, ESA)

*Other topics*

- WG1/WG2: Discuss the origin of some of the HAMR currently observed (A. Rossi ASI)
- WG1: ESA Classification of Geosynchronous Objects, Issue 14 (T Flohrer, ESA)
- WG1: The IADC re-entry database Web-frontend (T. Flohrer, ESA)
- WG1: IADC re-entry predictions campaigns For UARS, ROSAT, and Phobos-Grunt (H. Klinkrad, given by T. Flohrer, ESA)
- WG1: Search for fragments caused by breakup of Titan 3C transtage in the geostationary region (Toshifumi Yanagisawa, JAXA)
- WG1: Light curve observations of LEO objects at the innovative technology research center of JAXA (Toshifumi Yanagisawa, JAXA)

**3.8 10:15 – 11:30 Session 3.2**  
**Open Internal Tasks**

**Feedback from SG**

The steering group request WG1 to propose a second candidate for the WG1 Deputy Chair. After some discussions WG1 proposes P. Herridge (UK Space Agency) as candidate.

Technical Presentation (electronic copies included in the IADC 30 Proceedings):

- First results on comparison of GEO and HEO object brightness (V. Agapov, Roscosmos)

**IT25.2 Preparation of future High AMR campaign (V. Agapov, Roscosmos)**

The WG concluded that a future campaign should not be limited to high AMR objects and coordinated observation campaigns. IT25.2 is closed and merged with a new Internal Task IT30.2 with a wider scope to investigate “Feasible options to study high orbit population of space debris” (see Annex D)



## Conclusions from joint WG1/WG2 session (IT25.1 Data Exchange format, etc.)

Three major new topics/data types to be covered by the document were identified:

- new regions of interest to be observed
- new data type “detection list”
- new data type “light curve”

It was decided that the WG1 shall provide a consolidated response to WG2 proposing an updated data exchange document by August 2012, and that WG2 shall assess specific modeling needs concerning the light curves (all altitude regimes and object classes) by September 2012.

A new Internal Task IT30.1 to revise the document was initiated (see Annex C)

### **3.9 13:30 – 15:00 Session 3.3** **Open Internal Tasks (cont.), Future Activities**

#### **IT26.1 Preparation of new high Earth orbit campaign (P. Seitzer)**

Presentation by P. Seitzer (NASA)

The IT is closed and merged with IT30.2 due to missing arguments to perform the “classical” coordinated survey campaigns.

#### **IT 28.1 Calibration (V. Agapov, Roscosmos, T. Schildknecht, ESA)**

V. Agapov (Roscosmos) will distribute a document by September 2012 in order to prepare an AI for the IADC 2013.

#### **IT28.2 Comparison of CCD image processing approaches (P. Richard, CNES)**

A draft of the questionnaire will be uploaded to the IADC WG1 website (by May 24) for comments by the WG members until June 25. The consolidated form shall then be distributed and completed by the delegations by the end of 2012.

### **3.10 15:30 – 16:45 Session 3.4** **Open Internal Tasks (cont.), Review and Closing**

#### **IT29.1 Investigation and comparison of techniques for tumbling rate assessment of massive LEO objects (F. Piergentili, ASI, G. Stansbery NASA)**

Technical Presentations (electronic copies included in the IADC 30 Proceedings):

- NASA contribution to IT29.1 (G. Stansbery, NASA)
- Investigation and comparison of techniques for tumbling rate assessment of massive LEO objects (F. Piergentili, ASI)

The IT leaders F. Piergentili, ASI and G. Stansbery, NASA will re-iterate the list of targets and prepare a corresponding Action Item to be circulated within WG1 in August for a submission to the SG by its meeting in October.

#### **New International LEO space debris measurement campaign**

The Haystack radar will not be available throughout 2012 and BPEs with the TIRA radar will not be funded in 2012. The Initiation of a new campaign (and a corresponding Action Item) is postponed to the next IADC.



**16:45 – 17:00 Preparation of WG1 report to SG & Closing Plenary**

**17:00 – 18:00 WG reports to SG**

**19:30 – 22:00 Conference Dinner**

**Day 4: Friday, May 25**

**3.11 10:00 – 12:00 Closing Plenary**

- There were no new AIs opened and no AIs closed during this IADC (AI23.3 submitted to SG in January 2012)
- Two new Internal Tasks, IT30.1 „WG1 Review of WG2 Proposal for (AI 25.1) Data Exchange Document“, and IT30.2 “Feasible options to study the high orbit population of space debris” were opened.
- The WG1 Internal Task IT25.2 and IT26.2 were both closed (and merged with IT30.2).
- P. Herridge (UKSpace) was appointed new Deputy Chair of WG1 by the SG.
- Future Meetings:
  - 2012 SG meeting will be held in Napoli (Italy) during the IAC 2012.
  - the 31<sup>th</sup> IADC will be organized by ESA in Darmstadt in April 2013 in conjunction with the 6<sup>th</sup> European Conference on Space Debris.



## Annex A Agenda

TIME	May 22 Tuesday	May 23 Wednesday	May 24 Thursday	May 25 Friday
08:30-10:00	<b>9:00-10:00</b> Registration & Welcome Reception	<b>WG1 Session 2.1</b> Instrumentation	<b>WG1/WG2 Session 3.1</b>	
10:00-10:15	<b>10:00-11:30</b> Opening Plenary McGill Stephen Leacock Building Rm 232	Coffee Break	Coffee Break	<b>10:00-12:00</b> Closing Plenary McGill Stephen Leacock Building Rm 232
10:15-11:30		<b>WG1 Session 2.2</b> Observations	<b>WG1 Session 3.2</b> Open ITs	
11:30-13.30	Lunch	Lunch	Lunch	
13:30-15:00	<b>WG1 Session 1.1</b> General	<b>WG1 Session 2.3</b> Observations	<b>WG1 Session 3.3</b> Open Its, Future Activities	
15:00-15.30	Coffee Break	Coffee Break	Coffee Break	
15:30-17:00	<b>WG1 Session 1.2</b> Open AIs	<b>WG1 Session 2.4</b> WG1/WG2 preparation	<b>WG1 Session 3.4</b> Review and Closing	
17:00-18:00	WG1 Chair report to SG	WG1 Chair report to SG	WG1 Chair report to SG	

<b>20:00-21:00</b> Public Lecture McGill (IASL) Moot Court	<b>19:30-23:00 Dinner</b> Old Montreal
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## Annex B Attendee contact information

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## Annex C Description of Internal Task IT 30.1

Internal Task: <b>WG1 30.1</b>	Title: <b>Review of WG2 Proposal for (AI 25.1) Data Exchange Document</b>	Assignment <b>WG1</b>
<p><b>Description:</b> This task is to review the input received from WG2 on the data exchange format. It shall facilitate and coordinate the technical review within WG1. This task shall finish by preparing a consolidated WG1 response to WG2 proposing an updated data exchange document by August 2012.</p> <p><b>Coordinators:</b> T. Flohrer (ESA), P. Herridge (UKSA)</p> <p><b>History:</b> – on-going</p>		
<b>Opening date:</b> May 2012		<b>Closure date:</b>
<b>Report reference:</b>	<b>Access:</b>	



## Annex D Description of Internal Task IT 30.2

Internal Task: <b>WG1 30.2</b>	Title: <b>Feasible options to study the high orbit population of space debris</b>	Assignment <b>WG1</b>
<p><b>Description:</b> The aim of the IT is producing a WG1 internal document based on the contribution of all delegations on feasible options to study the population of objects in HEO (Molniya, GTO...) and other orbital regimes, as well as specific subgroups of space debris objects (like HAMR), with optical instruments using improved existing or newly developed observation techniques and strategies. All suggestions will be considered at the next IADC meeting in order to propose a new Action Item.</p> <p><b>Coordinators:</b> V. Agapov (Roscosmos) , F. Piergentili (ASI)</p> <p><b>History:</b> – on-going</p>		
<p><b>Opening date:</b> May 2012</p>		<p><b>Closure date:</b></p>
<p><b>Report reference:</b></p>	<p><b>Access:</b></p>	