29th Inter-Agency Debris Committee Meeting
Berlin, Germany
Apr 4-7 2011

WORKING GROUP 1 (Measurements) MINUTES

1 Attendees

Delegation members attending the WG1 meeting:

ASI:	Fabrizio Piergentili, Giuseppe Pupillo, Emma Salerno, Stelio Montebugnoli, Paolo Teofilatto, Filippo Graziani, Chantal Cappelletti, Chiara Massimiani.
CNES:	Damien Gardien, Olivier Fleury, Pascal Richard, Bruno Vidal
CNSA:	Dong Wei, Changyin Zhao
CSA:	none
DLR:	Ludger Leushacke
ESA:	Thomas Schildknecht, Tim Flohrer
ISRO:	None
JAXA:	Nobuo Kudoh
NASA:	Paul Kervin, Timothy Payne, Patrick Seitzer, Gene Stansbery
NSAU:	Pavlo Fedorov
ROSCOSMOS:	Vladimir Agapov, Nail Bakhtigaraev, Igor Molotov
UK Space Agency:	Phil Herridge

Contact details are listed in the Annex A.

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

2 Minutes

Day 1: Monday, April 11

2.1 11:30 – 12:30 Session 1.1 General

2.1.1 Update and approval of Agenda

Description and updating of the Agenda; the topic “tumbling rate of LEO objects” is added for discussion in the joint WG1-WG4 session. The modified Agenda is agreed by the members.

2.1.2 Meeting overview & objectives; status of Action Items, Summary of SG meeting September 2010

Report by T. Schildknecht

2.1.3 Agency Status Reports

Reports on space debris related activities in 2010/2011: all delegation gave a brief description of activities related to measurements carried out during the passed year. CSA and ISRO were not represented in WG1.

ASI

CNES

Studies and development:

- First step of a study on infrared observation, satellite observations will be done on 2011
- First step of a study to determine what can be done by a telescope network to improve LEO orbits in case of collision risk.
- Telescope simulator development
- Tarot data ground segment improvement (request scheduling, data processing speed, adaptation for LEO observation)

Observations:

- Daily observations for CDAOA
- Daily update of our GEO and MEO satellites catalogue (not operational)

CNSA

We finished data analysis work on our observations for AI23.4, and we have sent our brief report to the AI leader. We also participated in observation and predication of IADC Re-Entry campaign 2010-1.

As usual, using our optical facilities, we continued to observe some new launch upper stages by China in supporting mitigation measures. We began to observe some operational space debris in GEO region, such as apogee motor.

We plan to start space debris photometry project on our 65 cm telescope, and we will give a short presentation about this in this meeting.

ESA

The report on ESA activities during 2010 covers optical and radar observations, instrument upgrades and activities related to the SSA preparatory program. Monthly optical survey campaigns using the 1-m ESA telescope at the OGS, Tenerife, are ongoing with observations carried out 10-12 nights around every New Moon. The main focus of the optical observations is on continuing GEO/GTO surveys, and on maintaining a catalogue of high AMR GEO objects. The telescope was used for a total of 60 nights in 2010. A highly successful spectroscopy study using the OGS installation was completed in 2010. ESA ran 2 parallel studies on defining and experimentally validating surveying approached of the MEO region. Those studies included the use of 30 nights each of the Zimmerwald and Starbrook sensors. Concerning radar observations a 24h campaign was carried out in 2010. The next 24h ESA beam-park is provisionally planned for summer 2011 with EISCAT involvement. Instrument upgrades are ongoing at the OGS. A new telescope control subsystem became operational in July 2010, and tests of the new camera are ongoing. A design study of optical sensor network architecture and related observation strategies, which is related to ESA's SSA preparatory program finished recently. Relevant for WG1 are various support activities for the SSA PP, which include tasks on requirements definition, system architecture, sensor design, and the federation of European assets.

JAXA

JAXA uses three telescopes to observe GEO, GTO and MEO space debris.

1. Bisei 1m
2. Bisei 50cm
3. Nyukasayama 35cm

Main target (@Bisei):

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 evaluate the accuracy of their conjunction assessment.

Dr. Yanagisawa's team improved the method to detect faint GEO space debris. He shortened the processing time of observation data using FPGA board.

JAXA also uses Kamisaibara active phased array radar to observe LEO space debris. Especially, we observed some reentry objects.

1. Rocket body whose origin is from Japan
2. The target of IADC reentry prediction campaign

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

NASA

- NASA's workhorse sensor for debris measurements for objects smaller than the US Space Surveillance Network (SSN) can detect, the Haystack radar, was unavailable this year due to the upgrade of its antenna to accommodate operation at W-band (~95 GHz).
- The Haystack Auxiliary Radar (HAX) continued to collect data as normal. ~1000 hrs were collected.
- The Michigan Orbital Debris Survey Telescope (MODEST) made 5 data collection runs totaling about 30 nights. All the runs used the new CCD camera. This new 4K x 4K camera has 1.4 arcsec pixels, improves the field-of-view of the telescope from 1.3° to 1.6° square and improves the readout time from 33 secs to 13 secs.
- For the first time, NASA and U. Michigan collected 9.5 hrs of data on the 6.5m Magellan telescope in Chile.
- Data was also collected on the 1.8m Pan-STARRS telescope in Hawaii.
- Examination of the Wide Field Planetary Camera (WFPC) 2 from the Hubble Telescope was completed. However attempts to core some of the craters to determine the material composition of the impactors continues.
- Basic research on shape & material composition of debris continues at a low level.

UK Space Agency

UK Space Agency Debris Activities 2010-11

As the head of the UK delegation said during the Opening Plenary the most important activities by the UK during the last year took place at the political level. On 1st April 2011, after a year in preparation, the new UK Space Agency was formally made an Executive Agency, giving the Agency its own budget. The new government has signalled its support for UK space activities with additional funding announced in the 2011 Budget Statement, in contrast to very many deep cuts in other areas of UK government spending. The new Agency has stated that it remains committed to being active in debris studies.

On the same day as the formation of the UK Space Agency, a new International Space Innovation Centre (ISIC) was also formed (again after a year in preparation) to act as a hub to stimulate space- related activities. Part of the ISIC is a Security and Resilience Unit (SRU) responsible, amongst other issues, for ensuring safe access to space. The SRU recognises that space debris and space situational awareness play a critical underpinning role in all space activities.

Because of their small aperture Space Insight's Starbrook sensors are poorly suited to make a useful contribution for the search for small debris. However, as in past years, they have been used to test possible strategies for debris searches. During the last year the sensors have been used in two studies for ESA (into MEO and Upper LEO survey strategies). The Starbrook sensors have also been used in the ESA preparatory programme looking into how observations from multiple disparate sensors can fused to provide an SSA service.

The 25m dish radar at the Chilbolton Meteorological Observatory has also been involved in supplying data to the ESA preparatory programme. The ESA campaign was the first time in over 10 years that the radar has been used for observation of space resident objects.

For its contribution to the programme the radar used its L-band transmitter to look at a selection of LEO objects with sizes down to ~ 0.5 m2 and ranges from ~500 to 3000 km. The Observatory has recently taken delivery of a more powerful transmitter with which it hopes to participate further in future debris studies and re-entry campaigns.

2.1.4 Contact information

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

2.2 13:30 – 15:00 Session 1.2 General (continue)

Continuation of Agency Status Reports

NSAU

ROSCOSMOS

2.2.1 New objectives for the IADC

T. Schildknecht presents the CNES initiative for “new objectives for the IADC”.

In an open discussion on new objectives of the IADC WG-1 the following points were addressed:

- WG1 should make its work and in particular the usage of observation data more transparent to the SG and the other WGs
- WG1 work essential in identifying sources of debris (long term sustainability in high-altitude orbits)
- the conclusions of observational studies, e.g. the identification of debris sources, should be stated clearly in order to facilitate mitigation or protection measures.
- observation performed under the umbrella of WG 1 require expensive facilities, new activities usually require that existing ones have to be stopped (be taken into account when “tasking” WG1)
- the delegations (agencies) should foresee budget lines to support IADC observation activities
- the WG looking forward to ideas from other WG/SG (e.g. tumbling rates of LEO objects)
- public outreach activities of IADC are proposed

2.2.2 Open Action Items

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

Fabrizio Piergentili gave a presentation on the status. Reports from 5 delegations are available (9 delegations were acquiring data).

It is decided to close the draft report by the end of the week (including only the reports that will be included by that time) and to circulate the draft within the WG.

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

- The Final Report for the 2006 campaign shall be completed by mid of May 2011 (G. Stansbery, NASA)
- The Final Report for the 2008 campaign (including a comparison with the 2008 data) shall be completed by June 2011 (G. Stansbery, NASA)
- The date for the Final Report for the 2008 campaign is to be defined (T. Flohrer, ESA)

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

- NASA, ESA, ROSCOSMOS delegations participated, data from 2 delegations received
- draft by the end of this week to be circulated in WG1

2.3 15:30 – 16:45 Session 1.3 Instrumentation

Technical Presentations (electronic copies included in the IADC 28 Proceedings):

- PMO's Project of Space Debris Photometry with 65cm Telescope (Zhao, Changyin and Dong Wei, CNSA)
- Plans for the Meter Class Autonomous Telescope and Potential Coordinated Measurements With Kwajalein Radars (G. Stansbery, NASA)
- New dedicated observation facilities for near-Earth space monitoring (I. Molotov, Roscosmos)
- Initial Comparison of the 2006 and 2008 IADC 24 hour LEO Campaigns (G. Stansbery, NASA)

Day 2: Tuesday, April 12

2.4 09:00 – 10:30 Session 2.1 Instrumentation/Observations

Technical Presentations (electronic copies included in the IADC 28 Proceedings):

- Design and Integration of the HUSIR Antenna (G. Stansbery, NASA)
- Results from a three-year ASI-INAF campaign of Space Debris radar observations (Giuseppe Pupillo, ASI)
- The 2010 LEO debris campaign - TIRA results (L. Leushacke, DLR)
- Radar with digital array for detection of space debris (Pavlo Fedorov, NSAU)
- LEO optical observation (B. Vidal, CNES)

2.5 11:00 – 12:30 Session 2.2 Observations

Technical Presentations (electronic copies included in the IADC 28 Proceedings):

- University of Bologna activities for space debris measurements (F. Piergentili, ASI)
- The Implementation of the Italian Space Debris Activities at University of Rome (C. Cappelletti, ASI)
- A New Search for Optically Faint GEO Debris (P. Seitzer, NASA)
- Results of a statistical MEO survey (T. Schildknecht, ESA)

2.6 13:30 – 15:00 Session 2.3 Observations (cont.)

Technical Presentations (electronic copies included in the IADC 28 Proceedings):

- Automation of development of GEO and HEO region survey strategies - implementation for faint space debris surveys (V. Agapov, Roscosmos)
- Photometry and spectroscopy of GEO objects with the Loiano 1.5 m telescope (A. Rossi, F. Piergentili, ASI)
- Physical characterization of high AMR debris by optical reflectance spectrometry (T. Schildknecht, ESA)
- Collaborative ESA/NASA spectroscopic and multi-color observations of HAMR objects (T. Schildknecht, ESA, P. Seitzer, NASA)

2.7 15:30 – 16:45 Session 2.4 Observations (cont.)

Technical Presentations (electronic copies included in the IADC 28 Proceedings):

- High area-to-mass GEO-like and HEO objects - updated results of research (V. Agapov, Roscosmos)
- High Area to Mass Ration Satellites (T. Payne, NASA)
- ESA classification of geosynchronous objects (T. Flohrer, ESA)

2.8 WG1/WG2 Session preparation

2.8.1 IT25.1 Data Exchange format

- The IT is put “on hold” waiting for input from WG2.
- What data is most required by WG2 (taking into account the limited resources of WG1)? The data format is a secondary issue.
- Maybe the current data exchange format is ready to be used?

2.8.2 Issues to be discussed with WG2

- Observations of potential targets for Active Debris Removal (ADR): estimation of tumbling rates of massive LEO objects; what are the most important targets?
- HAMR objects: explanation for unexpected semimajor axes?
- Ask WG2 how the data collected by WG1 is used.

Day 3: Wednesday, April 13

2.9 09:00 – 10:30 Joint WG1/WG2 Session 3.1

2.9.1 Various topics

Technical Presentations (electronic copies included in the IADC 28 Proceedings) and discussions:

- Light curve observations of large/massive rocket bodies and spacecraft in LEO (J.-C. Liou, NASA)

Models show that ADR is required to stabilize the environment in some LEO regions. In order to devise capture techniques, the tumbling rates and rate changes of potential target objects need to be analyzed. There are currently more than 100 candidate objects, mostly large rocket bodies. NASA will provide a list of candidates.

- Orbit determination and catalogue building in GEO and LEO (Rossi, ASI)

A tracklet correlation and orbit determination techniques based on so-called “attributables” and “admissible regions” was presented (the technique is used by the NEO community). The technique works best when the observation strategy is optimized for the orbit determination technique. A second part was devoted to LEO catalogue build-up using wide-field fly-eye telescopes.

- High area-to-mass GEO-like and HEO objects - updated results of research (V. Agapov, Roscosmos)

WG1 asks WG2 to establish a study on a specific set of objects identified as possible sources of HAMR objects.

WG2 established a new internal task (IT29.2) with the objective to identify sources of HAMR objects starting from elements and AMR provided by WG1.

2.9.2 IT25.1 Data Exchange format

There is no presentation from WG2 on this topic and it was decided to postpone the discussion to the IADC. NASA will take the lead to propose a format.

2.10 11:00 – 12:15 Session 3.2 Open Internal Tasks

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

- IT25.1: The IT is put “on hold” waiting for input from WG2 until next IADC; the format should include light curve observations (new type of observations).
- Discussion on the identification of tumbling rates of massive LEO objects.

A new Internal Task (IT 29.1, see Annex B) is formulated. The IT is intended as preparatory work for a new Action Item to be established at the next IADC.

The first step consists in collecting existing information on tumbling rates by analyzing in particular the extensive database of visual amateur observations of LEO objects, and identifying necessary observations to complement this information in an optimum way.

The working group will investigate its capabilities and gaps to contribute to the acquisition of radar and optical signatures of the objects of interest. The activity shall estimate the resources necessary to collect and analyze the signatures.

Coordinators: F. Piergentili (ASI), Gene Stansbery (NASA)

The following delegations intend to participate:

- ASI, University of Bologna and Medicina for optical/radar joint observation
- CNSA and CNES (radar and optical) will check availability of their facilities
- DLR radar observation
- ESA (optical) tbc
- NASA
- ROSCOSMOS will check the amateurs database for historical data

2.10.2 IT25.2 Preparation of future High AMR campaign (V. Agapov)

(Electronic copy of presentation included in the IADC 28 Proceedings.)

The real quantity and distribution of these objects is still widely unknown. The following key issues were identified: a) the observations should concentrate on objects with AMR>10m^2/kg, and b) surveys should focus on regions with the highest density of trajectories in inertial space. The latter requires the development of corresponding survey strategies.

Day 4: Thursday, April 14

2.11 09:00 – 10:30 Session 4.1
Open Internal Tasks (cont.)

2.11.1 IT26.1 Preparation of new high Earth orbit campaign (P. Seitzer, NASA)

(Electronic copy of presentation included in the IADC 28 Proceedings.)

There is very little need for a new GEO campaign at this time. It is proposed to organize a GEO campaign every 2-3 years to monitor changes in the environment. A new Action Item for a 2012 campaign could be established at the next IADC.

The possibility to merge this IT with other ITs (25.2) was discussed.

2.11.2 IT 28.2: Comparison of CCD image processing approaches

(Electronic copy of presentations included in the IADC 28 Proceedings.)

- IT 28.2: Some results of the internal task on the software and algorithms comparison for satellites and space debris search on astronomical images (C. Massimiani, ASI)

ASI, CNES and JAXA software were compared in terms of sensitivity, response time and flexibility. It became obvious that the different image analysis techniques require the observation scenarios to be designed accordingly.

- IT28.2 Comparison of CCD image processing approaches (B. Vidal CNES, 20min)

It is decided to proceed with the IT by preparing a questionnaire for every group.

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

(Electronic copy of presentation included in the IADC 28 Proceedings.)

Different tapes of biases may occur in astrometric positions. Most common are epoch registration biases, which may be identified and accounted for by observing calibration objects with precisely known orbits. A list of objects to be observed to calibrate observation from every delegation will by provided by ROSCOSMOS.

2.12 11:00 – 12:30 Session 4.2 Joint WG1/WG4 session

(Electronic copy of presentations included in the IADC 28 Proceedings.)

- Proposal for a WG1 action on Space Debris movement observation, as input for Active Debris Removal studies (Ch. Bonnal, CNES, 15min)

Theoretical studies on the attitude motion of large rocket bodies were performed, but data on real attitude motions is largely lacking. Although some amateur data exists a need for professional observations was identified.

The presentation was followed by a further discussion of the new IT29.1 “Investigation and comparison of techniques for tumbling rate assessment of massive LEO objects” (see Annex B). It was suggested to start observations with a reference/calibration object.

2.13 13:30 – 14:45 Session 4.3 Review and Closing

- 2012 LEO radar campaign: a new Action Item shall be prepared to be forwarded to the Steering Group for approval at the Cape Town meeting.
- Future Role of WG1:
  Observations should also be compared with models rather than only with other observations.
- IT26.1: All delegations are in favour of concentrating on the MEO region as a next step.

2.14 15:30 – 17:00 Closing Plenary

- There were no new AIs opened and no AIs closed during this IADC
- New WG1 Internal Task IT29.1 Investigation and comparison of techniques for tumbling rate assessment of massive LEO objects
- Future Meetings:
  - 2011 SG meeting will be held in Cape Town (South Africa) during the IAC 2011
  - the 30th IADC will be by CSA in Montreal in May 2012

Annex A Attendee contact information

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Annex B Description of Internal Task IT 29.1

Internal Task:	Title:	Assignment
WG1 29.1	**Investigation and comparison of techniques for tumbling rate assessment of massive LEO objects**	**WG1**

Description:

Considerable interest among the steering group and several working groups has been expressed to characterize the attitude stability of non-functional candidate objects for active debris removal (ADR).

A list of typical targets, relevant for ADR, will be provided to WG1 by WG2. The current list contains on the order of 500 objects. The list will be distributed among the WG1 members.

It is a challenging multi-year task to identify, test, and compare potential observation techniques and strategies to obtain optical and radar signatures of the objects of interest enabling to derive tumbling rates and possibly rate changes. Different optical and radar techniques will have to be investigated.

The first step consists in collecting existing information on tumbling rates by analyzing in particular the extensive database of visual amateur observations of LEO objects, and identifying necessary observations to complement this information in an optimum way.

The working group will investigate its capabilities and gaps to contribute to the acquisition of radar and optical signatures of the objects of interest. The activity shall estimate the resources necessary to collect and analyze the signatures.

Coordinators: F. Piergentili (ASI), G. Stansbery (NASA)

History:

– on-going

Opening date:		Closure date:
April 2011		
Report reference:	**Access:**	