# Synthesis of the

# 3rd European Workshop on Debris Modeling and Remediation
# Paris, 16 to 18 June 2014

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*IAA Space Debris Committee*
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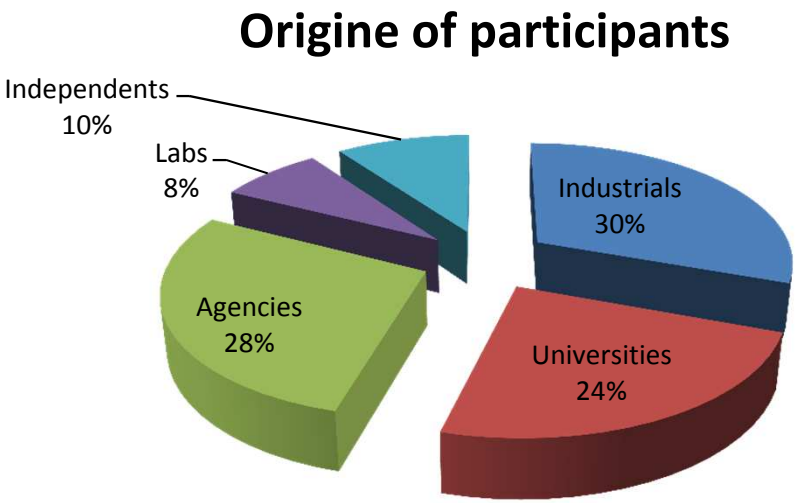
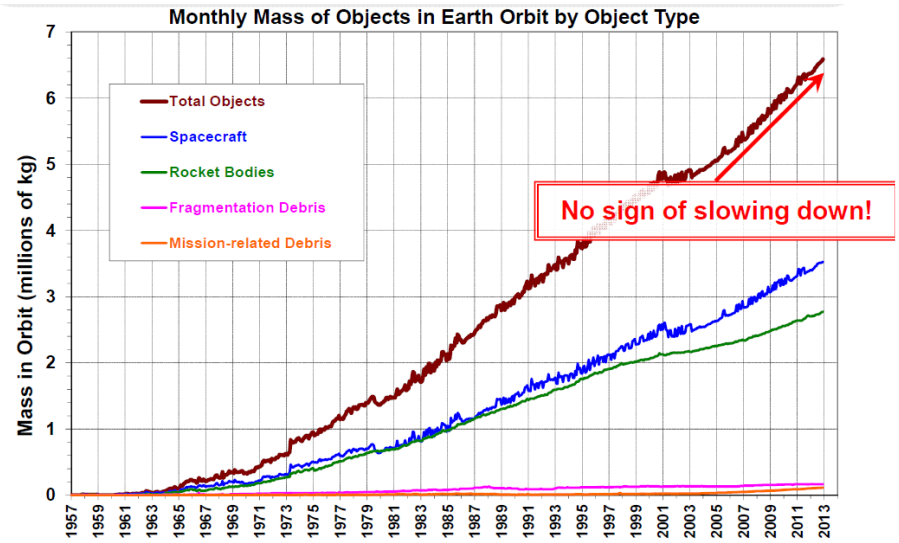
# 3rd European Workshop on Debris Modeling and Remediation

- **Workshop over 2.5 days, held in CNES-HQ, Paris:**
  - Program Committee: NASA, JAXA, Roscosmos, DLR, CNES
  - 131 participants coming from 15 countries (inc. Korea, Ukraine, Russia, Singapore…)
  - Good distribution among industrials – labs – agencies - academics + 13 independents
  - 56 interventions:  46 oral presentations + 10 posters
  - Proceedings available, of course, just ask…
- **2 new thematic compared to previous editions 2010 and 2012**
  - Modeling: understanding of differences between models
  - Small debris: laser cleaning




# 3rd European Workshop on Debris Modeling and Remediation

## Theme #1: Modeling




- Status by J.C. Liou (NASA)
  - Increase of mass in orbit
  - Critical domains: $\phi$ 5 to 10 mm, and > 10 cm
  - Justification of the modeling hypotheses
  - Discussions concerning presentation of results
- MEDEE by B.Revelin (CNES)
  - Sensitivity of parameters:
    - Fragmentation model
    - Solar activity
    - Compliance to EOL measures
  - Additional activities are require prior to conclusion
- Selection of debris to retrieve by M. Zemoura from University of Kyushu
  - 3 scenario of debris retrieval
  - Results often surprising (Monte Carlo effect?)
- Revue of uncertainties by C. Pardini from University of Pisa
  - Critical analysis of the energy threshold leading to “catastrophic collision”
  - Analysis of the collision model, of traffic model, end of life rules, solar activity…
- Detailed analysis of atmospheric modeling by L. Deleflie IMCCE (+ CNES)
  - Critical comparison of the various models with applications
- Comparison of evolution models by J. Beck from University of Southampton
  - Robustness of results as a function of simulation date

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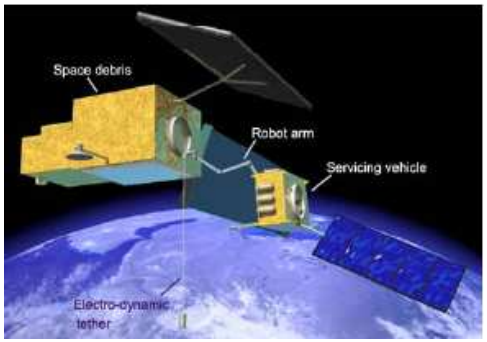
## Theme #2: High-level system considerations

- Synthesis of the ADR actions led in CNES by M.C. Desjean (CNES)
  - Revue of internal, industrial and academic studies these last years
  - Synthetic presentation of the results from Airbus DS and TAS + sub-co
  - Identification of technologies to be analyzed, precautionary principle
- Status of the e.Deorbit project by T. Soares (ESA)
  - Slice #4 of the Cleanspace initiative (15 à 20 M€)
  - Collection of multi-purpose technologies (satellite servicing, repair, orbital operations) enabling the potential deorbiting of Envisat by 2021
  - Two main system options: net or tentacles capture
  - Numerous complementary tasks (15 contracts in parallel?)



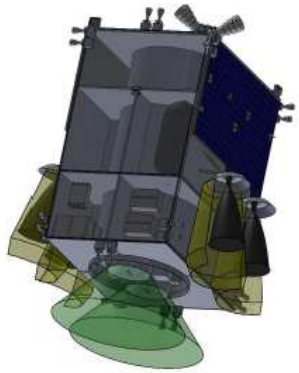

- Status of the Japanese activities by S. Kawamoto (JAXA)
  - Description of a reference scenario based on Electro Dynamic Tether
  - Details relative to non-cooperative rendezvous
  - EDT demonstration (700 m) during the HTV 6 mission
  - Debris retrieval demonstration planned by 2018
- Revue of “debris remediation activities” in Airbus by A. Pisseloup (ADS)
  - Identification of a potential market and commercial service
  - Numerous contracts from ESA, EU, CNES, DLR
- Description of the RemoveDEBRIS demonstrator by J. Forshaw Surrey Space Center
  - Developed in the frame of EU FP7 program (7 + 6 M€, 9 partners)
  - Numerous ambitious demonstrations at sub-system level (net, harpoon, sail, vision…)
- Concept proposal by US VisSidus start-up, B.Udrea
  - Chaser derived from the RS-34 from PeaceKeeper
  - Very complete presentation, but no Business Plan

## Theme #3: Selection of debris for Active Debris Removal

- Selection of target for deorbiting by A. Lidtke (University of Southampton)
  - Original approach with evaluation of sensitivities under ESA contract
- Selection of targets y N. Bérend (ONERA)
  - Original methodology and tools by Pareto front, under CNES contract
  - Numerous practical applications
- Selection of targets by A. Rossi (University of Bologna)
  - Proposal of an “index” identifying the interest to deorbit a given target
  - EU and ESA contracts
- Global mission analysis by E. Joffre (Airbus DS)
  - Numerous selection algorithms
  - Identification of global needs, mainly propulsive
- Classification of objects function of their ADR interest by N. Sanchez-Ortiz (Deimos)
  - ESA contract : DRAMA use
- System approaches to deorbit large debris by A. Kaliapin (Yuzhnoye, Ukraine)
  - Description of several solutions often original
  - Proposal to use existing Ukrainan stages

## Theme #4: Design

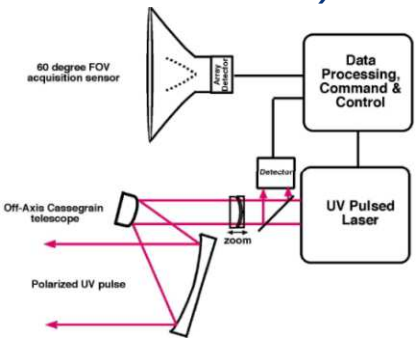
- Solutions proposed by Thales Alenia Space C. Billot (TAS)
  - ESA Cleanspace contract; phase A ongoing
  - Description of the complete trade-off following all mission phases
- System feasibility by J. Forshaw (Surrey Space Center)
  - ESA Cleanspace contract with 5 partners
  - Complete system trade-off and description of 2 potential systems
  - Identification of key-technologies and associated risks
- Envisat deorbiting byCranfield University students McLeod-Nolan
  - Nice complete system approach, with identification of risks
- Proposal of a Solid Propulsion based deorbiting kit by start-up D–Orbit S. Antonetti
  - Very complete description
  - Numerous open points
- Inflatable deorbiting system by B. Rasse (Airbus DS)
  - CNES contract for application on satellite Microscope
  - Very complete qualification status
  - Identification of future improvements for application to other missions



## Theme #5: Laser Orbital Removal

- Conclusions of the EU Cleanspace project by C. Jacquelard (CILAS + Airbus DS + DLR)
  - Deorbiting of small debris ≈ 1 cm by laser ablation
  - EU FP7 contract (9 partners, not to be confused with ESA Cleanspace)
  - Ground system: large telescope, large laser
  - Very complete description with some surprising videos
- Space based laser by C. Phipps (Photonics, US)
  - Follow-up of NASA Orion contract (ground based, 1996 – 2008)
  - Detection over a very large field, then laser 355 nm, 50 Hz, 380 J par pulse 100 ps
  - Very promising and surprising performances
  - Possibility to lower Envisat by 40 km; usable to reduce the risk of “major” collisions
  - Identification of key technologies and associated risks
- Space based laser proposed by University of Stuttgart + Airbus DS M. Schmitz
  - System approach to determine the target population
  - 1064 nm, 1 kHz, Pulse 372 J, 10 ns
  - Surprising and very promising performances
- Two Posters on the same thematics

⇨ Potentially promising subject, to be looked at in more depth



## Theme #6: Technologies

- Presentation of rendezvous technologies by J. Guo (University of Delft)
- Design of an innovating net by C. Dupont (Bertin Technologies)
- Use of an existing stage for ADR by E. Esther (NASA MSFC)
  - Concept based on RS-34
  - Probably studied in the frame of Hubble ST deorbiting
- Robotic solutions proposed by G. Hausmann (Kayser-Threde)
  - 3 concepts proposed to deorbit Envisat; ESA contract
  - Tentative de Business Plan proposal
- Original interface concept by G. Palmerini (University of Roma)
- ADR technologies demonstrator by M. Richard (EPFL)
  - ESA Cleanspace contract, 10 partners

- Technologies for ADR by A. Chiesa (Aviospace)
  - ESA Cleanspace contract, 10 partners
- Hybrid propulsion for deorbiting by F. Maggi (University of Milano + 7 partners)
- Russian proposal to deorbit upper stages by V. Trushliakov (Roscosmos)
- Ion beam shepherd technology b J. Cano (Deimos + 4 partners)
  - 50 M€ demonstration identified by ESA



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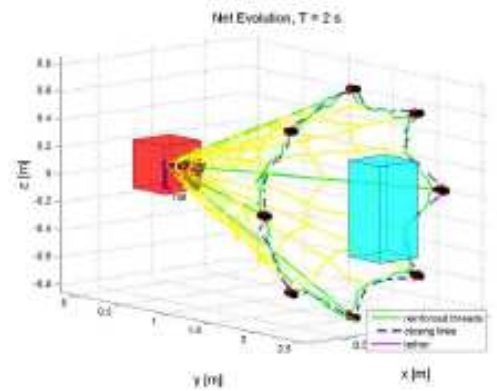
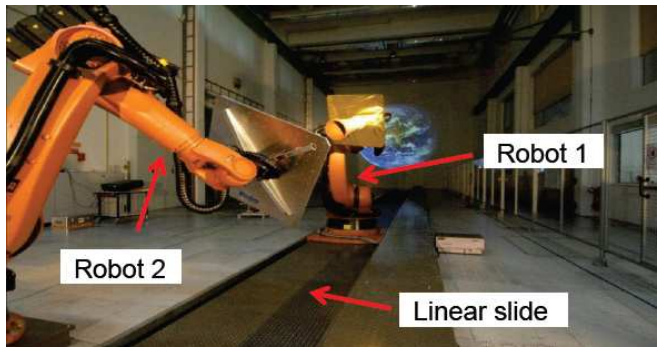
## Theme #7: GNC

- Controllability of the chaser + tether + debris assembly by V. Aslanov (University of Samara)
  - Very complete and mathematically advanced
  - Inclusion of solar panels and residual propellants
  - Identification of the main stability parameters
- Very complete modeling of the chaser + net + tether + debris assembly by M. Lavagna (University of Milano)
  - Detailed study of the interfacing and deorbiting phases
  - Analysis of the despin of the debris by ion beam

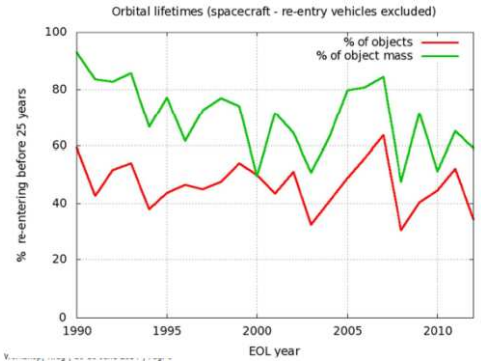


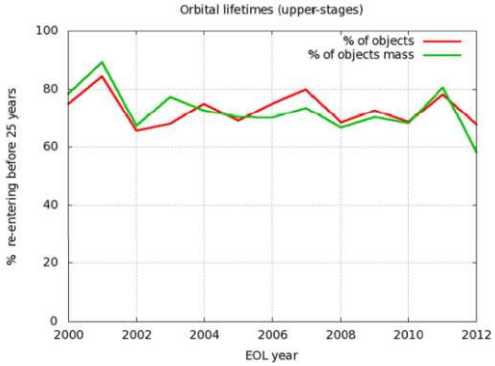
- Exhaustive review of the DLR robotic activities by R. Lampariello (DLR)
  - Simulations + experimental validations
  - Very significant test means
  - Status of the DEOS program
  - e.Deorbit contract for ESA

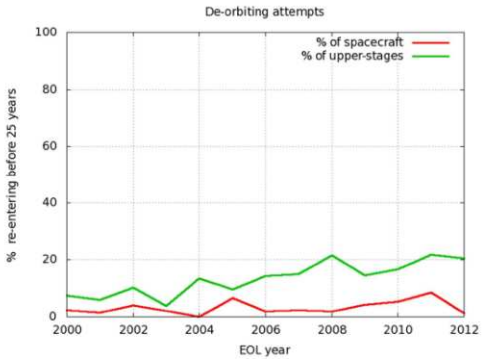



- Very complete presentation of the GMV test means by G. Binet (GMV)
  - Simulation platform in Madrid
  - Android project under ESA contract to capture Proba-V
  - Cobra-Irides project under ESA contract for Prisma-Picard rendezvous, with CNES

- **Theme #8: Policy, Economic, and Legal Aspects of Orbital Debris Removal**
  - Very complete presentation of the current compliance to mitigation rules, by H. Krag (ESOC)
    - 40% satellites and 70% upper-stages comply, with an objective > 90%
    - No trend for improvement
    - 20% upper stages and ≈ 0% satellites attempt a lifetime reduction maneuver at end of life




  - Original economical approach by HP. Schaub (University of Colorado)
  - Very “commercial” paper by T. Yasaka (University of Kyushu) and N. Okada (Astroscale, start-up from Singapore)
  - Japanese legal presentation, by A. Otsuka (Keio University)
  - Legal approach to the process leading to authorize an ADR operation by B. Weeden (Secure World Foundation)
    - Very complete and interesting: any operation can generate problems!
  - “Export Control” aspects presented by A. Soucek (ESA)
    - Rich and instructive!

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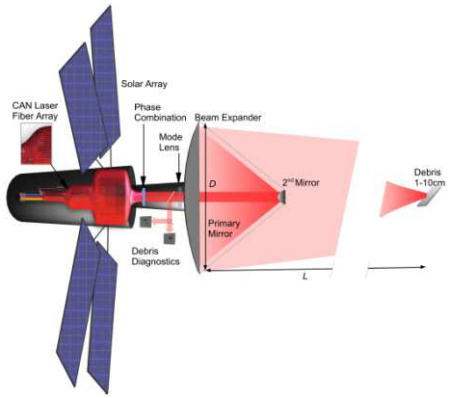
- **Posters**
  - Space based telescope to detect small debris (Airbus, AUIB, ESTEC, ESOC)
  - Electric propulsion applied to ADR by C. Billot (TAS)
    - CNES contract
    - Two interesting and credible concepts; synergy with other orbital missions
  - Two posters on space based lasers by Polytechnique + CEA
    - ICAN fiber laser original and promising, high efficiency
    - EU FP7 funding
    - Possibility to track small debris
    - Proposal of a demonstration on ISS




  - Electrostatic sail interacting with ionospheric wind by P. Janhunen (University of Helsinki)
    - In-flight demonstration ongoing with EST-1
  - “commercial” proposal of an ADR system by Astroscale (Singapore)
  - Proposal to despin a debris thanks to electrostatic forces by HP. Schaub (University of Colorado)
  - Description of simulation means of DFKI + Bremen University (Germany) aiming at capturing an asteroid or a debris (EU contract, 14 partners)
  - Proposal to start some work aiming at adapting French Space Act to allow some ADR operations without controlled deorbiting by Ch. Bonnal & B. Lazare (CNES)