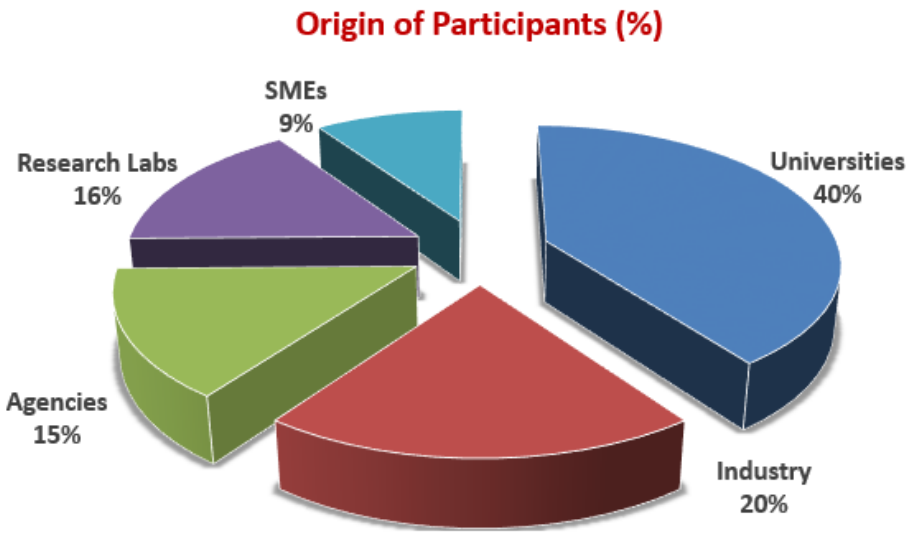
5th INTERNATIONAL WORKSHOP ON SPACE DEBRIS MODELING AND REMEDIATION

➢ Three workshops organized every two years:

- Conjunction Assessment: next edition June 2019 (contact Monique.moury@cnes.fr)
- Satellite End of Life: next edition January 2020 (contact pierre.Omaly@cnes.fr)
- Modeling and Remediation: 5th edition June 25-27, 2018, Paris

➢ General Statistics:

- Final: 125 Registered participants
  (room limitation!)
- 17 Countries
- 64 Presentations
  - 52 Oral (- 2 cancelled)
  - 12 Posters (- 2 No show)



➢ Proceeding are available:

- Just ask me

Session #1: Modeling for sustainability

#1.1 Space Traffic Management through the Control of the Space Environment's Capacity
H. Krag, S. Lemmens, F. Letizia
ESA/ESOC, Darmstadt, Germany

#1.2 Analysis of Space Occupancy in Low Earth Orbit
C. Bombardelli[1], G. Falco[2], D. Amato[3]
[1]Space Dynamics Group, Technical University of Madrid (UPM), Madrid, Spain, [2]University of Naples Federico II, Naples, Italy, [3]University of Arizona, Tucson, AZ, USA

#1.3 Representing Uncertainty in Space Situational Awareness
J. T. Kent[1], S. Bhattacharjee, M. K. Jah, D. McNeely
[1]Department of Statistics, University of Leeds, Leeds, UK

#1.4 A non-averaged approach to the numerical cartography of the LEO region
D. Amato, A. J. Rosengren,
The University of Arizona, Tucson, AZ, USA

#1.5 Implications of small satellites and large constellation on the on-orbit collision risk
J. C. Dolado-Perez[1], B. Revelin[2]
[1]Centre National d'Etudes Spatiales (CNES), Toulouse, France; [2]CS-SI, Parc de la Plaine, Toulouse, France

#1.6 An Analytical Approach for Evaluating the Environmental Sustainability of Large Satellite Constellations in Low Earth Orbit
L. Anselmo, C. Pardini
Space Flight Dynamics Laboratory, ISTI/CNR, Pisa, Italy

Session #2: Economical and Legal aspects

#2.1 Funding the cleaning of space debris. A first economic proposal
Sylvain Béal[1], Marc Deschamps[1], Hervé Moulin[2]
[1]CRESE EA3190, Univ. Bourgogne Franche-Comté, Besançon, France; [2]University of Glasgow, Adam Smith Business School, Scotland

#2.2 The development of an orbital risk assessment capability for novel, disruptive systems
T. Harris,
Head of Orbital Systems, UK Space Agency, Didcot, Oxford, UK

#2.3 Integrating space debris modeling to environmental impact studies thanks to the Life Cycle Assessment (LCA) framework
T. Maury[1 2], C. Colombo[3], M. Trisolini[3], P. Loubet[1], A. Gallice[2], G. Sonnemann[1]
[1]CyVi group - ISM, Université de Bordeaux, Talence, France; [2]ArianeGroup - Design for Environment, , St Médard en Jalles, France; [3]Politecnico di Milano – Aerospace department, Milan, Italy,

#2.4 Normative and legal implications of passive de-orbiting strategies
R. Popova[1], Y. Kim[1], A. Rossi[2], C. Colombo[3], V. Schauss[4], E.M. Alessi[2], G. Schettino[2], K. Tsiganis[5], I. Gkolias[3], D.K. Skoulidou[5]
[1]Institute of Air and Space Law, University of Cologne, Germany; [2]IFAC-CNR, Sesto Fiorentino, Italy;
[3]Politecnico di Milano, Milan, Italy; [4]TU Braunschweig, Institute of Space Systems, Germany; [5]Aristotle University, Thessaloniki, Greece

#2.5 The Surge in Small Satellites and Debris Remediation: Employing Lex Lata and Lex Ferenda for Regulation
K. Nair
McGill University, Montreal, Canada

#2.6 Insurance involvement on space debris remediation
C. Gaubert[1], S. Devouge[2]
[1]Lawyer - Paris Bar, Paris, France; [2]Contracts Specialist – Swiss Re Corporate Solutions, Paris, France

Session #3: Remediation solutions

#3.1 REMOVEDEBRIS preliminary mission results
G. Aglietti[1], S. Fellowes[1], B. Taylor[1], T. Salmon[2], A. Hall[3], T. Chabot[4], A. Pisseloup[5], S. Ainley[6], D. Tye[6], C. Bernal[7], F. Chaumette[8], Alexandre Pollini[9], Willem Steyn[10]
[1]Surrey Space Centre, University of Surrey, United Kingdom; [2]Airbus Safran Launchers, France;
[3]Airbus Group, United Kingdom; [4]Airbus Defence and Space (DS), France; [5]Airbus Group, France;
[6]Surrey Satellite Technology Ltd (SSTL), United Kingdom; [7]ISIS Bv, The Netherlands; [8]INRIA, France;
[9]CSEM, Centre Suisse d'Electronique et de Microtechnique SA, Switzerland ; [10]Stellenbosch University, South Africa

#3.2 e.Deorbit – An Update ESA's Active Debris Removal Mission
A. Wolahan, R. Biesbroek, L. Innocenti
ESA/ESTEC, Noordwijk, The Netherlands

#3.3 Status of the development of the CleanSpace One System and Mission
L. Piguet, M. Richard-Noca, M. Juillard
Space Engineering Center, Ecole Polytechnique Fédérale de Lausanne, Switzerland

#3.4 The Cycler: The affordable companion for Post Mission Disposal in massive constellations
D. Alary, A. Grasso, C. Tourneur, C. Pruvost
Airbus Defence & Space, Toulouse, France

#3.5 The D-SAT Mission: an In-Orbit Demonstration of an Autonomous and Reliable Satellite Removal Technology
A. Fanfani, M. Bevilacqua, L. Ferrario, S. Brilli, M. Trotti, A. Dainotto, M. Cazzaniga, F. Palumbo, S. Antonetti
D-ORBIT SRL, Fino Mornasco, Italy

#3.6 An Overview of ASTROSCALE and the ELSA-d Mission
J. Forshaw, C. Blackerby, N. Okada
ASTROSCALE, Didcot, Oxford, UK

Session #4: Modeling - Mitigation

#4.1 ORDEM 3.1 Development Status

P. Anz-Meador[1], A. Manis[2], M. Matney[3]
[1]Jacobs, Houston, TX, USA; [2]HX5-Jacobs JETS Contract, Houston, TX, USA; [3]NASA Johnson Space Center, Houston, TX, USA

#4.2 The H2020 ReDSHIFT project: summary of the main results

A. Rossi[1], C. Colombo[2], J. Beck[3], F. Letterio[4], J. Becedas Rodriguez[5], F. Dalla Vedova[6], S. Walker[7], K. Tsiganis[8], V. Shaus[9], R. Popova[10], A. Francesconi[11], H. Stokes[12], T. Schleutker[13], E.M. Alessi[1], G. Schettino[1], I. Gkolias[2], D.K. Skoulidou[8], I. Holbrough[3], F. Bernelli Zazzera[2], E. Stoll[9], Y. Kim[10], and The ReDSHIFT team
[1]IFAC-CNR, Sesto Fiorentino, Italy; [2]Politecnico di Milano, Milan, Italy; [3]Belstead Research Ltd, United Kingdom; [4]Deimos Space, Madrid, Spain; [5]Elecnor Deimos Satellite Systems, Puertollano, Spain; [6]LuxSpace Sarl, Luxemburg; [7]University of Southampton, United Kingdom; [8]Aristotle University, Thessaloniki, Greece; [9]TU Braunschweig, Institute of Space Systems, Germany; [10]Institute of Air and Space Law, University of Cologne, Germany; [11]University of Padova, Italy; [12]PHS Space Ltd, United Kingdom; [13]DLR, German Aerospace Center, Germany

#4.3 Measuring the impact of the current level of adherence to Space Debris Mitigation guidelines

F. Letizia, S. Lemmens, H. Krag
ESA/ESOC, Darmstadt, Germany

#4.4 A long-term collision risk prediction tool for constellation design

R. Lucken[1 2], D. Giolito[1]
[1]Share My Space, Paris, France
[2]Laboratoire de Physique des Plasmas (LPP), UMR CNRS 764, Ecole Polytechnique, Palaiseau, France

#4.5 An Introduction to SOLEM---the Space Objects Long-term Evolution Model

Z. Yao
National Astronomical Observatories, Chinese Academy of Science, Beijing, China

Session #5: Modeling – Attitude

#5.1 Long-term Attitude Dynamics of Space Debris In Sun-synchronous Orbits: Cassini Cycles and Chaotic Stabilization
V.V.Sidorenko[1], S.S. Efimov[2], D.A.Pritykin[2 3]
[1]Keldysh Institute of Applied Mathematics, Russian Academy of Science, Moscow, Russia; [2]Moscow Institute of Physics and Technology, Dolgoprudny, Russia; [3]Skolkovo Institute of Science and Technology, Moscow, Russia

#5.2 Contact Detumbling and Compliant Capture Control of a Spinning Space Debris
Cancelled
H. Zhang, W. Duan, S. Xu
Beijing Institute of Control and Engineering, Beijing, China

#5.3 Space Debris TOPEX/Poseidon Attitude Motion: Interplay of Conservative, Damping and Propelling Torques
D. Pritykin
Moscow Institute of Physics and Technology, Skolkovo Institute of Science and Technology

#5.4 Rapid assessment of rendezvous delta-v between space debris
M. Li, X. Li, Y. Wang
National Space Science Center, Chinese Academy of Sciences; University of Chinese Academy of Sciences

#5.5 Eddy Currents Torque Acting on Space Debris: Analytical Expressions for Magnetic Tensors of Geometric Primitives
S. Efimov
Moscow Institute of Physics and Technology, Dolgoprudny, Russian Federation

Session #6: Modeling - Dynamics

#6.1 SRP Driven Transfers to Resonant Orbits
M. M. Pellegrino, D.J. Scheeres
Smead Aerospace Engineering Department, The University of Colorado Boulder, USA

#6.2 Orbital flips due to solar radiation pressure in the vicinity of GNSS region
E. Kuznetsov, Belkin Sergej
Ural Federal University, Yekaterinburg, Russia

#6.3 Dynamical Systems Approach to Debris Mitigation and Remediation
A. J. Rosengren[1], D. K. Skoulidou[2], K. Tsiganis[2], G. Voyatzis[2]
[1]University of Arizona, Tucson, AZ, USA; [2]Aristotle University of Thessaloniki, Thessaloniki, Greece

#6.4 Accurate collision warning using Gaussian mixture method in orbit uncertainty propagation
R. Yan, R. Wang, S. Liu, J. Gong
National Space Science Center, Chinese Academy of Sciences, Beijing, China

Session #7: Laser applications

#7.1 Feasibility Analysis on Active Debris Removal with Joule-class Space-based Laser System

W. Yang[1], Q. Yu[2], C. Chen[2], M. Li[3], Z. Gong[2]

[1]Beijing Institute of Spacecraft Environment Engineering, CAST, Beijing, China; [2]National Key Laboratory of Science and Technology on Reliability and Environment Engineering, Beijing Institute of Spacecraft Environment Engineering, CAST, Beijing, China; [3]China Academy of Space Technology, Beijing, China

#7.2 Remote maneuver of space debris using photon pressure for active collision avoidance

C. Smith EOS Space Systems Pty Ltd, Australia

#7.3 Study on the Influence of Geometry of Space Debris on Laser Ablation Impulse

C. Chen[1], W. Yang[2], Q. Yu[1], M. Li[3], Z. Gong[1 2]

[1]Beijing Institute of Spacecraft Environment Engineering, Science and Technology on Reliability and Environmental Engineering Laboratory, Beijing, China; [2]Beijing Institute of Spacecraft Environment Engineering, Beijing, China; [3]China Academy of Space Technology, Beijing, China

#7.4 Deorbiting Mission of cm-Sized Space Debris by Laser Ablation

T. Ebisuzaki, S. Wada *RIKEN, Wako, Japan*

#7.5 Mission Planning and Simulation System Study on Active Debris Removal with Space-based Laser System

W. Yang[1], C. Chen[2], Q. Yu[1], M. Li[3], Z. Gong[12]

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#7.6 Using Lasers for Large Debris Traffic Management

C. Phipps[1], C. Bonnal[2], F. Masson[2] *[1]Photonic Associates, Santa Fe NM, USA; [2] CNES, Direction des Lanceurs, Paris, France*

#7.7 High average/peak powers laser architecture based on Coherent Beam Combining of fiber amplifiers for space applications

J.-C. Chanteloup[1], A. Heilmann[1], J. Le Dortz[2], L. Daniault[1], I. Fsaifes[1], S. Bellanger[1], M. Antier[3], A. Brignon[2], J. Bourderionnet[2], E. Durand[3], E. Lallier[2], C. Larat[2], C. Simon-Boisson[3], G. Mourou[4]

[1]LULI, Ecole Polytechnique, CNRS, CEA, UPMC, Palaiseau, France; [2]Thales Research & Technology, Palaiseau, France; [3]Thales LAS France SAS, Elancourt, France ; [4]IZEST, Ecole Polytechnique, Palaiseau, France

#7.8 A new laser driven relay small satellite constellation for space debris active removal

C. Chen[1], W. Yang[2], Q. Yu[1], M. Li[3], Z. Gong[12]

[1]Beijing Institute of Spacecraft Environment Engineering, Science and Technology on Reliability and Environmental Engineering Laboratory, Beijing, China; [2]Beijing Institute of Spacecraft Environment Engineering, Beijing, China; [3]China Academy of Space Technology, Beijing, China

Session #8: Modeling End-of-Life

#8.1 Death of a small satellite; demise test of a cubesat, and determining the demise impact of dragsail
James Beck[1], Ian Holbrough[1], Thorn Schleutker[2], Ali Guelhan[2]
[1]Belstead Research Limited, Ashford, Kent, UK; [2]DLR, Supersonic and Hypersonic Technologies Department, Cologne, Germany

#8.2 ReDSHIFT software tool for the design and computation of mission end-of-life disposal
F. Letterio[1], E.M. Alessi[2], I. Gkolias[3], D.K. Skoulidou[4], V. Shaus[5], J. Beck[6], G. Vicario de Miguel[1], G. Schettino[2], A. Rossi[2], C. Colombo[3], K. Tsiganis[4], I. Holbrough[(5)]
[1]Deimos Space, Madrid, Spain; [2]IFAC-CNR, Sesto Fiorentino, Italy; [3]Politecnico di Milano, Milan, Italy; [4]Aristotle University, Thessaloniki, Greece; [5]TU Braunschweig, Institute of Space Systems, Germany; [6]Belstead Research Ltd, United Kingdom

#8.3 Surrogate Aerodynamic Models of Cuboidal Space Debris Objects During Atmospheric Entry
Cancelled
N. L. Donaldson
Osney Thermofuilds Laboratory, University of Oxford, Oxford, Oxon, UK

#8.4 Megaconstellation re-entry and ISS conjunctions probability
A.Sita
Thales Alenia Space, Cannes, France

#8.5 Indication of break-up location and epoch from fragments using backwards spatial density propagation
S. Frey[1 2], C. Colombo[1], S. Lemmens[2]
[1]Politecnico di Milano, Milan, Italy; [2]ESA/ESOC, Darmstadt, Germany

#8.6 Space Debris Refined Collision Risk Study
R. Wang, W. Liu, R. Yan, L. Shi, S. Liu
National Space Science Center, Chinese Academy of Sciences, Beijing, China

Session #9: Remediation technologies

#9.1 Consideration on active debris removal target
S. Kawamoto,
Research and Development Directorate, JAXA, Chofu, Tokyo, Japan

#9.2 Space Debris: how to increase the active removal effectiveness via an altitude-shell-dependent approach
G. L. Somma[1], H. G. Lewis[1], C. Colombo[2]
[1]Faculty of Engineering and the Environment, University of Southampton, UK; [2]Department of Aerospace Science and Technology, Politecnico di Milano, Italia

#9.3 Progress-M spaceship as the basis of the vehicle for ADR missions
V. I. Trushlyakov, V. V. Yudintsev
Omsk State Technical University, Russia

#9.4 Interaction of passive de-orbiting devices with the space debris environment
C. Colombo[1], A. Rossi[2], F. Dalla Vedova[3], A. Francesconi[4], C. Bombardelli[5], J. L. Gonzalo[1], P. Di Lizia[1], C. Giacomuzzo[4], S. Bayajid Khan[4], R. García-Pelayo[5], V. Braun[6], B. Bastida Virgili[6], H. Krag[6]
[1]Politecnico di Milano, Italy; [2]IFAC-CNR, Sesto Fiorentino (FI), Italy; [3]LuxSpace, Luxemburg; [4]CISAS "G. Colombo" - University of Padova, Italy; [5]Universidad Politécnica de Madrid, Spain; [6]ESA/ESOC, Germany

#9.5 Optimization of Accurate Rendezvous for Multiple Space Debris Mission
I. Sharf
McGill University, Montreal, Canada

#9.6 Multiscale modeling of fragmentation in solids upon hypervelocity impact
M. O. Steinhauser[1 2]
[1]Fraunhofer-Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI, Freiburg, Germany; [2]University of Basel, Faculty of Science, Department of Chemistry, Basel, Switzerland

Posters

#P.1 OHB Space Debris Centre of Competence (SDCOC)
M. Fittock, C. Bewick
OHB, Bremen, Germany

#P.2 Study of Collision Probability Considering Non-Uniform Cloud of Space Debris
J. K. S. Formiga[1], D. P. S. Santos[2], A. F. B. A. Prado[3]
[1]Institute of Science and Technology, ICT/UNESP, São José dos Campos (SP), Brazil; [2]Sãao Paulo State University, UNESP, São João da Boa Vista (SP), Brazil; [3]National Institute for Space Research, INPE, Brazil

#P.3 Calculating collision rates within large constellations of satellites in long-term simulations using a deterministic approach
J. Radtke, E. Stoll
Technische Universität Braunschweig, Institute of Space Systems, Braunschweig, Germany

#P.4 Using deployable flexible beam for capturing of a tumbling large debris
V. S. Aslanov, V. V. Yudintsev,
Samara National Research University, Samara, Russia

#P.5 Removal of Small-Sized Space Debris by Laser-Ablative Momentum Generation
S. Scharring[1], R-A. Lorbeer[1], M. Zwilich[1], M. Zabic[1], L. Eisert[1], J. Wilken[1], D. Schumacher[2], M. Roth[3], H-A. Eckel[1]
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#P.6 Research on quasi-periodic resonance relative orbit control for active debris removal with space-based laser
Q. Gan, J. Fu, Y. Zhang, J. Cai
Academy of Opto-electronics, Chinese Academy of Science, Beijing, China

Posters

#P.7 Removal of Geostationary Debris In Light of Commercialized Space Activities
M. Cui, A. Hoenen, A. Payet, A. Weiss, N. Xu
Institut Polytechnique des Sciences Avancées - IPSA, Ivry-sur-Seine, France

#P.8 Symmetrical Hyperloop System for Management And Mitigation Of Space Debris In Low Earth Orbit
No Show
S. Ojha[1], U. Guven[2]
[1]University of Petroleum and Energy Studies, Jaipur, India; [2]UN Center for Space Science and Space Technology Education in Asia and Pacific

#P.9 Deorbiting CubeSats and Nanosatellites Using Inbuilt Tethers and Micro Thrusters
No Show
S. Ojha[1], U. Guven[2]
[1]University of Petroleum and Energy Studies, Jaipur, India; [2]UN Center for Space Science and Space Technology Education in Asia and Pacific

#P.10 Experimental investigation of laser and materials parameters for space debris removal by laser solutions
S.A.E. Boyer[1], S. Baton[2], E. Brambrink[2], L. Berthe[3], J.-M. Chevalier[4], L. Videau[5], C. Rousseaux[5], M. Boustie[6], C. Phipps[7], S. Scharring[8], S. Oriol[9], F. Masson[9], C. Bonnal[9]
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#P.11 The implementation of the collision probability estimation method in SOLEM
Wang Xiaowei[1,2,3], Liu Jing[1,2], Zhang Yao[1,2]
[1]National Astronomical Observatories, Chinese Academy of Sciences, Beijing, China, [2]Space Debris Observation and Data Application Center, CNSA, Beijing, China, [3]University of Chinese Academy of Sciences, Beijing, China

#P.12 An autonomous space debris chaser for on-orbit servicing
V. Marsat[1 2], F. Solt[3], A. Avenas[3], L. Lacaille[3], C. Liu[3], J. Song[3], D. Giolito[1], R. Lucken[1 4]
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