STARDUST

PUSHING THE BOUNDARIES OF
SPACE RESEARCH TO SAVE OUR FUTURE

Stardust – Opening Training School

Week Plan and Timetable

Contents

Programme

Venue

The school will be held in the Collins Building at the University of Strathclyde in Glasgow, Scotland.

⇢Map of the University

⇢More about Glasgow

Invited evening public talks:

- Tuesday 19th November, "The Search for Gravitational Waves on ground and in space" by Prof Jim Hough, University of Glasgow, UK
- Thursday 21st November, "Why are we here? - Our cosmic origins" by Prof Martin Hendry, University of Glasgow, UK

Both lectures will take place in the Collins Building, 22 Richmond Street, Glasgow, G1 1XQ
To register, please RSVP by Tuesday 12 November, indicating which event you will attend, to the Strathclyde Events team:
corporate-events@strath.ac.uk or 0141 548 2245.

Teachers and Lectures

Invited guest lectures:

- "Optimizing Interplanetary Trajectories With Particular Application to Asteroid Deflection" by Prof Bruce Conway, University of Illinois at Urbana-Champaign, USA
- "Manipulation of Asteroids and Space Debris" by Prof Hiroshi Yamakawa, Kyoto University, Japan
- "JAXA's Space Debris Related Activities: Mitigation and R&D" by Prof Seishiro Kibe, Japan Aerospace Exploration Agency (JAXA), Japan
- "Lasers for Asteroid and Debris Deflection" by Dr Pierre Bourdon, Office National d'Études et de Recherches Aérospatiales (ONERA), France

Network speakers:

- "Advanced orbit propagation methods and application to space debris collision avoidance", Dr Claudio Bombardelli, Universidad Politécnica de Madrid, Spain
- "Orbital dynamics about small bodies", Ing Juan L. Cano, DEIMOS Space SLU, Spain
- "From regular to chaotic motions in Dynamical Systems with applications to asteroid and debris dynamics", Prof Alessandra Celletti, Universitá di Roma Tor Vergata, Italy
- "Orbit determination methods", Dr Giovanni Gronchi, Universita' di Pisa, Italy
- "Analytic modelling of the long-term evolution of orbital debris", Prof Colin McInnes, University of Strathclyde, UK
- "Physical properties of NEOs from space missions and relevant properties for mitigation", Dr Patrick Michel, Centre National de la Recherche Scientifique (CNRS), France

- "Numerical methods for entry flow simulations", Dr Edmondo Minisci, University of Strathclyde, UK
- "Linking NEAs to their main belt source regions", Dr Bojan Novakovic, University of Belgrade, Serbia
- "Overview of DFKI-RIC research topics, focused on space robotics", Dr Jan Paul, German Research Centre for Artificial Intelligence (DFKI), Germany
- "On the accessibility of the Near-Earth Asteroids", Dr Ettore Perozzi, DEIMOS Space SLU, Spain
- "Dynamics of space debris and simulation of long term evolution of space debris population", Dr Alessandro Rossi, Consiglio Nazionale delle Ricerche (CNR), Italy
- "Introduction to optimal control and space trajectory optimization", Dr Francesco Topputo, Dinamica Srl, Italy
- "Methods and techniques for asteroid deflection", Prof Massimiliano Vasile, University of Strathclyde, UK
- "Rotational dynamics and attitude control of spacecraft", Dr Scott Walker, University of Southampton, UK

Complementary skills lectures:

- "Research/Professional Planning and Development" and " Presentation skills" Dr Stuart Boon, University of Strathclyde, UK.
- "Engaging the public—who, what, how and why?", Dr Mark Haw, University of Strathclyde, UK.
- "Writing skills for academic purposes", Dr Elsa João, University of Strathclyde, UK.

Schedule

There will be 6 lectures per day, with each technical lecture lasting 55 mins (including questions and discussion). In addition there will be roundtable discussions and workshops in the morning and 2 public talks or social activities planned for the evenings. (Timetable of the week)

Lunch will be provided, with coffee available throughout the day.

OTS Timetable

All the morning and afternoon lectures will be held in the Collins Building at the University of Strathclyde in Glasgow. On Monday, Tuesday and Friday the lectures will be held in the conference area of the Scottish Universities Insight Institute (former Collins Gallery). Wednesday and Thursday the lectures will be held in the Senate Room (CL205).

	Mon 18th November	**Tue 19th November**
8.15:8.30	COFFEE	COFFEE
8.30:9.25	Welcome and Project description (Prof. Vasile) and Attendees Presentations	Workshop/Round table
9.25:10.20	Prof. Conway (UIUC)	Prof. McInnes(US)
20 min	COFFEE	COFFEE
10.40:11.35	Prof. Conway (UIUC)	Dr. Minisci (US)
11.35:12.30	Prof. Vasile (US)	Prof. Conway (UIUC)
12.30:13.30	LUNCH	LUNCH
13.30:14.25	Prof. Yamakawa (KU)	Prof. Vasile (US)
14.25:15.20	Prof. Yamakawa (KU)	Prof. Yamakawa (KU)
20 min	COFFEE	COFFEE
15.40:16.35	Prof. Kibe (JAXA)	Prof. Kibe (JAXA)
16.35:17.30	Dr. Boon (US)	Dr. Joao (US)
17.30:19.00		Transfer
19.00:20.00		Prof. Hough (GU)
20.00:23.00	Drinks/ Dinner	Dinner

	Wed 20th November	Thu 21st November
8.15:8.30	COFFEE	COFFEE
8.30:9.25	Workshop/Round table	Workshop/Round table
9.25:10.20	Dr. Perozzi (DEIMOS)	Dr Novaković (UBG)
20 min	COFFEE	COFFEE
10.40:11.35	Dr. Bourdon (ONERA)	Dr. Paul (DFKI)
11.35:12.30	Dr. Bourdon (ONERA)	Dr. Rossi (CNR)
12.30:13.30	LUNCH	LUNCH
13.30:14.25	Dr. Gronchi (UniPi)	Dr. Bombardelli (UPM)
14.25:15.20	Dr. Gronchi (UniPi)	Dr. Topputo (Dinamica)
20 min	COFFEE	COFFEE
15.40:16.35	Dr. Paul (DFKI)	Ing. Cano (DEIMOS)
16.35:17.30	Dr. Boon (US)	Dr. Haw (US)
17.30:19.00	Transfer	Transfer
19.00:20.00	Whisky tasting	Prof. Hendry (GU)
20.00:23.00	Whisky tasting/Dinner	Dinner

Fri 22nd November	
8.45:9.00	COFFEE
9.00:9.55	Dr. Topputo (Dinamica)
9.55:10.50	Dr. Walker (Southampton)
20 min	COFFEE
11.10:12.05	Dr. Walker (Southampton)
12.05:13.00	Dr. Michel (CNRS)
13.00:14.00	LUNCH
14.00:14.55	Prof. Celletti (UTV)
14.55:15.50	Prof. Celletti (UTV)
20 min	COFFEE
16.10:17.05	Workshop/Network meeting
17.05:18.00	Workshop/Network meeting
18.00:18.30	CLOSING/Network meeting
18.30:19.30	CLOSING/Network meeting
19.30:23.00	Social Dinner

For more details or questions, contact the organising team at stardust@strath.ac.uk.

Invited evening public talks

Prof Jim Hough

Jim Hough is a graduate of the University of Glasgow where he became Professor of Experimental Physics in 1986 and is currently the emeritus holder of the Kelvin Chair of Natural Philosophy. JH has been Director of the University's Institute for Gravitational Research from 2000 to 2009, is now CEO of the Scottish Universities Physics Alliance and the initiator and director of the first International Max Planck Partnership worldwide. This partnership, between five Scottish Universities and five Max Planck Institutes in Germany, is centred on Observation and Measurement at the Quantum Limit and is planned to boost the academic and innovative impact of Scottish Physics in the area of quantum measurement and information.
Research interests are centered on laser instrumentation and delicate mechanical systems as applied to Gravitational Wave Detection on ground (GEO 600 in Germany and Advanced LIGO in the USA) and in space (eLISA).
A JILA Fellow in 1983 he was, along with Karsten Danzmann, winner of a Max-Planck research prize in 1991, was elected to the Royal Society of Edinburgh in 1991 and to the Royal Society of London in 2003, was awarded the Duddell Prize of the Institute of Physics in 2004 and the Gunning Victoria Prize lectureship of the Royal Society of Edinburgh in 2008. He was elected to Fellowship of the Institute of Physics in 1993 and of the American Physical Society in 2001, and was awarded Fellowship of the International Society for General Relativity and Gravitation in 2010, and Fellowship of the Royal Society of Arts in 2012.
For his wide-ranging research and advisory work he was awarded an OBE in the 2013 Queen's Birthday Honours.

The Search for Gravitational Waves on ground and in space.
Gravitational waves – a prediction of Einstein's General Relativity – are still among the most elusive signals from far out in the Universe. Over the past decade the laser interferometric detectors LIGO, Virgo and GEO 600 have been commissioned and operated at their design or close to design sensitivity, and the design for a space borne interferometer of very long base-line, eLISA, has been optimised. However, in keeping with source strength predictions and, as expected, no gravitational wave signals have been observed as yet.
Now the ground based detectors are being upgraded and observations will begin again around 2015 with the real expectation that signals from coalescing binary systems will be observed. Such is the confidence, currently, that a new detector is being built in Japan in the Kamioka mine and the third of the LIGO detectors is to be transferred to India, thus creating a truly world-wide network. On the space side eLISA is a very strong candidate for the next ESA Large Mission.
In this talk I will explain the nature of gravitational waves, why it is scientifically important to observe them, and the challenges in ground and space faced by the experimenters.

Prof Martin Hendry

Martin Hendry is Professor of Gravitational Astrophysics and Cosmology and Head of the School of Physics and Astronomy at the University of Glasgow. His main research interests are in cosmology - the branch of astronomy concerned with the "big questions" about the origin and evolution of our universe - and gravitational waves: the so-called "ripples" in spacetime predicted by Einstein and produced by some of the most violent events in the cosmos - colliding black holes, exploding stars even the Big Bang itself. He co-chairs the public outreach group of the LIGO Scientific Collaboration: the international team of more than 900 scientists leading the search for gravitational waves. Martin is a passionate enthusiast for promoting public engagement in science and regularly delivers lectures and workshops at science festivals throughout the world.

Why are we here?
Since the dawn of civilisation human cultures have sought to understand our place in the universe, asking big questions about our cosmic origins. Modern cosmology provides some startling answers to these questions: not only is the universe expanding, but we believe the expansion to be accelerating - driven by a mysterious "dark energy" that challenges our ideas about gravity and the very nature of space and time. Moreover our runaway universe appears to be rather delicately balanced, in the sense that small changes in the laws of nature would result in a very different cosmos - most likely unsuitable for life like us. What does all of this mean for our cosmic origins? Is our universe unique, or do we belong to a "multiverse" - a vast ensemble of universes, each with its own laws of nature? In this lecture we will explore these, and other, questions posed by the latest cosmological discoveries, and discuss what implications they might have for the existence of life in the universe.

Invited guest lectures

Prof Bruce Conway

Bruce Conway is a Professor of Aerospace Engineering at the University of Illinois at Urbana-Champaign. He has been on the faculty since 1981. He received the Ph. D. in Aeronautics & Astronautics from Stanford University in 1980, working with John Breakwell. He is a fellow of the AAS and an associate fellow of the AIAA. He is an associate editor of the AAS J. of the Astronautical Sciences and of the J. of Optimization Theory and Applications. He is the author (with John Prussing) of the textbook Orbital Mechanics (Oxford University Press) and is the editor of the book Spacecraft Trajectory Optimization (from Cambridge University Press). His research is primarily in the fields of celestial mechanics, spacecraft trajectory optimization, numerical optimization methods, metaheuristic methods for trajectory optimization, and differential games. Prof. Conway is also a commercial pilot and instrument flight instructor with more than 2000 hours of flight experience.

Optimizing Interplanetary Trajectories With Particular Application to Asteroid Deflection
There are many proposed methods for mitigation of the danger posed by a hazardous near-Earth asteroid. All require that a spacecraft be sent to either rendezvous (for methods such as the gravity tractor) or intercept (for methods such as kinetic impact) the asteroid. The method of propulsion of the spacecraft might be a conventional chemical rocket engine that provides “impulsive” thrust or a low-thrust electric (ion) engine or possibly even a solar sail. The trajectory may even benefit from using planetary flybys. The choice depends in great measure on the time available to implement the strategy and the objective, which might be delivering the largest possible mass for a gravity tractor vehicle or nuclear weapon, or causing the largest deflection via a kinetic impactor vehicle. It is clear that there are many combinations of all of the factors that need to be considered in designing the mission. Not surprisingly, there is no single method for optimization of the trajectory of the mission that is the best for all possible cases. In this sequence of three lectures we will first provide a summary (and in some cases a derivation) of the best extant methods for space trajectory optimization. Then we will show how to formulate the objective, e.g. moving the predicted impact point off the surface of the Earth as much as possible, which is not a straightforward function of the deflection impulse. Finally we will show how these tools can be combined to optimize trajectories for some of the most likely mitigation missions and even for precursor, threat characterization missions, including sample returns.

Prof Hiroshi Yamakawa

Hiroshi Yamakawa was born in Geneva, Switzerland in 1965. He received master's degree of engineering in 1990 and Ph. D in 1993 both from the University of Tokyo. He became a research associate and an associate professor at the Institute of Space and Astronautical Science in 1993-2003, and an associate professor at Japan Aerospace Exploration Agency in 2003-2006. He engaged in mission design of numerous Earth-orbiting scientific satellite projects as well as in lunar and interplanetary missions. He also engaged in the navigation, guidance, and control systems of the solid propellant rocket, M-V, and liquid propellant reusable sounding rocket, RVT. He was a study manager and a project manager of the Euro-Japan collaborative mission to Mercury "BepiColombo" from 2000 through 2006. He was a visiting scientist at NASA JPL in 1997-1998 and at ESA ESTEC in 2002. He moved to Kyoto University in 2006 as a professor of the Research Institute of Sustainable Humanosphere, a professor of the Graduate School of Engineering (cooperating chair) and a deputy director of the Unit for Synergetic Studies of Space. He was appointed as secretary general at the Secretariat of Strategic Headquarters for Space Policy, Cabinet Secretary, Government of Japan in July 2010 through July 2012. He was assigned member of the Committee for National Space Policy, Cabinet Office in July 2012. His academic interest lies in orbital mechanics (spacecraft formation dynamics, solar sail dynamics, Halo orbits), trajectory optimization (interplanetary trajectory design, low-thrust trajectory optimization), and space propulsion (magnetic sail, solar sail, Coulomb force, Lorentz force orbit control).

Reaching Asteroids
Reviewing spacecraft transfer trajectories from the Earth to asteroids including the Hayabusa mission, two types of asteroid transfers are discussed: one is to make rendezvous with the asteroid and the other is to impact the asteroid with large relative velocity. The use of solar electric propulsions and solar sails are discussed. For the latter case, some detailed discussions will be given to the optimal interplanetary trajectories for impulsive deflection of potentially hazardous asteroids under velocity increment uncertainties.

Moving Asteroids
Vairous ideas of orbital deflection methods of potentially hazardous asteroids are discussed. Some detailed discussions on the combinatorial use of gravity and electrostatic forces applicable for small asteroids will be provided. The latter half of the lecture will investigate the possibility of an asteroid survey mission enabled by advanced solar sailing technology. The discussion focuses not on the solar sail spacecraft itself but on its orbital dynamics to realize the missions. A novel near-earth asteroid flyby survey mission with a lightweight solar sail spacecraft to increase the observability is discussed.

Tackling Space Debris
Reviewing various methods to decrease orbital debris, the lecture investigates the possible methods of decreasing or changing the altitude of space debris by Lorentz force which is an interaction between the Earth geomagnetic field and the current induced by, for example, electrodynamic tether attached to space debris. Approximated equations of motion for the altitude variation are derived. The motion of a satellite utilizing the geomagnetic field around space debris is also discussed for observation of and rendezvous

with space debris. Analytical approximations for the relative motion in Earth orbit are obtained. The sequential quadratic programming method is applied to solve the orbital transfer problem.

Prof Seishiro Kibe

Seishiro Kibe received the B.S. degree of Aerospace Engineering in 1975, the M.S. degree of Structural Dynamics in 1977, and Doctoral degree of Engineering in 1981, all from Tokyo University. In 1981, he joined the National Aerospace Laboratory, Japan. He was engaged in research on the vibration suppression and control of large space structures, life support technology. In 1985, just after his coming back from one year stay in the United States as a research associate of Virginia Polytechnic Institute & SU, he temporally moved to the Science and Technology Agency of Japanese Government and was engaged in planning Japan's participation in the International Space Station program.
These about fifteen years he has been devoted to the space debris issues as a leading researcher for Japan's related activities and played actively as one of the official delegates to the International Space Debris Coordination Committee (IADC) and the Science and Technology Subcommittee of UN/COPUOS. Owing to his extensive contribution to the space debris issue, he received the award for exquisite research activity from Minster of Science and Technology Agency in 2000. From 1999 through 2003, he also worked for the Tokyo Metropolitan Institute of Technology as a full professor and, from 2000 through 2003, was appointed as a committee member of Space Activities Commission.
On the merger of three main space related organizations of Japan in 2003, he moved to the Strategic Planning and Management Department of JAXA as Deputy Director and returned to Institute of Aerospace Technology in JAXA as Advisor to the Director in 2005. Form July 2006, he has been appointed as visiting professor of Asian Institute of Technology and will stay there until July 2009.

JAXA's Space Debris Related Activities: Mitigation and R&D
National Space Development Agency(NASDA) of Japan, one of the former bodies of Japan Aerospace Exploration Agency(JAXA), was the second space faring organization in the world that issued its own Space Debris Mitigation Standard. On the merger of three main space organizations of Japan, NASDA, ISAS and NAL, in 2003, newly established JAXA inherited this standard(NASDA STD-18) as JAXA JMR 003, which covers whole life cycle of space systems including the disposal operation phase. In addition, by the new president directive, established was the cross-organizational group which supervises and promotes all space debris related activities in JAXA, including R&D.
This lecture is intended to introduce the details of above mentioned JAXA's Space Debris Mitigation Standard(JMR 003), implementing structure of debris mitigation activities in JAXA and comparison with major world wide space faring organizations mitigation standard. Recent activity of the above mentioned cross-organizational group and some of the space debris related R&D focusing on JAXA's major interest are also to be introduced.

Dr Pierre Bourdon

Pierre Bourdon received the Ph.D. degree in physics and optics from the Ecole Polytechnique, Palaiseau, France, in 1995. From 1995 to 2004, he was a researcher at Département Laser, Optique et Thermo optique, Centre Technique d'Arcueil, Délégation Générale pour l'Armement, Arcueil France. Since 2004, he is a researcher at Département Optique Théorique et Appliquée, Onera, the French Aerospace Lab, Palaiseau, France.
His main research interests are fiber lasers, nonlinear optics, optical parametric oscillators and solid-state lasers. He dedicates most of his work to the development of laser sources for military applications such as laser weapons and laser dazzling.

High power lasers for laser-matter interaction: an overview of available technologies
The directivity of laser light enables remote deposition of very high levels of power over small beam diameters resulting in extremely high power-density delivered on a target material.
This capability to emit very intense beams with lasers is commonly used in many industrial applications such as laser cutting, laser welding or laser marking. High power lasers can also be considered for military applications and integrated in anti-structure laser weapons aimed at destroying military targets such as ammunitions or vehicles from kilometers away. As an introduction, I will give a general presentation of these industrial and military applications and the thermal and thermo-mechanical effects they rely on.
The lecture will go into more details about the different laser technologies available today and their basic principles of operation. The pros and cons of the different families of lasers will be compared, especially in terms of emitted power and wall-plug efficiency but also in terms of practicality.
Most of the talk will be focused on the many advantages offered by solid state lasers as well as on their main limitation which is the build-up of thermal load in the laser material when high levels of average power are solicited. The specific case of the semiconductor lasers will be discussed and the reasons for their use as pump sources for other solid-state lasers rather than as high power beam generators will be given.
Among all the solid state lasers available, fiber lasers stand out as an interesting choice for industrial and military applications, and the levels of power and efficiency that can be achieved with this type of lasers will be detailed.
Finally, the challenge of integration of high power lasers on aircrafts or space vehicles with limited space, load and available power supply, will be addressed. Some ways to estimate the weight, volume and electrical consumption of a laser will be proposed and from these figures, the limitations in terms of emitted power for airborne or spaceborne laser systems will be inferred.

The challenge of asteroid and debris deflection with high power lasers: fiction or (future) reality?
After introducing, during the first lecture, the pros and cons of high power lasers for laser-matter interaction in the frame of industrial and military applications, this second talk will focus on the use of lasers for the specific challenge of asteroid and debris deflection.
This lecture will proceed through comparison with very similar applications: laser cutting and laser weapons. As a matter of fact, in both cases, the laser system has to deliver very intense beams on a remote

target, an asteroid or debris in the first case, a material to be cut, a vehicle or an ammunition in the second case, in order to deliver energy on the remote target through heating of this target. In the case of laser cutting, matter melts under the high power laser beam resulting in drilling of the material. In the case of a laser weapon, the laser beam drills its access to the sensitive part of the target (either some explosive material, some fuel or some electronic component) through the superficial material of the target, thus resulting in its destruction.
Asteroid and debris deflection relies on similar effects: laser ablation of matter from the asteroid or the debris will induce a "rocket-like" effect and deflect the trajectory of the target.
In order to understand the main similarities and differences between laser cutting or laser weapon applications and space object deflection, the talk will discuss in more details the levels of power and characteristics of laser emission necessary to generate different physical effects from basic heating to more complex laser breakdown resulting in ablation of matter from the target.
Thresholds will be calculated and we will show how laser weapon ranges can be inferred from these threshold calculations in the case of laser weapon systems.
Referring to the limitations of high power lasers introduced during the first lecture, an analysis of the potential of high power lasers for this kind of purpose will be given and the main technological challenges yet to be overcome will be highlighted.
Finally, illustrating the talk by some examples of projects proposed recently, like the US DE-star project, feasibility of asteroid and debris deflection using lasers will be discussed and first technological milestones to be achieved in order to succeed will be proposed.

Network speakers

Dr Claudio Bombardelli

Claudio Bombardelli is a senior researcher in Space Science and Technology at the Technical University of Madrid, with 12 years of research experience in space dynamics, mission analysis, and advanced space technologies. He has so far published 26 papers in peer reviewed ISI-recognized journals and more than 30 papers in conference proceedings. He has been research fellow at the Harvard-Smithsonian Center for Astrophysics, the European Space Agency, and was recently awarded a "Ramón y Cajal" research fellowship from the Spanish ministry of education. He filed a patent on the Ion Beam Shepherd (IBS) space debris and asteroid deflection concept.

Advanced orbit propagation methods and application to space debris collision avoidance
The lecture will give an overview of the several orbit propagation methods proposed in the literature discussing their main features and comparing their performance with reference to classical orbit dynamics problems relevant to asteroid and space debris propagation. A special emphasis will be placed on the "Dromo" propagation scheme proposed by the Technical University of Madrid. It will be shown that the method can be exploited to provide a simple formulation of the dynamics of collision avoidance in the framework of the two-body problem.

Relevant Publications:
C. Bombardelli, "Optimal Impulsive Collision Avoidance", Advances in the Astronautical Sciences Volume 148. In press.
G. Baù, C. Bombardelli, J. Peláez, "A new set of integrals of motion to propagate the perturbed two-body problem", Celestial Mechanics and Dynamical Astronomy 116 (1), 53-78.
J. Peláez, M. Hedo, A. Pedro Rodriguez, "A special perturbation method in orbital dynamics", Celestial Mechanics and Dynamical Astronomy 97 (2), 131-150.

Ing Juan L. Cano

Juan Luis Cano is an Aeronautical Engineer graduated in 1994 at the School of Aeronautics of the Technical University of Madrid. Between 1995 and 1997 he enjoyed a grant at ESA / ESTEC at the Aerothermodynamics Section participating in several atmospheric ascent and re-entry studies as FESTIP and X-38. He then joined GMV in Spain and moved for two years to the Mission Analysis Section at ESA / ESOC in Germany, where he did support the SMART-1 study in mission analysis activities. Back to Spain in 2000, was co-founder of DEIMOS Space in 2001 where he has been involved in or managed many ESA projects, many of them related to interplanetary missions and NEO missions as BepiColombo, ExoMars, Don Quijote, A-Track, Proba-IP, SysNova/MOSAIC, SysNova/KABOOM, SSA-SN-VII, etc, and leads DEIMOS contribution to the FP7 projects NEOShield and Stardust. He is currently Head of the Mission Analysis and Navigation Division at ELECNOR DEIMOS.

Orbital dynamics about small bodies

Space missions to minor bodies have represented a limited field of exploration in the recent past (e.g. Giotto, NEAR, Hayabusa, Deep Impact and Rosetta), however represent a very promising field of research and space application in the future particularly after NASA's proposal to bring a small asteroid to Earth's vicinity in the next years. At ESA, a number of missions have been and are under different degrees of development as Rosetta (bound to arrive to its target in 2014), Marco Polo-R (in assessment phase), Proba-IP (phase 0 study in 2009) and the first planetary defense mission proposed in Europe, Don Quijote. In all the cases where the spacecraft is planned to rendezvous with its target the mission designers have to confront an orbital environment which is quite remarkable: a very faint and irregular gravity field, complex rotation states of the minor body, other small forces, etc, and in general, the need to consider complex non-keplerian motions about the body. In this lecture we will analyse the space environment about minor bodies, the orbital dynamical solutions, the stable orbits about minor bodies and also present a summary of missions to the asteroids.

Relevant publications

J.L. Cano, M. Sánchez, et al., “A-Track a Mission to Tag Asteroid Apophis”, 5th Conference on New Trends in Astrodynamics and Applications, Politecnico di Milano, Milan, Italy, June 2008, http://www.astrodynamics.eu/Astrodynamics.eu/AstroconV_Talks_files/Sanchez-AstroconV.pdf
G. Bellei, J.L. Cano, M. Sánchez, "Operational Orbiting Strategies About Minor Bodies", 21st International Symposium on Space Flight Dynamics, Toulouse, France, September-October 2009, http://issfd.org/ISSFD_2009/InterMissionDesignI/Cano.pdf
J.L. Cano, et al., “An ESA NEO Technology Demonstration Mission: PROBA-IP” (IAC-09-A3.5.09), 60th International Astronautical Congress, Daewon, South Korea, October 2009, http://www.iafastro.net/iac/archive/browse/IAC-09/B4/2/4668/

Prof Alessandra Celletti

Alessandra Celletti is full professor of Mathematical Physics at the University of Roma Tor Vergata. She obtained her PhD at the Swiss Federal Institute of Technology in Zuerich, under the direction of Jurgen Moser and Joerg Waldvogel. She has been invited speaker at several international conferences among which the "6th European Congress of Mathematics". Since 2001 she is President of the "Italian Society of Celestial Mechanics and Astrodynamics" and since 2010 she is member of the "Celestial Mechanics Institute".
Her main fields of interest are Celestial Mechanics, KAM theory, dissipative systems, chaos theory. She is author of more than one hundred articles, 6 books and several popular papers.
The asteroid 2005 DJ1 (117539) bears her name.

"From regular to chaotic motions in Dynamical Systems with applications to asteroid and debris dynamics"
Resonances, chaos and regular motions shape the dynamics of the objects of the solar system. The main belt asteroid is populated by thousands small bodies on regular trajectories, but close-encounters with the nearby planets can provoke the occurrence of mean motion resonances as well as chaotic orbits.
In a similar way, space debris are subject to regular, chaotic and resonant dynamics (compare the latter with the geostationary and GPS regions).
After introducing the appropriate models to describe the dynamics of NEO and space debris, I will specify the notions of chaos, resonances and regular motions. A reference to the main mathematical methods to detect and study such dynamics will be covered.

Related publications:
Celletti A., "Stability and Chaos in Celestial Mechanics", Springer-Praxis 2010, XVI, 264 p., Hardcover ISBN: 978-3-540-85145-5
Celletti A., "Regular and chaotic dynamics of periodic and quasi-periodic motions", in "Space Manifold Dynamics: Novel Spaceways for Science and
Exploration", E. Perozzi, S. Ferraz-Mello eds., Springer 2010, ISBN:978-1-4419-0347-1
Rossi, A. (2008). Resonant dynamics of Medium Earth Orbits: space debris issues. Celestial Mechanics Dynamical Astronomy 100: 267-286.

Dr Giovanni Gronchi

Giovanni Federico Gronchi is Assistant Professor in Mathematical Physics at the Department of Mathematics, University of Pisa. His research is on Solar system body dynamics, perturbation theory, orbit determination, singularities and periodic orbits of the N-body problem.
He is author of several papers, published in international peer-reviewed journals, and is co-author, with Andrea Milani, of a monograph on orbit determination. He is also member of Divisions 7 and 20 of the International Astronomical Union.

Orbit determination methods
The methods by Laplace and by Gauss for the computation of preliminary orbits and the least squares method introduced by Gauss for the orbit improvement will be reviewed. Charlier's theory, giving a geometric interpretation of the occurence of alternative solutions in preliminary orbit determination with the method by Laplace, assuming geocentric observations, will be explained. Then a recent generalization of this theory, with topocentric observations, will be shown, allowing attendees to extend the theory to observations made from satellites of the Earth.

Prof Colin McInnes

Colin McInnes is Director of the Advanced Space Concepts Laboratory at the University of Strathclyde. His work includes the investigation of families of novel spacecraft orbits and their mission applications, autonomous control of multiple spacecraft systems and advanced space concepts, reported in over 150 peer-reviewed journal papers. His recent work is exploring new approaches to spacecraft orbital dynamics at extremes of spacecraft length-scale to underpin future space-derived products and services, funded by an Advanced Investigator Grant from the European Research Council. Over the last ten years McInnes[1] work has been funded by a diverse range of international partners including research councils (ERC, EU, EPSRC, STFC), agencies (ESA, NOAA) and industry (EADS Astrium, Lockheed Martin ATC, Clyde Space).

Analytic modelling of the long-term evolution of orbital debris

The dynamics of the long term evolution of orbital debris is investigated using closed-form, analytical methods. The analytical solutions thus obtained describe the evolution of the debris distribution under the action of atmospheric drag for a class of initial distributions. By the addition of a debris creation function, the interaction of debris deposition and removal by atmospheric drag can also be investigated. The solutions give insight into the global dynamics of the long-term evolution of orbital debris.

Dr Patrick Michel

Patrick Michel is a planetary scientist who began his advanced education with a degree in Aeronautical Engineering and Space Techniques in 1993 whereafter he moved to the study of asteroids. He received his PhD in 1997 for a thesis titled "Dynamical evolution of Near-Earth Asteroids". He is a Senior Researcher at CNRS (French National Center for Scientific Research) where he leads the Lagrange Laboratory Planetology group at the Côte d'Azur Observatory in Nice (France). He is specialist of the physical properties and the collisional and dynamical evolution of asteroids. His work on numerical simulations of collisional disruption and asteroid family formation has been the subject of several publications and made the covers of both international journals Nature and Science. He is a co-chair of the MarcoPolo-R sample return mission science team and is a co-I on the NASA OSIRIS-REx and JAXA Hayabusa 2 missions. He is also involved in the AIDA project with NASA and ESA aimed at deflecting the secondary of the binary asteroid Dydimos using a kinetic impactor. He is also responsible of the Work Package on numerical simulations of asteroid deflection by a kinetic impactor in the European Consortium NEOShield funded by the FP7 program of the European Commission. He has wide involvement in the IAU and other international organizations (such as the Action Team 14 of COPUOS at the United Nation devoted to Impact Hazard). In 2006 he received the "Young Researcher" prize from the French Society of Astronomy and Astrophysics, in 2012, he was awarded the Carl Sagan Medal by the Department of Planetary Science of the American Astronomical Society, and in 2013 he was awarded the Prize Paolo Farinella in recognition of his work on the collisional process.

Physical properties of NEOs from space missions and relevant properties for mitigation.
The lecture will give a short overview on items such as, 1) what we can know (and we do know) about Near-Earth Objects from the ground; 2) theoretical advances that contribute to better understand NEO physical properties; 3) previous space missions to asteroids, with some highlights; 4) physical properties of NEOs, influencin the efficiency of mitigation strategies; 5) next steps to improve our knowledge on NEO physical properties and their response to various processes (e.g. impacts, thermal processes, tidal effects).

Dr Edmondo Minisci

Edmondo Minisci is Lecturer in Multi-disciplinary Design Optimisation at the Department of Mechanical & Aerospace Engineering of University of Strathclyde. Affiliated to the Centre for Future Air-Space Transportation Technology, cFASTT, he has more than 10 years experience in the field of CFD based analysis and design, working on the analysis of single-stage to orbit lifting body configurations and bi-rotoric small/medium size UAVs, as well as of on the multi-objective design optimization of marine and aeronautical propellers, subsonic airfoils and wings, (re)-entry vehicles and wind turbines. He is currently involved in projects regarding: a) global optimization of trans-atmospheric and interplanetary trajectories, b) multi-disciplinary uncertainty based design of space transportation systems, and c) uncertainty based design of innovative horizontal and vertical axis wind turbines.
Dr Minisci is also founder member and former general manager of OPTIMAD Engineering S.r.l. - Italian SME, Spin-off of the Politecnico di Torino, active in the field of aerodynamic analysis, design, and optimization.

Numerical methods for entry flow simulations
The ability to provide simulations of hypersonic flows with well-defined uncertainties on the predicted aerothermal characteristics is one of the critical aspects for the risk analysis and impact footprint determination of planetary entry objects. This lecture gives a brief summary of the fundamental attributes of hypersonic flows and an overview of challenges and state of the art for numerical aerothermodynamic simulation and validation of hypersonic flows.

Dr Bojan Novakovic

Bojan Novakovic is an Assistant Professor at Department of Astronomy (University of Belgrade), arriving in 2011. He graduated with a Ph.D. in planetary sciences in 2011, having earned his B.S. in astronomy in 2004, both from the University of Belgrade. Dr. Novakovic's research includes different topics related to dynamics and physics of asteroids. In particular, his work focuses on colisionally-formed asteroid families and covers wide range of related studies. He has also studied a new class of solar system objects, the so-called main-belt comets, and has been involved in some supercomputing programs.

Linking NEAs to their main-belt source regions

Asteroids preserve information about the earliest times in solar system history, information long lost from planets that have have evolved significantly since then. The best known is the population of near-Earth asteroids (NEAs), the objects that occasionally come close to the Earth. This is because a typical near-Earth asteroid is much easier to reach than a typical main-belt asteroid. There is obvious interest in NEAs in order to understand the threat they pose and the resources they promise, but they carry a rich bounty of scientific information as well.

Dynamical calculations show that lifetimes of NEAs are typically about 10 million years, eventually meeting their ultimate fate by crashing into the Sun, being ejected from the solar system, or impacting one of terrestrial planets. With such short lifetimes, NEAs observed today cannot be residual bodies that have remained orbiting among the inner planets since the beginning of the solar system. Instead, the NEA population must have some source of resupply.

Thus, objects formed at a variety of solar distances currently find themselves in near-Earth space. As it was confirmed by numerous dynamical studies, most NEAs originated in the main-asteroid belt, between Mars and Jupiter. Moreover, the most important transport routes are identified and well known.

In the recent years, advances in ground-based and mission work open possibility to link a specific NEA to a potential source region in the main belt. A current orbit of an asteroid, combined with physical properties, can give a good sense of where this object originated. In turn, this allows study of these nearby objects to gain insight into the outer reaches of the solar system and vice-versa. A few such links has been already established, but many more are expected to be settled in the coming years.

Dr Jan Paul

Dr. rer. nat. Jan Paul studied Computer Science and Physics at the Christian-Albrechts-Universität Kiel, where he graduated in 2000. He received his PhD in 2008 with a thesis on "MaxControl : ein objektorientiertes Werkzeug zur automatischen Erstellung von 3D-Computeranimationsfilmen und dessen Integration in eine professionelle 3D-Animationssoftware" where a simulation framework was developed for 3D computer animations. Since he joined the DFKI-RIC in 2009, Dr. Paul was the leader of the simulation project "Virtual Crater" and of the hardware in the loop simulation project "INVERITAS", which was a joint project including the additional partners EADS-ASTRIUM and Jena-Optronik. The main goal of INVERITAS was the prototypic realization of a broad-spectrum rendezvous and capture (RvC) system for satellite servicing. The primary task of the DFKI RIC was the development of a long-distance movement simulation system in hard- and software, and the development of alternative grasping strategies. Dr. Paul's research interests are in the area of the simulation of physical and behavioral properties of robotic systems and their environments.

Overview of DFKI-RIC research topics, focused on space robotics
The lecture will focus on the INVERITAS hardware in the loop simulation system for rendezvous and capture simulations between two satellites, as it was developed in the project of the same name. The INVERITAS project was a joint project between Astrium, Jena-Optronik an DFKI, where each partner had their specific tasks, and the lecture will focus on the DFKI part. The lecture will begin with an overview over the system's hardware setup, then it will give some insight into the control of the system and how the system was optimized. Measuring the precision of the system and optimizing it is a very important topic. The lecture will close with how we used simulations to evolve new capturing systems and show our contributions to the processing of optical sensor data.

Dr Ettore Perozzi

Ettore Perozzi obtained a Laurea degree in physics in 1981 at the University of Rome (Italy). Main research interests are: celestial mechanics, dynamics of solar system bodies, near-Earth and interplanetary mission analysis, scientific and exploration missions, near-Earth objects (NEO) hazard and mitigation, education and public outreach.
He has worked at the CNR Space Astrophysics Institute (Roma, Italy), at the European Space Operations Centre (ESOC, Darmstadt, Germany), at Telespazio (Roma, Italy), at the Observatoire de Paris Meudon (France) and is currently at Deimos Space (Madid, Spain) as project manager of the ESA NEO Coordination Centre.
Associated to INAF(National Space Astrophysics Institute), member of the Societa' Italiana di Meccanica Celeste e Astrodinamica, member of the International Astronomical Union (IAU). Asteroid 10027 bears his name.

On the accessibility of the Near-Earth Asteroids

Near Earth Asteroids (NEA) represent increasingly attractive targets for space mission. The US mandate to discover all objects larger than 140m has fostered the improvement of ground- based surveys in terms of both, detection and follow-up performances. After the success of the WISE mission, orbiting observatories devoted to NEA detection have been or will be launched soon. Direct exploration for both, science and mitigation (e.g. sample return, deflection missions) are under study or in an advanced phase of realization. The possibility to send a manned mission toward a Near Earth asteroid has also become a high priority and the Asteroid Retrieval Mission proposal is gaining an increasing momentum. In particular, small to intermediate size objects with low eccentricity and inclination orbits and semimajor axis close to 1 AU are a potential source of interesting targets for both, ground/space based observations and human exploration.
Within this framework the possibility of obtaining a general picture of the accessibility of the NEA population as a whole is extremely helpful when addressing space missions having different goals which, in turn, translate into different energy requirements. The H-plot representation is introduced to this end, and case studies are presented.

Dr Alessandro Rossi

Alessandro Rossi is working in the field of astrodynamics and space debris since the early 90's. Alessndro Rossi is an expert in the modeling of the long term evolution of space debris and mitigation strategies, impact risk assessment, optical observation and orbit determination of space objects. Alessandro Rossi developed the first European models for the long term evolution of the space debris population since the early 90s. He is one of the developers of the long term evolution model SDM. Author of more than 50 papers on international Journal with referees and more than 60 papers in conference proceedings. Since 1999 is a member of the Inter Agency Debris Coordination Committee (IADC) and from 2004 to 2006 served as Chairman of IADC Working Group 2 on modelling. The asteroid 1990 RV2 was renamed (5185) Alerossi in recognition of his contributions in asteroids and debris studies.

Dynamics of space debris and simulation of long term evolution of space debris population
The lecture will first focus on the dynamics of the space debris population in the different orbital regimes, from Low Earth Orbit to the Geostationary region, with some details of a few peculiar cases such as, e.g., the Medium Earth Orbit resonances. Then a short overview of the models for the long term evolutions of the overall population of Earth orbiting debris will be given, with particular emphasis on the models developed in the last decades by our group. Some recent results on the future evolution of the debris population will be finally shown.

Relevant publications:
Milani, A., Farnocchia, D., Dimare, L., Rossi, A., Bernardi, F., "Innovative observing strategy and orbit determination for Low Earth Orbit space debris", Planetary and Space Science, 62, 10-22 (2012).
Milani A., Tommei G., Farnocchia D., Rossi A., Schildknecht T., Jehn R., "Orbit determination of space objects based on sparse optical data", Monthly Notices of the Royal Astronomical Society, 417, 2094-2103 (2011).
Deleflie F., Rossi A., Portmann C., Metris G., Barlier F., "Semi-analytical investigations of the long term evolution of the eccentricity of Galileo and GPS-like orbits", Advances in Space Research, 47, 811 - 821 (2011).
Farnocchia D., Tommei G., Milani A., Rossi A., "Innovative methods of correlation and orbit determination for space debris", Celestial Mechanics & Dynamical Astronomy, 107, 169- 185 (2010).
Rossi, A., "Resonant dynamics of Medium Earth Orbits: space debris issues", Celestial mechanics and Dynamical Astronomy, 100,267-286 (2008).
Tommei G., Milani A. and Rossi A., "Orbit Determination of Space Debris: Admissible Regions", Celestial Mech. Dyn. Astr., 97:289- 304 (2007).
Valsecchi G.B. and A. Rossi, "Analysis of the space debris impact risk on the International Space Station", Celestial Mechanics and Dynamical Astronomy, 83, 63 -- 76 (2002).
Rossi A., G.B. Valsecchi and P. Farinella, "Risk of collision for constellation satellites", Nature, 399, pp. 743--744 (1999).
Rossi, A., L. Anselmo, C. Pardini, R. Jehn, "The new Space Debris Mitigation (SDM 4.0) long term evolution code", Proceedings of the Fifth European Conference on Space Debris, Darmstadt, Germany, 30 March- 2 April 2009, CD-ROM SP-672 (2009).

Dr Francesco Topputo

Francesco Topputo is co-funder and ex-CEO of Dinamica Srl, an Italian engineering firm. He got his PhD from Politecnico di Milano, Italy, on non-Keplerian orbits for space applications. With Dinamica, he has managed the ESA ITT study on Hybrid Propulsion Transfers, and he has taken part to other ESA studies as the ITT on End-of-Life Disposal for Lagrange-Point and HEO Missions. He is responsible for the activities of Dinamica in the FP7 project Stardust. He has also a position as assistant professor at Politecnico di Milano. He has authored or co-authored more than 70 publications.

Introduction to Optimal Control and Space Trajectory Optimization
The aim of this lecture is to introduce the optimal control theory and to specialize it to the case of space trajectory optimization. First, the basic notions of both optimal control theory and nonlinear programming problems are introduced. These two concepts are presented with the aid of examples, and the numerical implementation into a computational environment is shown. Next, the space trajectory optimization problem is presented, and practical problems are given. Both impulsive and low-thrust propulsions are treated.

Prof Massimiliano Vasile

Massimiliano Vasile is currently Professor of Space Systems Engineering in the Department of Mechanical & Aerospace Engineering at the University of Strathclyde. Previous to this, he was a Senior Lecturer in the Department of Aerospace Engineering and Head of Research for the Space Advanced Research Team at the University of Glasgow. Before starting his academic career in 2004, he was the first member of the ESA Advanced Concepts Team and initiator of the ACT research stream on global trajectory optimisation, mission analysis and biomimicry. His research interests include Computational Optimization, Robust Design and Optimization Under Uncertainty exploring the limits of computer science at solving highly complex problems in science and engineering.

He developed Direct Transcription by Finite Elements on Spectral Basis for optimal control, implemented in the ESA software DITAN for low-thrust trajectory design. He has worked on the global optimisation of space trajectories developing innovative single and multi-objective optimisation algorithms, and on the combination of optimisation and imprecise probabilities to mitigate the effect of uncertainty in decision making and autonomous planning. More recently he has undertaken extensive research on the development of effective techniques for asteroid deflection and manipulation. His research has been funded by the European Space Agency, the EPSRC, the Planetary Society and the European Commission. Prof Vasile is currently leading Stardust, an EU-funded international research and training network on active debris removal and asteroid manipulation.

Methods and Techniques for Asteroid Deflection
In recent years it has become clear that the deflection and manipulation of asteroids is far from being pure science fiction, and instead is becoming more of a necessity. Recent events have shown that an impact from an asteroid is a high risk event, though its probability is low. This talk will introduce some basic techniques to modify the trajectory and the tumbling motion of an asteroid and estimate the miss distance achievable with either impulsive or low-thrust actions. It will then present the mechanics of some asteroid manipulation methods and their potential effectiveness at relocating asteroids, avoiding a catastrophic impact with the Earth or capturing them.

Relevant publications:
Zuiani, F., Vasile, M, and Gibbings, A., (2012) "Evidence-based robust design of deflection actions for near Earth objects", Celestial Mechanics and Dynamical Astronomy, 114 (1-2). pp. 107-136. ISSN 0923-2958. http://strathprints.strath.ac.uk/40474/
Sanchez, J.P., Colombo, C., Vasile, M., Radice, G., "Multi-criteria comparison among several mitigation strategies for dangerous near Earth objects", Journal of Guidance, Control and Dynamics, Vol. 32, No. 1, 05.01.2009, p. 121-142. http://arc.aiaa.org/doi/pdf/10.2514/1.36774
Vasile, M. and Maddock, C. (2012) "Design of a formation of solar pumped lasers for asteroid deflection", Advances in Space Research, 50 (7). pp. 891-905. ISSN 0273-1177.
http://strathprints.strath.ac.uk/40476/

Dr Scott Walker

Scott Walker completed his undergraduate Aerospace degree in 2000 specialising in Aerospace Structures and went on to do his PhD in the Astronautics Research Group at the University of Southampton in the field of small satellite deployable structures. His PhD was awarded in 2004 and he remained at the University as a post doctorate researcher studying structural dynamics and non-linear damping. In 2007 he obtained a lectureship in the Astronautics Research Group at the University of Southampton.
His current areas of research include: satellite deployable structures, multifunctional structures, morphing structures and inflatable structures. He has performed consultancy work for both Surrey Satellite Technology Limited and Astrium UK and regularly gives lectures as part of the University of Southampton's Spacecraft Systems Engineering course held at ESTEC (ESA).

Rotational dynamics and attitude control of spacecraft
Attitude control is one of the key subsystems for any normal spacecraft mission. However in the context of rendezvous and capture of a non-cooperative target it places significant unpredictable demands on the design of the satellite system. These issues will be presented and discussed over two lectures.
The first lecture, entitled 'Rotational Dynamics' will introduce and hopefully reinforce the fundamental concepts of rotational dynamics and how these concepts have been exploited for spacecraft attitude control. The second lecture will build on these fundamental concepts and outline the key implications of these concepts for rendezvous and capture.

Complementary skills lectures

Dr Stuart Boon

Stuart Boon is Course Director of the Advanced Academic Studies Programme at the University of Strathclyde. Operating in the Organisation and Staff Development Unit, he teaches academic and research staff in the areas of teaching, learning, and assessment within the disciplines, course (re)design, building a successful research career, research design and bidding, public engagement for research, innovative assessment and feedback, and management and leadership in Higher Education. His main areas of research are in the fields of researcher development, networked learning, phenomenography and variation theory, and identity and risk in the digital domain.
Nationally, Stuart is the convener of the Scottish Higher Education Developers group and works closely with the Higher Education Academy, Universities Scotland, Vitae, the Quality Assurance Agency, and the Staff and Education Development Association. Stuart has published in a number of national and international journals relating to academic and researcher development and networked learning. He acts as a reviewer/referee for the International Journal of Academic Development, Practice and Evidence of the Scholarship of Teaching and Learning in Higher Education, Library & Information Science Research, and the Arts & Humanities Research Council.

Research/Professional Planning and Development
This session will focus on highlighting opportunities for career and professional development in research and academia. Special attention will be given to mapping current experience to future ambitions and developing pathways for personal success. The session will make use of Vitae's Researcher Development Framework and provide time for individual planning as well as discussion with peers.

Presentation Skills
This session will introduce participants to three underlying principles for making successful presentations. Looking in depth at these three principles, we cover such topics as defining purpose, considering your audience, achieving impact, use of PowerPointPresi and other presentation formats, stance and breathing, and voice. Whether you are giving your first conference presentation, working with the public, or teaching in a classroom, this session will serve as a practical exploration of best practice in presentation skills.

Dr Mark Haw

Mark Haw is Lecturer in Chemical and Process Engineering at the University of Strathclyde. His research looks at how the behaviour of matter on the nanoscale and microscale leads to behaviour on the more familiar everyday 'macro' scale: how do the nano/micoscale activities of molecules, particles and granules lead to material properties, the design of processes, features of the natural environment, and even how living things function. The research uses a range of techniques from microscopy and laser scattering/tweezing in the lab, to computer simulations. Mark has a degree in Physics with Astrophysics and a PhD in the physics of soft and colloidal matter. Mark's experience in engaging the public with research includes a popular science book on the physics and history of Brownian motion to news and feature articles on topics as diverse as black holes and tuberculosis, as well as appearances at Café Scientifique and Famelab, and school lectures. Mark also heads up the University of Strathclyde's Public Engagement Group and has helped developed Strathclyde's accredited Becoming an Engaging Researcher class aimed at PhD students and researchers at all stages of their careers.

Engaging the public—who, what, how and why?
With various examples I will show how engaging people outside of your immediate circle of expertise can have big benefits to your career and your research, not to mention be a lot of fun. 'The public' can mean a lot of things—so just who is your audience? There are many ways to 'engage'—so what to do and how best to get started? And finally, why engage—how can it help you be a better researcher, get you more funds to do your research, and help everyone around you get more out of your results?

Dr Elsa Joao

Dr Elsa João is Senior Lecturer and Director of Postgraduate Studies at Department of Civil and Environmental Engineering, University of Strathclyde. She graduated in 1985 with a BSc in Environmental Engineering from the New University of Lisbon, Portugal, undertook an MSc in Geography at the University of North Carolina, USA and did her PhD in Geography at the University of London. In the UK she has taught at more than five Universities including the London School of Economics. At the University of Strathclyde in Scotland (where she has taught since 2001) she created and is the course leader of the first MSc in Environmental Entrepreneurship in Europe (http://www.strath.ac.uk/civeng/pg/enventrepreneurship/).
Dr João has expertise in the areas of Strategic Environmental Assessment (SEA), Environmental Impact Assessment (EIA), environmental analysis, Geographical Information Systems (GIS), scale effects, spatial data quality and enhancement of positive impacts. She is one of the academics leading SEA in the UK. Since 2002 she has trained more than 500 practitioners on SEA from more than 60 different organisations. Her current research focuses on how enhancement can improve project design & strategic planning. She is part of the newly created Scottish Government-sponsored Centre of Expertise for Climate Change, which includes more than 70 people from 18 different organisations in Scotland. She also contributes to the research of the sustainability category of the Scottish PLC awards.
In addition to her normal teaching duties in the Department of Civil and Environmental Engineering, every January for the last five years she also teaches writing for the PhD thesis and for publication to more than 150 PhD students across all disciplines at the University of Strathclyde.

Writing skills for academic purposes
This talk will discuss key writing skills: writing up vs. writing down, plain language, editing, rewriting, literature review, structuring and style decisions. In particular the talk will attempt to destroy two great myths associated with writing for research: a) that you do the research first, and then, maybe years later, you write it up, and b) that what matters is correctness of content and facts; the way it is written, presented and structured does not really matter.

Collins building