RAS Specialist Discussion Meeting

Science Enabled by the Global Exploration Roadmap

Abstracts


The second iteration of the Global Exploration Roadmap (GER) was released in August 2013 by the International Space Exploration Coordination Group (ISECG). The GER represents a major step forward by space agencies in collaboratively planning future human space exploration scenarios. The updated GER builds on the initial efforts by space agencies to prepare for future human exploration of the solar system and reflects the current status of their ongoing road-mapping effort. It reflects the work of space agencies to identify common exploration goals and objectives and look for feasible and sustainable approaches to meeting them. While this work focuses on human space exploration road-mapping, it is recognized that robotic missions are also planned to destinations where humans may someday live and work. Initially, robotic missions will gather high priority science information and contribute to the knowledge base that informs future human missions. Later, they will explore together with humans, taking on roles which increase return on exploration mission investments. Looking for ways to increase the synergies between human and robotic exploration missions for the benefit of all stakeholders is considered an important element of a sustainable space exploration effort.

This talk will provide an overview of the ISECG and its role as a non-binding, open coordination forum for space agencies interested in informing their individual exploration programs and projects, as well as contributing to planning future exploration mission scenarios. The talk will also provide an overview of the updated GER. Lastly, the importance of ISECG and the significance of the GER in NASA’s effort will be discussed.


Jeremy Curtis (UK Space Agency) has been the UK representative to ISECG since its inception in 2007 and before that helped draft the Global Exploration Strategy. This articulated an international shared vision of coordinated human and robotic space exploration focused on Solar System destinations where humans may one day live and work, and called for an international coordination mechanism - which came to be known as ISECG. Jeremy will talk about the UK involvement in the GER, and another ISECG product - the Benefits White Paper - which attempts to distil a large body of evidence into a few key observations about the capacity of
space exploration to benefit society through contributions to innovation, culture and inspiration, and new means to address global challenges.

**Sylvie Espinasse (ESA): Synergies between science driven missions and human exploration preparation: Strategic Knowledge Gaps**

In order to prepare for safe and efficient human exploration beyond low Earth orbit (LEO), mission planners will need access to data that characterizes the boundary conditions of exploration destinations environments, identifies hazards, and assesses resources. Such data can be obtained in space through robotic missions and/or on Earth. The ISECG Strategic Knowledge Gap Assessment Team was tasked with developing an internationally integrated and prioritized set of SKGs to inform efforts at planning human and robotic precursor exploration of human exploration destinations. The effort also mapped the SKGs to currently planned robotic missions that will contribute to filling the SKGs and identified those high priority SKGs not currently being addressed. This assessment showed how robotic science missions provide an important venue for obtaining the data needed to prepare for human exploration beyond LEO and that data sets obtained from these missions support both the advancement of science and preparation for human exploration.

**Helen Fraser (Open University): Researching and Understanding Future Solar System Exploration via ELIPS Science Facilities**

For me as an astrochemist there are a set of fundamental questions that drive my research; how does life originate - is it prolific in the universe? And when is life a by-product of the process of star and planet formation? On the one hand such research (as ASTRONET explains) requires observational and laboratory understanding of the chemical evolution of our universe as stars and planets form; on the other the debate is reliant on evidence and data from our nearby "laboratory" - the solar system. With Mars , the Moon and near-Earth Asteroids featuring as key exploratory elements in the Global Exploration Roadmap, it is clear that significant research and development work is required to both understand and interpret data from such exploration, and connect the missing links between remote observing and 'local' visits - by probes and humans. From the perspective of the Physical Sciences such preparatory activities will be strong rooted in utilising ELIPS microgravity facilities, particularly drop-tower experiments, parabolic flights (in '0'-g, lunar , Martian and asteroid gravitational conditions) as well as ISS experimental facilities. Here I hope to give a perspective of on-going and required research into dust aggregation and regolith formation (for data analysis and interpretation), as well as technology drivers for e.g. sample return missions, and linking chemical and biological processes to physical ones.

**Simon Evetts (UK Space Biomedicine Consortium): Space Biomedicine research opportunities from the Global Exploration Roadmap**

To fully explore our solar system we will require humans to spend long periods of time in an extreme environment which in many ways adversely affects the human body when Earth
standards are retained as the reference for 'normal'. At present the physical deconditioning (muscle, bone, neuromotor control) we see after six months on the International Space Station highlights that longer deep space missions will pose a challenge. Science will need to make advances in fields such as biomedicine, telemedicine and radiation protection, to prevent unacceptable detriments to our astronauts over the course of the 2 to 3 years these missions are expected to take. Furthermore, given the nature of this hazardous environment the risks of certain medical emergencies will need to be minimised, preventative measures will need to be taken and appropriate treatments will need to be developed to ensure an acceptable level of safety and care exists. Looking beyond the physical, we can see that the isolation, confinement, cultural and social deprivation and the stress of undertaking missions of this nature, are such that the psychological and team dynamic aspects of the mission will also be crucially important.

The need to deal with the above issues requires space life science researchers to understand the aetiology of the effects of long-term space travel to enable acceptable physical and psychological standards to be retained, and to be able to minimise medical risks and enable crew to react to and treat medical emergencies effectively, both in space and hypogravity environments. Given that the effects of long-term space travel can be likened to accelerated ageing, the search for solutions to space exploration needs will lead to a concomitant increase in our understanding and ability to prevent and treat terrestrial health issues related to ageing. Medical care through remote means, the prevention of the deleterious effects of space exploration and an augmented ability for autonomous diagnosis and treatment, will offer terrestrial healthcare advances that both developed and undeveloped societies will benefit from. The forthcoming ageing crisis in developed societies is such that biomedical R&D conducted now to prepare ourselves for the exploration of our solar system, will benefit healthcare on Earth in the years to come.

Heino Falcke (Radboud University/ASTRON): Astronomy and the Global Exploration Roadmap

The exploration of remote places on other planets has now become a major goal in current space flight scenarios. On the other hand, astronomers have always sought the most remote and isolated sites to place their observatories and to make their most precise and most breathtaking discoveries. Especially for radio astronomy lunar exploration offers a complete new window to the universe. The polar region and the far-side of the moon are acknowledged as unique locations for a low-frequency radio telescope providing scientific data at wavelengths that cannot be obtained from the Earth nor from single satellites. Scientific areas to be covered range from cosmology, to solar-system studies, exo-planet detection, and astroparticle physics. Moreover, it may be interesting to revisit the possibility of installing telescopes operating at other wavelengths, such as optical, near-infrared, or even X-rays, which would benefit form a large stable platform in space and a space infrastructure that provides access to it. Finally, as current space telescopes keep growing in size, also large free-flying observatories could benefit from heavy-lift and in-orbit assembly opportunities developed within the exploration program.
David Kring (Lunar and Planetary Institute, Houston): Integrated robotic and human exploration of the Moon within the context of the 2013 Global Exploration Roadmap

The Moon is the most accessible target for space exploration beyond low-Earth orbit. It provides technical challenges that will sharpen our ability to explore more distant targets. It is a destination worthy of exploration: we have never been to the far side of the Moon, the western limb, or either one of the polar regions. Most of the Moon remains unexplored. It is also a noble scientific destination: it is the best target to evaluate the origin and evolution of the entire Solar System, including the earliest evolutionary phase of our own planet, Earth, a period of geologic activity that has since been erased from Earth’s rock record. The Moon contains evidence of planetary accretion, the production of magma oceans and planetary differentiation, and the collisional processes that shape planetary surfaces, the latter of which is essential to our evaluation of environmental and biologic consequences of impact cratering events, both on Earth and other potentially habitable worlds like Mars. Recent work suggests there may be an intriguing array of volatile element deposits on the Moon, which can both be used to further tease apart the collisional evolution of the Earth-Moon system and provide in situ resources that may ease the economic hurdles of exploration beyond the Moon.

James Carpenter (ESA): GER enabled Science at the Lunar Surface

The Global Exploration Roadmap provides an indication of the combined plans and aspirations of many of the world’s space agencies and provides guidance for planning future scientific investigations. Science does not provide the justification for the GER and the GER is not derived to meet scientific objectives, however once established the sequence of missions outlined in the GER would provide an unprecedented opportunity for scientific research. In this presentation we will discuss some of the scientific opportunities that the GER can offer, with an emphasis on science that can be enabled by renewed access to the lunar surface and the return of lunar samples. Such samples can be used to address scientific questions relating not just to the Moon but to areas as diverse as the emergence of life, the history of the inner solar system and the passage of the Solar System through the Galaxy.

Monica Grady (Open University): Exploration of Mars: rocks, then robots, then people?

Mars has always exerted a fascination on humans in terms of its potential for exploration (it is relatively close) and also its potential for hosting life (it is a rocky planet that has obviously had volcanoes and water in its past). Mars is the ultimate goal of the recently published Global Exploration Strategy: obviously robotic exploration prior to human exploration. We know a lot about Mars from the different missions (fly-by, orbiter, lander) that have visited the red planet in the five decades since space exploration began. We also explore Mars from analysis of martian meteorites, igneous rocks removed from the surface of Mars by impact and delivered at random to the Earth. But there is more that we need to know and understand before we can send humans to Mars and bring them back again safely. At the very least, we need to bring a rock back from the surface of Mars. In this talk I will describe briefly a possible mission that will be a valuable and important step in the progress towards human exploration of Mars. In the longer term the
exploration of Mars, and the search for past or present life, is likely to benefit from eventual human exploration

Mark Sephton (Imperial College London): Astrobiology research opportunities arising from the Global Exploration Roadmap

The Global Exploration Roadmap prescribes a stepwise development of exploration into the Solar System with the medium term goal of human missions to Mars. The necessary development of technologies and investigation of planetary environments provides opportunities for astrobiology. In the search for life, assessment of habitability and solar system targets such as the asteroids, Moon and Mars can all act as indicators of how planet formation can evolve to produce different consequences. The detection of organic remains is another high priority activity and various biosignatures can be sought with a focus on both how they may be produced and how they may be preserved. Many of our space based astrobiological objectives can have terrestrial applications in the form of education, public engagement, health and industrial stimuli.

Mark Burchell (University of Kent): Asteroid science opportunities resulting from the Global Exploration Roadmap

Human and robotic exploration of space are often discussed totally separately, with apparently independent aims. Part of this of course is because there has been little human exploration in space since the Apollo era – whilst astronauts now conduct research on the ISS no one has ventured beyond Low Earth Orbit since the last Apollo mission. The development of a new human deep space capability by NASA offers the opportunity to remedy this. It is timely therefore to integrate scientific goals into mission objectives as early as possible. Over the last few years the topic of an asteroid mission by NASA astronauts has arisen. The goals have varied somewhat as the proposal develops. In this talk the importance of asteroid studies is reviewed (see Burchell et al., 2013 for a recent review of future robotic missions to minor bodies including asteroids) and the role human spaceflight can play in best achieving and extending these goals is considered.


Ian Crawford (Birkbeck College): The Global Exploration Roadmap: towards an integrated scientific and societal case for global space exploration

An ambitious programme of robotic and human space exploration, such as envisaged by the Global Exploration Roadmap, will add greatly to human knowledge. Gathering such knowledge is the primary aim of science, but science's compartmentalisation into isolated academic
disciplines tends to obscure the overall strength of the scientific case. Any consideration of the scientific arguments for space exploration must therefore take a holistic view, and integrate the potential benefits over the entire spectrum of human knowledge. Moreover, science is only one thread in a much larger overall case for space exploration. Other threads include economic, industrial, educational, geopolitical and cultural benefits [1]. Any responsibly formulated public space policy must weigh all of these factors before deciding whether or not an investment in human space activities is scientifically and socially desirable, and the Global Exploration Roadmap is a significant positive step in this direction.

http://www.homepages.ucl.ac.uk/~ucfbiac/Space%20Interests_files/EMP_HSF_paper.pdf

POSTERS

Setnam Shemar (1), George Fraser (2), Lucy Heil (2), Adrian Martindale (2), Philippa Molyneux (2), John Pye (2), Robert Warwick (2) & Andrew Lamb (1): XNAV – Deep Space Navigation with X-ray Pulsars

The discovery of the first pulsar was made in 1967 after noticing the periodic pulsations from an extremely strong astronomical radio source. Such sources are now widely known to be compact and strongly magnetised neutron stars, remnants of the death of a massive star in a supernova. Here we describe a recently completed study, conducted by the National Physical Laboratory and the University of Leicester for the European Space Agency, on the feasibility of using X-ray timing observations of pulsars for deep space navigation, a technique commonly referred to as ‘XNAV’. We have used simulations to identify the best combination of navigation strategy and X-ray pulsars with respect to predicted performance, taking account of current and future X-ray instrumentation. The XNAV technique would allow increased spacecraft autonomy, improved position accuracies and lower mission operating costs compared to the NASA and ESA Deep Space Networks (DSN). We have also used a high-level navigation algorithm together with real data for the Crab pulsar to demonstrate key elements of XNAV. X-ray instrumentation suitable for use as a spacecraft operational subsystem must be designed to use only modest spacecraft resources. Potential instrumentation has been designed in the context of the Mercury Imaging X-ray Spectrometer for ESA’s BepiColombo mission to Mercury and is in development.

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A highly skilled six-person crew of scientists and engineers, primarily from the UK, have just been confirmed a place for the coming season at the Mars Desert Research Station (MDRS).

MDRS is a facility based in the high-altitude desert of Utah dedicated to developing the required field tactics and protocols associated with a manned-mission to Mars. There, whilst under constant observation and undergoing psychological and food studies, selected crews conduct relevant research and fieldwork in a full astronauts-on-Mars simulated environment over two-week rotation periods.

The Mars UK Crew will be conducting a wide range of projects in association with NASA, ESA, and CSA between Jan 18th and Feb 1st, 2014. Some of these projects include the field-testing of a 270kg CSA lunar rover, the Artemis Jr., scheduled for launch in 2018, with a range of NASA and ESA instruments on-board, terrain-mapping with a CSA drone built to fly in the tenuous atmosphere of the Red Planet, extreme weather-testing of candidate micro-organisms for terraforming the Martian atmosphere to something more hospitable for humanity, and even testing of prototype spacesuit ultrasonic glove technologies and a NASA microgravity countermeasure biosuits.

On top of this, the crew will be conducting public-outreach activities including the partaking in the filming of a documentary of the two expedition, daily Skype classes with UK schools, writing articles in popular science magazines, and radio interviews.

(1) University of Bristol, International Space University, Applied Computing & Engineering Ltd., (2) GLCS Consortium (ESA, NASA, MIT, KCL, Wylie GmBh), The Space Clinic, (3) University of Bristol, NASA JPL, UCL, Caltech (4) Neptec, CSA, International Space University, (5) University of Bristol, (6) International Space University, NASA Ames, Hindustan Aeronautics Ltd.

Abigail Calzada-Diaz (Birkbeck) and Jane MacArthur (UCL): Young Perspectives on the Global Exploration Roadmap

The student and young professional community were surveyed via such channels as the Space Generation Advisory Council (SGAC) and UK Students for Exploration and Development of Space (UKSEDS), to find out levels of awareness of the Global Exploration Roadmap (GER) in the 18-35 age group, and canvassed for their opinions about its central themes of robotic and human exploration. Over 50 people replied and here is a summary of the results and ideas.

Most of the respondents showed that they are aware of the GER and its implications for the future of exploration, however, a considerable percentage (up to 36%) had not heard of it. Among the projects proposed in the GER for the next 20 years, additional projects were proposed such as robotic missions through the Solar System, prioritising Europa and Titan, and the creation of a Lagrange point (L2) Space Station.

The majority of the respondents agree on the need to create a special proposal for the GER international policy (80%) and 1 out 4 think that is important to include a specific legal proposal of regulations that might be applicable to the GER. Also, the survey shows that the young community is quite sceptical about the role that the United Nations should play in an international space cooperation scenario placing greater importance on special inter-agency collaborations. It was widely agreed that China should be participating in this roadmap.
More than 70% of responses think that “to inspire young people in Science, Technology, Engineering and Maths (STEM)” is very important. It was indicated that space agencies should have higher presence in schools and high schools. Additionally, raising space exploration awareness among the space community should be considered a duty.