# THE 10TH ANNUAL SPACE GENERATION CONGRESS

SGC

2011

29 SEP - 1 OCT

CAPE TOWN

# FINAL REPORT

www.spacegenerationcongress.org

SPACE GENERATION ADVISORY COUNCIL
in Support of the United Nations Programme on Space Applications

c/o European Space Policy Institute (ESPI)

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# SPONSORS AND PARTNERS

The 2011 Space Generation Congress (SGC) would not have been possible without the generous support of our sponsors. This year our sponsors provided more support than ever through subject matter experts, speakers, reports, data, and other support to the intellectual content of the Space Generation Congress. The Space Generation Advisory Council (SGAC) would like to thank them for their contributions to one of the most successful Space Generation Congresses in SGAC history.

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The Department of Trade and Industry (DTI) of the Republic of South Africa

## Awardees of the Space Generation Keystone Supporter Award

In light of SGC's 10th Anniversary, SGAC's leadership felt it was necessary to recognise key people and organisations who have consistently and significantly supported SGAC through its growth, particularly in the past few years. SGAC extends its deepest gratitude to its Keystone Supporter awardees for their dedication and commitment to supporting the next generation of space sector leaders.

Cynda Collins Arsenault Jim & Lin Burke Secure World Foundation

NASA Lockheed Martin

# LETTER FROM SGC CHAIRS

It is with great pleasure that we present to you the Executive Summary of the Space Generation Congress 2011 report, held September 29 to October 1 in Cape Town, South Africa.

This year's congress attracted the largest number of delegates since 2002 – 130 university students and young professionals from 43 countries. All were highly motivated and worked hard to tackle the issues that the five project groups invited them to discuss and make recommendations. Additionally, a remarkable group of guest speakers attended SGC delegates including, Charles Bolden (NASA Administrator), Berndt Feuerbacher (President of the International Astronautical Federation), Dumitru Prunariu (Chairman of the United Nations Committee on the Peaceful Uses of Outer Space), and many others.

SGAC strives to to increase the participation of university students and young professionals in more space events around the world. This year we provided 35 travel and registration scholarships to people who would otherwise be unable to attend SGC and the International Astronautical Congress. Year on year, SGC provides an opportunity for young people from all over the world to come together, connect with similarly enthusiastic young people, learn a little more about their industry and provide their input to the space community. We hope that SGC 2011 helped to foster new ideas and showcase the creative thinking of this generation of space leaders.

We would like to thank Ariane Cornell, SGAC Executive Director, and the Cape Town Local Organising Team for their tireless efforts coordination the event.

We look forward to building on the success of this year's SGC and furthering our involvement in the international space community. In particular, we welcome to our team Deputy Executive Director, Andrea Jaime, who will be leading the organisation of the SGC in Naples, Italy in 2012.

We hope to work with you all again next year and thanks once again for making SGC 2011 such a success!

Michael Brett — Chair

Catherine Doldirina — Co-Chair

# LETTER FROM SGC CONGRESS MANAGER

At the beginning of the planning of SGC 2011, the SGC 2011 organising team knew the task was going to be difficult. SGC 2010 had broken SGAC scholarship records, had produced reports with intellectual depth, and had garnered many new partners and supporters of SGAC. How were we to top that?

With any challenge, though, comes opportunity, and the SGC 2011 organising staff rose to the occasion. This year our organising team was comprised of 21 people from 16 different countries on six continents. The team worked together to develop a strong programme for the working groups, a lineup of speakers that included the top leaders from around the international space sector, colorful, cultural networking events, and a group of sponsors that led to another record-breaking scholarship year.

We would like to personally thank the organising staff for their hard work and dedication in making the tenth edition of SGC truly a historic event for SGAC. SGAC would also like to thank the local organising team for their support throughout the organisation process.

The bar has been raised yet again for 2012. We look forward to seeing you back next year at SGC, this time in Naples, Italy, for what will be another historic Space Generation Congress!

Ariane Cornell

Executive Director and Congress Manager

# SGC 2011 CONFERENCE OVERVIEW


**Delegates of the 10$^{\text{TH}}$ Annual Space Generation Congress**

The Space Generation Congress is the annual meeting of Space Generation Advisory Council in Support of the United Nations Programme on Space Applications. The three days of the SGC 2011 brought together both young and experienced players in the space sector from more than 40 countries for inspiring, resourceful engagement. The milestone 10$^{\text{th}}$ Annual SGC 2011 was held in Cape Town, South Africa from September 29 to October 1, prior to the 62$^{\text{nd}}$ International Astronautical Congress (IAC). The Congress sold out at 130 delegates which was a 30% increase compared to last year, which demonstrates SGC is becoming a highly desirable opportunity on the space community's calendar.

Attendees heard perspectives on space issues from leaders of the world's space organisations, including: the International Astronautical Federation (IAF), National Aeronautics and Space Administration (NASA), Nigeria's National Space Research and Development Agency (NASRDA), South African National Space Agency (SANSA) and United Nations Committee for the Peaceful Uses of Outer Space (UN COPUOS), among others. Conversely, leaders from these space organisations had the occasion to gain an insight into the fresh, innovative and bold perspectives of the incoming space generation regarding the five main SGC 2011 themes: Industry, Agency, Exploration, Society, and Outreach. SGC 2011 was organised by a group of volunteers from across the world and supported by several sponsors. The 2011 Space Generation Congress would not have been possible without either, and SGAC would like to express, again, its appreciation and gratitude.

# SPEAKERS

| | |
|---|---|
| Charles Bolden | NASA Administrator |
| Berndt Feuerbacher | President of the International Astronautical Federation (IAF) |
| William Gerstenmaier | NASA Associate Administrator for Space Operations |
| Alison Gibbings | PhD student at University of Strathclyde |
| Graham Gibbs | Senior Policy Coordinator Government Liaison Office, Canadian Space Agency (CSA) |
| Kevin Govender | Director of the Global Office of Astronomy Development (OAD) |
| Andreas Hornig | Aerospace engineering student Stuttgart University |
| Sandile Malinga | CEO of the South African National Space Agency (SANSA) |
| Peter Martinez | Head of Space Science and Technology Division at the South African Astronomical Observatory (SAAO) |
| Fritz Merkel | Member of the Executive Board OHB System AG |
| S.O. Mohammed | Director General of Nigeria's National Space Research and Development Agency (NASRDA) |
| Dumitru Prunariu | Chairman of the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS) |
| Sergey Saveliev | Deputy Head of Russian Federal Space Agency (ROSCOSMOS) |
| Will Watson | Executive Director of the Space Frontier Foundation |
| Ray Williamson | Executive Director of the Secure World Foundation |
| Tanja Masson-Zwaan | President of the International Institute of Space Law |

Confirmed but unable to attend: Vladimir Popovkin (Head of ROSCOSMOS), Johann-Dietrich Wörner (Chairman of the Executive Board of DLR), & Steve MacLean (CSA President).

*Please see [www.youtube.com/user/spacegeneration](www.youtube.com/user/spacegeneration) for selected speeches.*

# CONGRESS HIGHLIGHTS

## Day One

- SGAC Chair, Michael Brett, officially opened the conference and welcomed delegates, expressing his excitement and high expectations about this year's tenth anniversary Congress.
- SAASTA Outreach speaker, Kevin Govender, talked about both the benefits from space for developing countries as well as the necessary steps to implement space technologies into the societies of developing countries.

Kevin Govender

- Move an Asteroid Competition Winner, Alison Gibbings, shared her innovative, technical solution for deflecting Near Earth Objects (NEOs) using a smart cloud.
- Delegates dispersed into each of their working groups to discuss about the specific topics of the project groups.
- Secure World Foundation Society Speaker, Ray Williamson, talked about integrating space technology into society and overcoming societal, political, economic and logistical roadblocks through identifying the difficulties as well as potential ways to facilitate the integration of space technologies into society.
- The second session for Working group time started right after the speech.
- A *Getting to Know the IAC* presentation was given by Michael Brett to help introduce the big annual Congress that follows SGC.


Ray Williamson

- SGC 2011 delegates participated in the Opening Dinner and Culture Night Presentations, which truly emphasized the multi-cultural and multi-talented nature of the SGC attendees.

## Day Two

- OHB-SGAC Award Winner, Andreas Hornig, presented his innovative mission to the Moon that earned him the 2011 OHB-SGAC scholarship.
- Exploration Session Speaker, Fritz Merkle, made a short overview of the history of exploration, focusing on the necessity to design cost-effective lunar exploration missions. He encouraged SGC 2011 delegates to get involved in

Merkle and Gerstenmaier

exploration.

- NASA Agency Speaker, William Gerstenmaier, talked about the importance of spectrum in relaying mission data transmitted back to Earth. He also touched upon the complexity of spectrum management and how the international players interact.
- William Watson gave an introduction to the Space Frontier Foundation and put forward the ideas that the human species needs to extend our lives into space and that commercial competition is an important enabler.
- Our delegates, then, joined for the Working group time, to keep their discussions.
- Industry Session Speaker, Peter Martinez, talked about current international space security activities and initiatives. He focused on space infrastructure and the difference between space security and space sustainability.
- The fourth Working group time session started, where delegates focused even more on their debates and the preparation of the presentation of their conclusions.
- SGC 2011 delegates attended the SGAC Project Team Info Session where they were introduced with the four main projects SGAC supports throughout the year: Near Earth Objects (NEO) Working Group, SGAC Group on Space Technologies for Disaster Management, Space Safety and Sustainability (SSS) Working Group and Youth for Global Navigation Space Systems (YGNSS).

**Delegates discussing and debating space debris in the Industry Project Group**

### Day Three

- SGAC Executive Director, Ariane Cornell, gave a short introduction of this year's special SGC Anniversary Day, which celebrated the ten years of SGC and was highlighted by the Congress' Featured Speakers.

- Sandile Malinga talked about South Africa's involvement in space and astronomy, pointing out how important it is for a developing country to use space science and technology to benefit people on the street.
- Sergey Saveliev introduced the Russian space activities and their heritage and commented that he was proud that the example of his country inspires the young generation to explore space.
- Berndt Feuerbacher in his speech underlined the strong bonds and partnership between SGAC and IAF and encouraged students and young professionals to voice their opinions on space activities.
- Graham Gibbs talked about Canada's investment in space activities with the goal to advance national policy issues as security. He also touched on CSA's contribution to spaceflight, next to international partners.
- Tanja Masson-Zwaan gave a short presentation on Women in Aerospace Europe and its goal. She also highlighted the partnership opportunities between WIA-Europe and SGAC, encouraging delegates, both female and male to get involved.

S.O. Mohammed

- SGAC Co-Chairs and WIA-Europe representatives also signed a cooperation agreement between the two organisations.
- S.O. Mohammed introduced the Nigerian space programme and talked about the need for space technology development in Africa.
- Dumitru Prunariu introduced the SGC delegates to the goals of UN COPUOUS and presented his view in regards to the diverse pool of benefits that space brings to people.
- SGC delegates presented their fresh perspectives on the issues connected with Industry, Agency, Society, Exploration and Outreach, which they had discussed in the previous two days. The presentation session was moderated by SGAC Co-Chair, Catherine Doldirina, and was attended by many of the day's Featured Speakers including Charles Bolden and Sandile Malinga.


Charles Bolden

- The formal closing dinner was attended by SGC delegates and prominent international leaders of the space sector. The featured speaker, Charles Bolden started with a short summary of the ideas he had learned during the SGC presentations earlier in the day and assured the delegates that he will take the SGC insights back home to share with other leaders of the space sector. Bolden also stressed that he is well aware that he "has to provide the leadership and exploration you [SGC 2011 delegates] expect from me."

- Also during the closing dinner, the first Space Generation Keystone Supporter Awards were given to five supporters – Cynda Collins Arsenault, Jim & Lin Burke, Lockheed Martin, NASA, and the Secure World Foundation – in recognition of their dedication to the development of SGAC and its members. Also during the dinner, SGAC's Co-Chairs, Michael Brett and Catherine Doldirina, and SGAC Executive Director, Ariane Cornell, presented certificates to the 32 delegates that SGAC had supported through sponsorship with support of its partners to come to Cape Town. These scholarship winners came from 24 different countries.

# CONGRESS THEMES & RECOMMENDATIONS

At the core of SGC 2011 were the working groups, where delegates discuss their views on the development of space and prepare a set of recommendations to be published internationally by SGAC. Each theme-working group produces a report on their discussions and recommendations, which will be shared with the United Nations as well as SGAC sponsors, members, and alumni around the world. SGAC would like to thank its key session supporters for making these SGC sessions possible: NASA SCaN, DLR, SAASTA, the Secure World Foundation and SGAC's anonymous donor.

**Crowded Earth Space.**

**Credit: Universe Today**

## Industry – The Political and Technological Challenges of Space Debris and Its Mitigation

**Supporter: SGAC's anonymous donor**

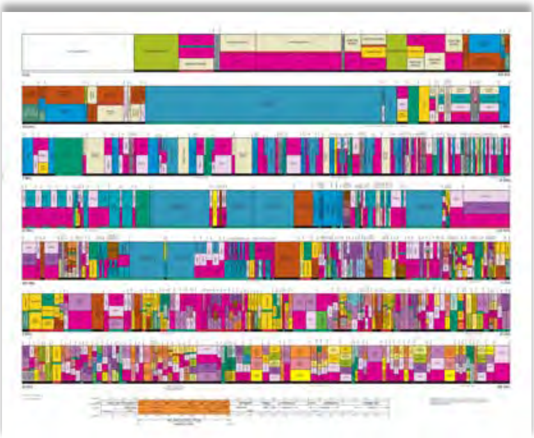
**Subject Matter Experts: Minoo Rathnasabapathy and Chijioke Cj Nwosa**

This group focused their debates and recommendations on three areas: space situational awareness, better and internationally adopted debris mitigation guidelines and, finally, the more challenging topic of active debris removal.

Recommendations / Conclusions:

- Foster collaboration among established and emerging space nations to improve Space Situational Awareness (SSA)
- Encourage investment in infrastructure to broaden coverage
- Establish a neutral center to operate a two-pronged approach to data sharing that would:
    - compile voluntarily contributed SSA data into one public catalogue,
    - offer black box solution for compiling sensitive/proprietary SSA data;
- Encourage adoption of the Guidelines on national level supplemented by the Inter Agency Space Debris Coordination Committee (IADC) guidelines for technical specifications
- Promote effectiveness and ensuring compliance with the Guidelines
- Increase awareness of emerging space actors on significance of debris and mitigation issues
- Develop a mechanism to determine which orbital objects to remove and how to manage their removal
- Endeavour to create long-term, stable demand for commercially provided Active Debris Removal (ADR) services

- Establish domestic and international mechanisms to incentivise and fund the purchase of ADR services
- Focus security and space policy decisions on mitigating irresponsible behaviours rather than prohibiting the development of particular technologies



Radio Frequency Allocations.

Credit: Discover Magazine

**Agency – Radio Frequency Spectra and Satellites: The Technological, Logistical and Political Implications of Regulation**

**Supporter: NASA SCaN**

**Subject Matter Expert: Stephanie Wan**

This group looked at the interference of essential services, at competing socio-economic needs and at public versus commercial uses of spectrum bands. The recommendations were connected with the assessment of emerging capabilities based on experience, the standardisation of emergency services, applications for safety of life and methods to decrease unintentional upward radiation.

Recommendations / Conclusions:

- Consider long-term implications over short-term tactics
- Assess emerging capabilities based on experience
- Standardise of emergency services
- Prioritise lifesaving services
- Use methods that decrease unintentional upward radiation;
- Coordinate strategically spectrum allocation:
  - protection of non-commercial services (e.g., education and medical)
  - grouping high-noise applications together
  - creation of a formula for how to prioritise conflicting uses of a band

Earth Night Lights Mapped from Space

Credit: NASA

**Society – Integrating Space Technology into Society: Overcoming Societal, Political, Economic, and Logistical Roadblocks**

**Supporter: Secure World Foundation**

**Subject Matter Expert: Agnieszka Lukaszczyk**

This group based their discussion on the UN Millennium Development goals and identified lack of awareness as one of the biggest barriers that prevents space technologies from penetrating society. Their recommendations were to continue the investment in research and development, share the results with international bodies which work with identifying world problems, involve specialists in communication and outreach from outside the space community and finally coordinate development of standard training curricula and best practices dialogue.

Recommendations / Conclusions:

- Encourage application focused research and development aimed at high-impact economic and development objectives
- Integrate space activities and policies with other mission-oriented bodies and entities (e.g., World Health Organisation, World Bank, International Monetary Fund, & the United Nations)
- Develop outreach and awareness strategies appealing/understandable to a layperson
    - reframe the dialogue about space: focus on benefits, not features
    - make space common knowledge through education and outreach activities
- Create coordinated standard training curricula, best practices dialogue, and technology development agenda which are:
    - responsive to new technologies and opportunities
    - separate for managers and on-ground personnel.

### Exploration – Robotic Exploration in Today's Evolving Global Space Sector

**Mars Rover. Credit NASA**

**Supporter: DLR**

**Subject Matter Expert: Andreas Hornig**

This group focused on two destinations, Near Earth Objects and Europa, and identified ways in which robotic and human exploration can work together with the support of international collaboration. The group also looked at outreach initiatives that could make robotic exploration as exciting as human missions.

Recommendations / Conclusions:

- Robots are uniquely suited for two main types of missions:
    - precursor missions to human exploration (e.g., NEOs);
    - destinations otherwise inaccessible to humans (e.g., Europa);
- Robots may lack human dexterity, autonomy, and inspirational traits but are strong in other areas:
    - enabling riskier and longer missions,
    - saving mass requirements and cost,
    - allowing scalable technical contributions, therefore easier collaboration;
- Robotic and human exploration should be analysed as complimentary not competitive approaches to exploration
- International collaboration is encouraged through modularised missions
- Robotic exploration should be incorporated into space outreach activities

Africa Mapped from Space.

Credit: 62 Mile Club (.com)

**Outreach – Space for Developing Regions: The African Case Study**

**Supporter: SAASTA**

**Subject Matter Expert: Brad Inggs**

This group focused its analysis on Africa but its conclusions are meant to be applicable more broadly across other developing regions, as well. The group concluded that investing in space technology applications is more beneficial than spending resources on terrestrial applications. For example, in terms of telecommunication, space applications could help in distance education, whereas satellite observations are cost-effective in mapping. The recommendations are meant to address space outreach from a top-down policy approach and a bottom-up grassroots approach.

Recommendations / Conclusions:

For policy makers:

- Establish a liaison between each country's department of education and space-related organisation
- Create a UN resolution, which requires countries to focus on implementing; space related educational activities (e.g., International Year of Space Science 2015)
- Encourage researchers to make public the knowledge generated in a way understood by the general public
- Prioritise policies that encourage international and local human capital development
- Work towards the development of national space agencies

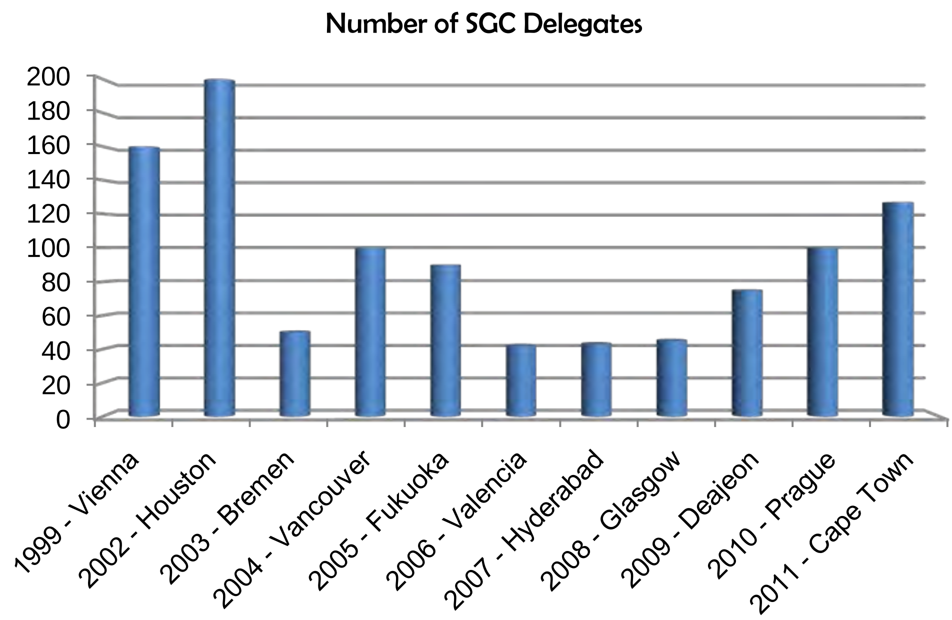
For young professionals:

- Teach
- Engage by workshops, games and competitions
- Form clubs/societies and organise events
- Use social media or mobile phones
- Create entrepreneurial startups for grassroots/field teaching, technology development and space advocacy think tanks
- Get involved in policy making
- Create financial startups for scholarships to study space related subjects
- Encourage one's employers to get involved in initiating scholarships and internships

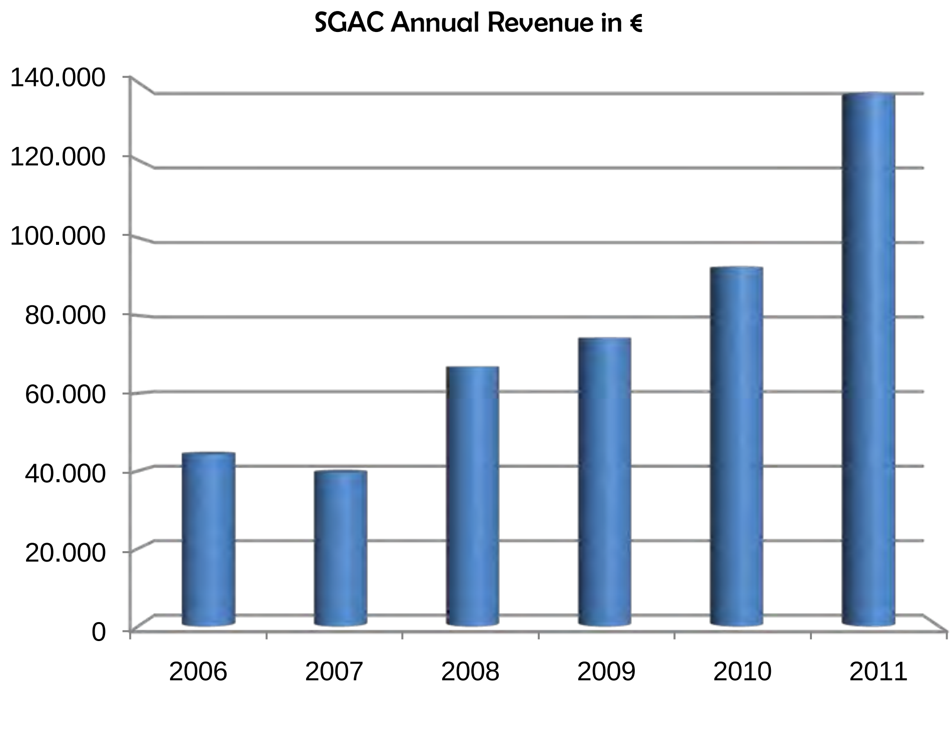
# GROWTH OF SGAC AND SGC STATISTICS

The 10th Anniversary of SGC was an excellent opportunity to demonstrate how both the Congress and SGAC have grown since the organisation's creation in 1999.

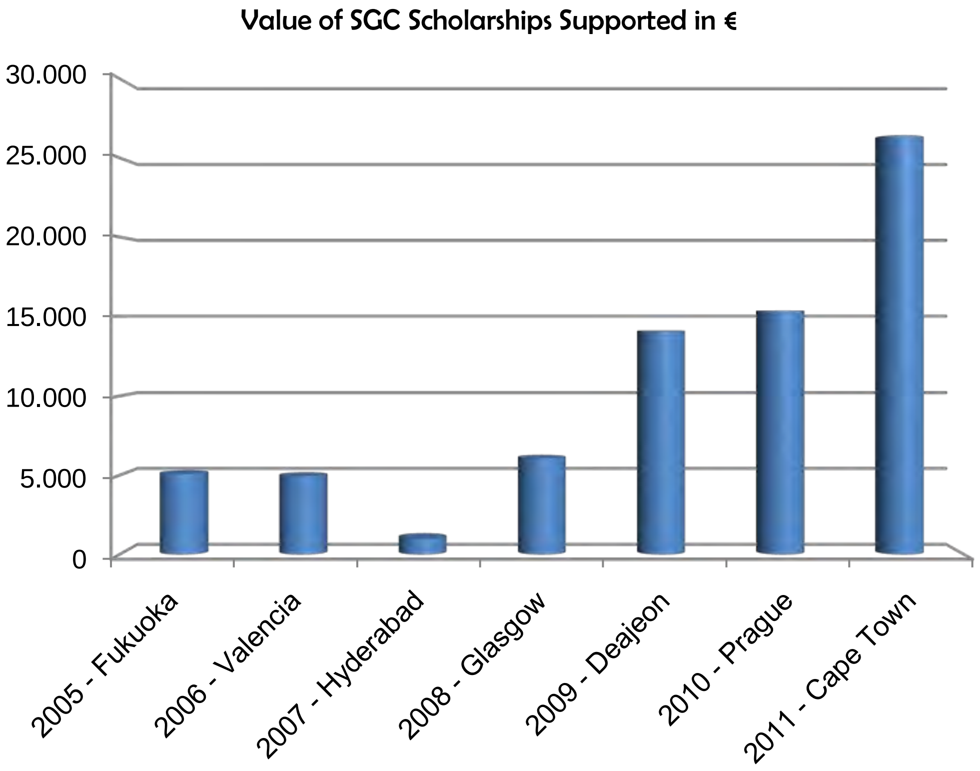
The number of delegates participating in the Congress has tripled in just three years.




As the quality of SGC and SGAC programming has improved, so has the organisation's ability to attract generous supporters. The revenue has steadily been growing over the past three years.



Another important fact that SGAC is proud to show is the growth in the value of scholarships given. In 2011, an additional 12,000 Euros were allocated towards scholarships, setting an SGAC record at approximately 27,000 Euros.




# CONGRESS STATISTICS

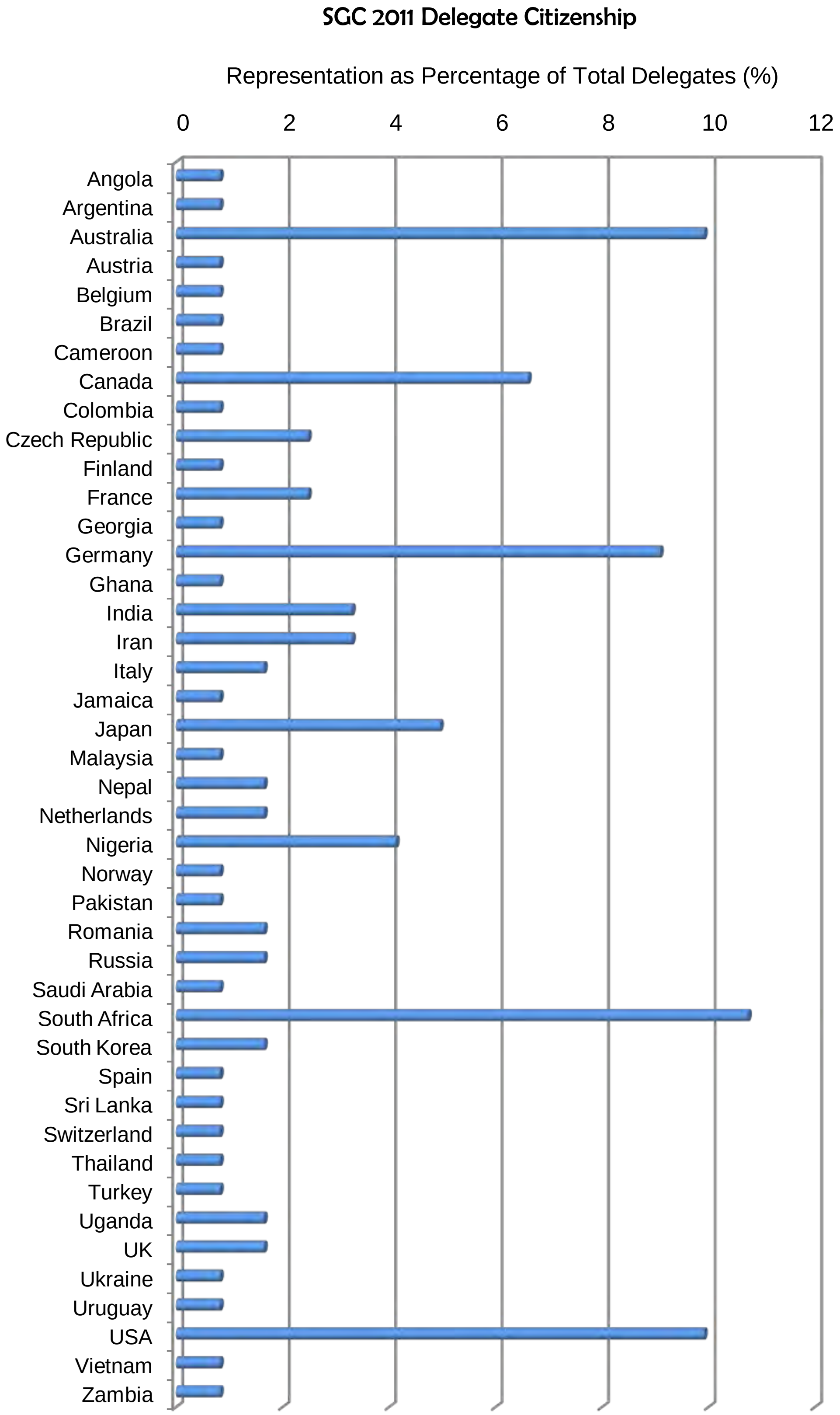
As of the SGC 2011 application deadline of July 15, 276 applications had been received – a more than 20% increase over 2010. This interest and the quality of the applications underlined growth and development in the status of the event.

After careful selection, a total of 130 delegates participated in the SGC 2011. Of those 130, a ground-breaking 32 participants from 24 countries were given scholarships with the help from SGAC and its partners to attend SGC 2011 in Cape Town. Regarding gender distribution of the final delegates, there was a relative equality of men (58%) and women (42%), which is uncommon for the space sector. 20% were undergraduate students, 38% of delegates were masters students, 12% PhD students, 25% were young professionals, and the 5% remaining had other backgrounds. We believe this number demonstrates how significantly SGAC's reach has improved. This gives SGAC the momentum to build a stronger and more representative network of young space professionals and university students.

Finally, SGAC is proud to have had secured broad national and regional representation: SGC 2011 attendees came from more than 40 countries and six continents. This international diversity is the key in the development of the substantiated and a truly international voice of space generation for which SGAC strives.

**SGC 2011 Closing Dinner – from left: Anthony Tsourgranis (NASA International Programs Specialist) Michael Brett (SGAC Chair), Charles Bolden (NASA Administrator), Ariane Cornell (SGAC Executive Director) and Catherine Doldirina (SGAC Co-Chair)**

Representatives of more than 40 countries participated in SGC 2011. The highest percentage of delegates came from South Africa, followed by the USA, Germany and Canada.



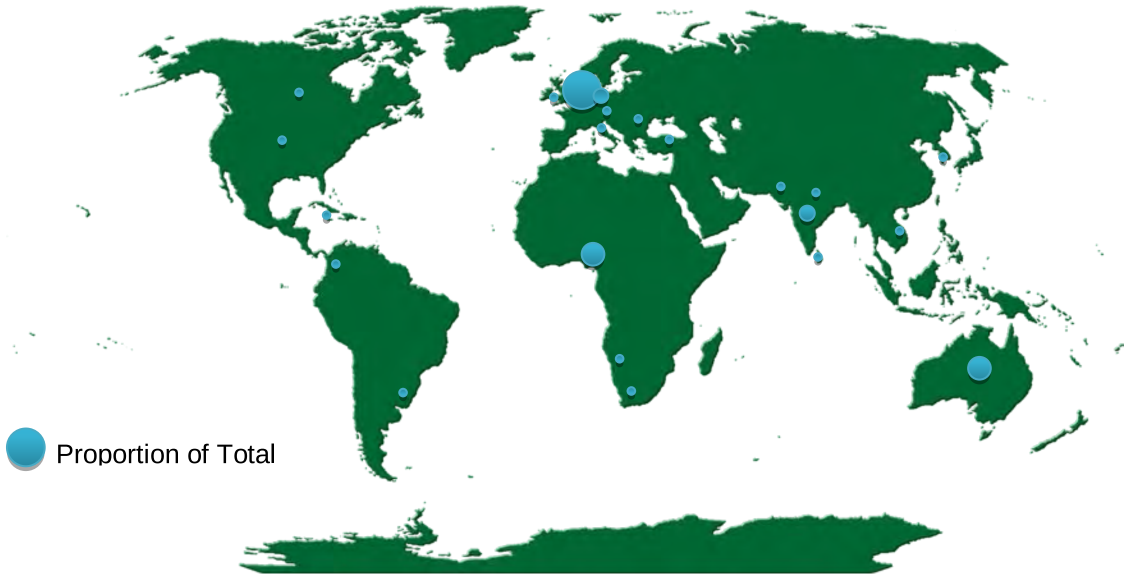
Most of the SGC delegates were students (undergraduate, masters, and PhD) while 25% were young professionals (industry, postdoc, space agencies, etc.).


SGAC is proud to have had a gender balance in the delegate pool which is unusual for the space sector. More than 40% of delegates were female.

# SCHOLARSHIP STATISTICS

SGAC provided 32 scholarships to the organisation's top performing members to attend SGC 2011, which represents an increase of more than 80% in scholarship spending over last year's record figure. 24 countries from five continents were represented in the winner pool. Since one of SGAC's goals is to bring the young members of the international space community together to discuss space issues, the 32 scholarships are seen as a key indicator of the success of the SGC 2011.

Global Distribution of SGAC Scholarship Awardees




| Last Name | First Name | Scholarship Type | Country (main) |
|---|---|---|---|
| Ricardo | Leandro | SGAC Young Leader Award | Angola |
| Kretzenbacher | Michael | Australian Futures Award | Australia |
| Chen | Cynthia | Australian Futures Award | Australia |
| Grayson | Kristian | Australian Futures Award | Australia |
| Vasko | Chris | SGAC Young Leader Award | Austria |
| Bonin | Grant | SSPI Satellite Futures | Canada |
| Jordan | Nicole | SSPI Satellite Futures | Colombia |
| Schlutz | Juergen | SGAC Young Leader Award | Germany |
| Frey | Anja | DLR Standout Student Scholarship | Germany |
| Maier | Philipp | DLR Standout Student Scholarship | Germany |
| Renten | Pascal | DLR Standout Student Scholarship | Germany |
| Hornig | Andreas | OHB Scholarship Award | Germany |
| Chatterjee | Joyeeta | SGAC Young Leader Award | India |

| | | | |
|---|---|---|---|
| Nag | Sreeja | SSPI Satellite Futures | India |
| Paradiso | Nunzia Maria | SGAC Young Leader Award | Italy |
| Cornwall | Marc | SGAC Young Leader Award | Jamaica |
| Bhattari | Suresh | SGAC Young Leader Award | Nepal |
| Offiong | Etim | Ade Abiodun African Space Scholarship | Nigeria |
| Anyina | Chidi | NASRDA Award | Nigeria |
| Shadare | Adebowale | NASRDA Award | Nigeria |
| Mohammed | Shafiq | UN/IAF Workshop Scholarship | Pakistan |
| Mäihäniemi | Beata | SGAC Young Leader Award | Poland |
| Bruna | Ondrej | Czech Space Office Award | Poland |
| Sandu | Oana | SGAC Young Leader Award | Romania |
| Rathnasabapathy | Minoo | SGAC Young Leader Award | South Africa |
| Chung | So Young | UN/IAF Workshop Scholarship | South Korea |
| Ferreira | Yohan | SGAC Young Leader Award | Sri Lanka |
| Kayihan | Aziz | SGAC Young Leader Award | Turkey |
| Gibbings | Alison | Move an Asteriod | UK |
| Alonsoperez | Victoria | Peter Diamandis Scholarship | Uruguay |
| Guthrie | Paul | SGAC Young Leader Award | US |
| Trong | Thu Vu | UN/IAF Workshop Scholarship | Viet Nam |

# SCHEDULE

| | Wed., 28 Sep | Thu., 29 Sep | Fri., 30 Sep | Sat., 1 Oct |
|---|---|---|---|---|
| 09:00 | Delegate Arrivals | SGC 2011 Welcome<br>Outreach Spotlight Speaker<br>Move An Asteroid Winner | OHB-SGAC Award Winner<br>Exploration Spotlight Speaker<br>Agency Spotlight Speaker | SGC Anniversary Day Intro<br>Malinga<br>Saveliev |
| 10:00 | | Coffee Break<br>Working Group Time | Space Frontier Intro<br>Coffee Break<br>Working Group Time | Coffee Break |
| 11:00 | | | | Feuerbacher<br>Gibbs |
| 12:00 | | SANSA Lunch | Space Frontier Foundation Lunch | Women in Aerospace Lunch |
| 13:00 | | Society Spotlight Speaker | Industry Spotlight Speaker | Women in Aerospace Intro |
| 14:00 | | Working Group Time | Working Group Time | Mohammed<br>Prunariu |
| 15:00 | | Coffee Break | Coffee Break | Group Picture<br>Coffee Break |
| 16:00 | | Working Group Time | Working Group Time | Group Presentations |
| 17:00 | | Getting to Know the IAC (Optional) | SGAC Project Team Info Session (Optional) | Free Time |
| 18:00 | | Free Time | Free Time | |
| 19:00 | Optional Dinner (Marco's African Place) | Opening Dinner & Culture Night (Karibu Restaurant) | | Closing Dinner & Speech by Bolden (Marimba Restaurant) |
| 20:00-21:30 | | | | |

# SGC 2011 ORGANISING TEAM

| | | |
|---|---|---|
| Michael Brett | Australia | Chair |
| Catherine Doldirina | Georgia | Co-Chair |
| Ariane Cornell | USA/France | Executive Director and Congress Manager |
| Andrea Jaime Albalat | Spain | Deputy Executive Director |
| Leandro Ricardo | Angola | Intern Vienna Office |
| Minoo Rathnasabapathy | South Africa | Logistics Lead Coordinator |
| Philip Harris | USA | Logistics Co-Coordinator |
| H. Tuğça Şener Şatır | Turkey | Logistics Co-Coordinator |
| Joyeeta Chatterjee | India | Project Lead Coordinator |
| Victoria Alonsoperez | Uruguay | Project Co-Coordinator |
| Kate Becker | USA | Project Co-Coordinator |
| Beata Mäihäniemi | Poland | Delegate Lead Coordinator |
| Crystal Forrester | Australia | Delegate Co-Coordinator |
| Zillin Elizabeth Tang | USA/China | Delegate Co-Coordinator |
| Farnaz Ghadahki | Canada/Iran | Communications Lead Coordinator |
| Oana Sandu | Romania | Communications Lead Coordinator |
| Julio Aprea | Argentina | Communications Co-Coordinator |
| Christopher Vasko | Austria | Communications Co-Coordinator |
| Pierre Van Heerden | South Africa | Local Team – Organising Lead Coordinator |
| Chijioke CJ Nwosa | South Africa | Local Team – Organising Co-Coordinator and IAC Booth Coordinator |
| Michael Afful | Ghana | Local Team – Organising Co-Coordinator |
| Dayne Kemp | South Africa | Local Team – Organising Co-Coordinator |

# SGC 2011 SESSION REPORTS

### INDUSTRY SESSION REPORT:

The Political and Technological Challenges of

Space Debris and Its Mitigation

### AGENCY SESSION REPORT:

Radio Frequency Spectra and Satellites

Technical, Economic, & Political Implications of Regulations Regarding Access and Use

### SOCIETY SESSION REPORT:

Integrating Space Technology into Society

### EXPLORATION SESSION REPORT:

Robotic Exploration in Today's Evolving

Global Space Sector

### OUTREACH SESSION REPORT:

Space for Developing Regions

# INDUSTRY SESSION REPORT

THE 10TH ANNUAL
SPACE GENERATION CONGRESS

SGC 2011
29 SEP - 1 OCT
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# INDUSTRY SESSION REPORT

## The Political and Technological Challenges of Space Debris and Its Mitigation

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Cape Town, South Africa, September 2011

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# 1 INTRODUCTION

In recent years, the international space-faring community realised that space endeavours may, and in fact, do negatively impact outer space and its environment. Space debris has become a major danger to future and present spaceflight. This issue was given little consideration in early mission designs, but today orbital crowding is threatening launched space assets, as well as the execution of future missions.

The IADC and the UN COPUOS Space Debris Mitigation Guidelines define space debris as man-made objects in outer space that are no longer operational for their intended or expressed purpose and not manoeuvrable for collision avoidance. [10] [18] The approximate number of objects that fall into this category that are larger than ten centimetres [3] is more than 20,000 and an estimated 600,000 pieces are between one and ten centimetres in diameter. [17] However, absence of effective tracking system makes it impossible to determine the exact number and precise location of the debris objects. The sources and the forms of space debris include: mission related objects (e.g., bolts, pyrotechnical devices), parts of launch vehicles (especially empty upper stages), non-functional satellites and fragments of space objects (e.g., formed during collisions).

Following their extensive use, space debris has led to a crowding in the most highly used orbital areas: Low Earth Orbit (LEO) and Geosynchronous Orbit (GSO). Analysis done by the U.S. military shows that 190 close encounters between space debris and operational satellites occur per week. This is based on information from satellite operators who claim to perform an average of three collision avoidance manoeuvres per week. [17]. Models anticipate this number of collisions to will continue to grow.

The subsequent sections will examine each of the following issues, identify the distinct challenges involved and propose recommendations.

- Space Situational Awareness: Positional data and information about orbital crowding
- Space Debris Mitigation: Prevention of the future generation of space debris
- Active Debris Removal: Removal of debris already in orbit

# 2 SPACE SITUATIONAL AWARENESS

Space Situational Awareness (SSA) is the collection of information about the space environment and objects in orbit. SSA plays a critical role in reducing the impact of space debris because it provides information on the extent of the problem, as well as situational data, which can be used to reduce the probability of orbital collisions.

Currently, the vast majority of SSA data is collected via ground-based tracking stations that predominantly use either radar technology or optical telescopes. The present global SSA capability consists of two primary operating space surveillance networks. The first, the Space Surveillance Network (SSN) of the United States (US), operates the largest network of sensors and has the most complete catalogue of space objects. There are gaps in the US catalogue and coverage, however. The second, the Russian Space Surveillance System (SSS), operates the second largest space surveillance network and maintains its own catalogue of space objects. [4] Additionally, there is a number of European sensors that are currently being integrated into a European SSA network [4]. The International Scientific Optical Network (ISON), which is a partnership of international scientific and academic institutions organised by the Russian Academy of Sciences in Moscow also has a space surveillance capability. [4] There are also many amateur satellite observers loosely organised through the Internet but capable of a non-trivial SSA contribution. [4]

## 2.1 Challenges and Recommendations

### 2.1.1 Challenge: Data Quality and Quantity

The current state of global SSA data suffers from issues with data quality and quantity. While the current sensor networks provide a large amount of SSA data, the overall picture is far from complete. The vast majority of SSA sensors are located in the northern hemisphere, leaving gaps in southern hemispheric coverage.

The sensors currently employed in SSA also suffer from limitations in the size of objects that can be detected. A common form of SSA sensors, phased radar arrays, can track objects up to ten centimetres in diameter at altitudes below 600 kilometres. But as the altitude increases to 5000 kilometres, such sensors can only track objects over a metre in diameter. [17] Objects smaller than ten centimetres are numerous and still large enough to cause significant damage to hardware in space. [10] Thus, there is a dangerous lack of tracking capability in LEO, not to mention the difficulty with tracking debris in GSO, which is approximately 36000 kilometres from Earth. [17]

**RECOMMENDATION:**

- ***Foster collaboration among established and emerging space nations to improve SSA***
- ***Encourage investment in infrastructure to broaden coverage***

Many emerging space nations have shown interest in recent years in expanding their space related infrastructure. Reference can be made to the competitive efforts between southern African nations and Australia in the bid for the Square Kilometre Array. [20] The fact that many of these emerging nations are interested in investing in space technology and are situated in the southern hemisphere shows that there is an opportunity for established space nations to collaborate with these emerging nations in order to establish SSA capabilities and improve coverage in the southern hemisphere. By investing in improved SSA infrastructure, such as better ground tracking and orbital-based detection capabilities, additional smaller orbital objects can be tracked. This facilitates a more comprehensive creation and maintenance of a SSA database, which can help in collision avoidance manoeuvres for satellites and reduces the risk to orbital hardware.

### 2.1.2 Challenge: Need for Improved International Data Sharing

While a number of SSA networks exists, and others are currently being created, there is very little data sharing between these networks and subsequently no single global SSA catalogue. U.S. and Russian SSA networks are run by their corresponding militaries, and so data sharing could be seen as a potential security risk. [4] This has thus far prevented the creation of a global catalogue. Issues in data formatting also exist. In addition, there is currently no universal SSA data format, which makes data sharing difficult in practice.

**RECOMMENDATION:**

***Establishment of a neutral center to operate a two-pronged approach to data sharing to***

- ***Compile voluntarily contributed SSA data into one public catalogue***
- ***Offer black box solution for compiling sensitive/proprietary SSA data***

International data sharing is necessary to facilitate global SSA and reduce orbital collision incidences. The Working Group recognised that SSA-capable nations are unwilling to give other SSA nations their data and that these nations will never entirely share all data due to security concerns. However, its members also recognised that any increase in situational awareness is beneficial to reduce collisions.

The working group recommendation for improving international data sharing is to establish a neutral centre to operate a two-pronged approach to data sharing. The neutral centre would be an international organisation, which is not aligned to any single state and exists only to compile an open catalogue of SSA data.

This neutral centre would process SSA data in two ways. The first would be to maintain an open catalogue of non-sensitive orbital objects. The vast majority of objects in orbit are space debris and therefore their position and movement is in most cases, not sensitive information. The SSA data with the position of such objects would need to come voluntarily from SSA capable nations. These nations would be encouraged to provide SSA data they are comfortable with sharing with the neutral body. This does not create a 100 percent complete SSA catalogue, but all data that can be shared, would be shared. This would be a step forward from the current situation with international data-sharing.

Second closed data collection would exist for objects that are sensitive for commercial or security reasons. This regime would take a ”black box” approach, to sensitive or proprietary data. The positional data of sensitive hardware would be confidentially compiled and if such hardware were at risk of collision, the “black box” operation of the neutral centre would provide the owners of at-risk hardware only with information on how to avoid the imminent collision. Nothing about the nature of the sensitive object would be revealed. It would also be up to this neutral body to convert any data it receives into a standard data format. An accurate and open SSA network is crucial in tackling the orbital debris issue. One cannot hope to effectively reduce orbital debris without knowing the size, number, location and movement of objects in orbit.

While the Space Data Association, an organisation that supports a partnership of several commercial actors to track objects in space, is in concept similar to the group’s recommendation, it is early in its existence and need to be proven effective [21]

# 3 SPACE DEBRIS MITIGATION

The objective of space debris mitigation is to protect the environment of space by limiting the amount of debris produced in the launch, on-orbit and re-entry phases of space operations. Several of the established space actors formed the Interagency Space Debris Coordination

Committee (IADC) in 1993, which issued a set of debris mitigation guidelines in 2004. These guidelines were later endorsed by the UN COPUOS in 2007. [17]

There is no definition of space debris in the space law conventions or treaties. Although both the abovementioned sets of Guidelines have attempted to define space debris, yet it is considered as a soft law definition since the Guidelines are neither binding nor enforceable.

## 3.1 Legal and Regulatory Challenges

The existing international legal regime needs to be further developed and elaborated in order to be able to address most of the challenges created by space debris and efforts directed at their mitigation and removal. The 2007 UN COPUOS Space Debris Mitigation Guidelines (UN Guidelines) is a set of seven non-binding principles that do not create any legal compliance obligation on the States. Its implementation is voluntary and countries can choose to adopt them through their national legislative framework and domestic policies. They apply only to mission planning and operation of newly designed spacecrafts and orbital stages. [17]

## 3.2 Challenges and Recommendations

Although the UN Guidelines are the primary international legal instrument addressing the issue of debris in space, they have certain inherent limitations.

### 3.2.1 Challenge: Interpretation of the Language of the UN Guidelines

The text of the UN Guidelines contains significant scope for ambiguity in its interpretation due to the lack of technical specifications in its directives. Furthermore, the Guidelines do not attempt to address any liability issues brought about from damage sustained from space debris. [17]

**RECOMMENDATION:**

***Encourage adoption of the Guidelines on national level***

Since the language offers a broad scope for interpretation, this can be remedied by encouraging its implementation on a national level by individual States. The States can adopt the Guidelines in a manner that will exclusively cater to the politico-economic and policy requirements of each State. States can create domestic laws and regulations separately and as appropriate to their national interests. This will also help to resolve the issue of ambiguity in technical parameters. Furthermore, it is recommended that the UN Guidelines be read along with the IADC Guidelines for more comprehensive results.

### 3.2.2 Challenge: Implementation of the Guidelines

To date, the Guidelines have only been adopted by prominent space actors, such as the United States, Russia, France, Germany and China. Thus, it suffers from a poor rate of implementation since there is a severe lack of incentive for emerging space actors to adopt them.

**RECOMMENDATION:**

***Promote effectiveness and ensure compliance with the Guidelines***

The States must promote effectiveness of the Guidelines and attempt to abide by the standards prescribed therein. This would help generate the international harmony and coordination that is key to establishing successful mitigation measures.

**RECOMMENDATION:**

***Promote effectiveness and ensure compliance with the Guidelines***

Increased awareness of the risks created by space debris has prompted States to take measures in mitigating the production of new debris. In 2002, five European space agencies (ASI (Italian Space Agency) ASI, UKSA (UK Space Agency), CNES (Centre National d'Etudes Spatiales), DLR (German Aerospace Centre), ESA (European Space Agency)) issued the European Space Debris Safety and Mitigation Standard which became the European Code of Conduct on Space Debris in 2004. CNES prepared technical regulations in 2009 and these regulations are now applicable through the French Space Operations Act. [17]

It has been observed that most of the emerging space actors have not adopted the UN Guidelines in their domestic legislation. A greater awareness regarding the potential threat caused to space assets by the proliferation of space debris will help in highlighting the significance of debris mitigation to these States. This will, in turn, lead to an initiative to concentrate on the implementation of the UN Guidelines.

# 4 ACTIVE DEBRIS REMOVAL

Recent studies have indicated that even without additional satellites being placed into orbit, the amount of orbital debris is likely to increase through collisions between existing debris.[5] Hence, it is important to develop the technology to actively remove the existing debris from orbit.

Active debris removal (ADR) has been considered for over 30 years. [11] However, associated high technological and financial burdens have so far prevented their implementation. This section provides an overview of the current technological situation, the legal and policy challenges involved, and elaborates on the policy recommendations suggested by the Working Group.

## 4.1 Technological Capability

The following two strategies have been considered feasible for ADR:

a. Transfer to a non-hazardous orbit (“graveyard” orbit) for highflying objects.
b. Destruction by means of a controlled re-entry into the Earth’s atmosphere for low flying objects.

Depending on the debris' size and orbit, different technological solutions already have been proposed in order to pursue the above strategies. ESA suggests five potential methods for removing space debris: [1]

- Electromagnetic methods (i.e., electro-dynamic tethers, magnetic sail)
- Capture (i.e., nets)
- Momentum exchange methods (i.e., solar sail, drag augmentation device)
- Remote methods (i.e., lasers)
- Modification of material properties or change of material state.

Most of these concepts, however, lack technological readiness. Their development is primarily hindered by the lack of investment necessary to build these sophisticated systems.

A related technology under consideration is on-orbit servicing whereby an unmanned servicing spacecraft attaches itself to a spacecraft on orbit. At this stage ADR operations can be performed. On-orbit servicing is currently under development by various space agencies and one commercial company, MDA Corp. [8] [13] [14]

## 4.2 Demand and Priorities

The incentives and motivations to engage in ADR are similar to that of addressing space debris in general. The major differences are two-fold in terms of cost and dual use concerns. ADR technology is more costly than any other space debris mitigation effort and, more importantly, it could potentially be used as an anti-satellite capability. [3]

Concerning the peaceful use of ADR, the high costs so far have kept governmental agencies and private satellite operators from developing technologies up to flight readiness. As with the general issue of space debris, the payoffs for an individual operator to remove their own or other non-functional objects on an ex post basis are small. No market for ADR services exists at the moment.

There is an additional hindrance relating to ADR technology. Given the fact that only a limited number of objects can be removed within a certain period of time, the removal of a specific object will most likely benefit only some, but not all, satellite operators. Therefore different studies have been conducted analysing priorities of removal based on effectiveness. However, these studies not only show different outcomes depending on the weighing of beneficiaries, but also on the defined objective. If the objective were to minimise the risk of collisions and damage to existing spacecraft, the most effective measure would be removing objects with a size between one and ten centimetres. [2] However, if the objective is to stabilize the long-term accumulation of debris, larger objects (with the highest product of mass and probability of fragmentation) should be removed. [2]

## 4.3 Legal and Policy Challenges

Even if ADR services were available, many legal and political questions relating to ADR have not been solved. They include:

The Outer Space Treaty [16] grants jurisdiction and control over an object in space to the Launching State. Therefore legal measures would need to be found if a state or a third party is to remove another state's object [3]. Additionally, the Registration Convention does not require launching states to provide any information about debris created after the launch of a spacecraft. [6] Since this kind of debris cannot easily be tracked to a launch event or a spacecraft [3], no Launching State can be determined. There is a legal vacuum with respect to the debris' treatment. A similar problem exists for unregistered space objects.

Additionally, within the applicable space law, there is no distinction between functional satellites and non-functional space debris. [3]

Both issues have not been identified as critical factors hindering the start of ADR activities by the 2011 SGC Working Group. The details will be laid out in the following section.

Other issues to clarify include the liability during ADR operations, the protection of intellectual property rights on recovered space debris and the avoidance of anti-satellite actions under the disguise of ADR.

## 4.4 Challenges and Recommendations

### 4.4.1 Challenge: Creation of Demand for ADR

The sustainability of ADR is dependent on its affordability and access to technology and operations. Affordability and wide-spread access to ADR capabilities can best be provided if either the ADR devices or the complete service is offered by one or more commercial players. A private satellite operator, a national agency or an international body could purchase the services or the means for debris removal from a commercial provider. This would ensure general accessibility and cost-effectiveness due to an optimised number of applications. The nature of the customer is not determined in this scenario and can possibly change over time.

**RECOMMENDATION:**

- ***Endeavour to create long-term, stable demand for commercially provided ADR services***
- ***Establish domestic and international mechanisms to incentivise and fund the purchase of ADR services***

In order to stimulate the development of commercial ADR services, a long-term, stable demand for these services needs to be created through the establishment of domestic and international mechanisms to incentivize and fund the purchase of ADR services.

However, a sustainable ADR industry can only be created if the framework for managing and controlling ADR activities accounts for the prevailing political and legal challenges.

### 4.4.2 Challenge: Management of ADR activities

Given the implications space debris can have for international politics, any ADR activity should be undertaken with close international coordination and monitoring.

**RECOMMENDATION:**

***Develop a mechanism to determine which orbital objects to remove and how to manage their removal***

The details of the mechanism are vital to solving most of the unresolved issues involved in ADR. Establishment of a collaborative fund could be one of the possible solutions (such as proposed by Prasad and Lochan in their 2008 article [19]). Additionally, operators (i.e. launching states) could be motivated to declare their own objects non-functional according to Article IV of the Registration Convention [6] without facing negative consequences. Given the anticipated number of removals during the initial years of ADR, this approach has the potential to generate a sufficiently large pool of removable objects. Having agreed on the removal of an object, the owner/launching state could engage in a bipartisan contract with the ADR service provider thereby settling intellectual property rights issues.

### 4.4.3 Challenge: Dual-use Capability

As mentioned above, ADR technology can also be used as an anti-satellite weapon against other satellites. Since the exact determination of events in orbit is difficult even for states with highly developed SSA capabilities, [3] transparency, trust, sensitivity and reliability of ADR operations are crucial to maintain stability in the space domain. Furthermore, security concerns related to the dual-use potential of ADR technologies can hinder their development and operation. Therefore, measures should be taken to prevent the aggressive use of these technologies.

**RECOMMENDATION:**

***Focus domestic and international security and space policy decisions on mitigating irresponsible behavior rather than prohibiting the development of particular technologies***

Forbidding every technology that could be used aggressively would significantly lower the chance of ADR being implemented at all, without providing a guarantee that the technologies are not developed and used in another context. The Working Group concluded that while the development of possibly harmful technologies cannot be impeded completely, through a close, open and sensitive cooperation between all members of the international space community irresponsible behavior can be confined effectively.

# 5 CONCLUSIONS

Space debris is a complex multi-faceted issue, that cannot be solved by only focussing on one of its major aspects. It must be treated as one treats a chronic illness, where constant effort is required to keep it in check. Attempting to solve only one aspect of the problem, without reducing debris creation or improving space situational awareness would serve to only treat the symptoms, not the 'illness' itself. Thus, approaches are required to cover space situational awareness, debris mitigation as well as active debris removal. The key to solving the space debris issue lies in extensive international cooperation. By treating space debris as a shared problem, and cooperating in its response, the global space community will best utilise the available resources and increase its ability to tackle all the major aspects of the space debris issue.

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THE 10TH ANNUAL
SPACE GENERATION CONGRESS
SGC 2011
29 SEP - 1 OCT
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# AGENCY SESSION REPORT

## Radio Frequency Spectra and Satellites

## Technical, Economic, & Political Implications of Regulations Regarding Access and Use

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Cape Town, South Africa, September 2011

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# 1 INTRODUCTION

The radio spectrum is a subset of the electromagnetic spectrum situated between the frequencies 9 kilohertz and 3000 gigahertz.

The International Telecommunication Union (ITU) is an overseeing 35tandardized allocating spectra and providing recommendations globally, with national bodies implementing legislations and regulations for domestic activities.

The issue of spectra allocation is technologically, economically, and politically complicated for a number of reasons. The radio spectrum is an inherently limited natural resource, which makes allocation of frequency bands a matter that requires coordination and transparency. In addition, the current competitive environment involving spectrum allocation for terrestrial and space-based services requires all nations to carefully consider their priorities and act accordingly, respecting the interests and needs of others.

The main objective of the Space Generation Agency Working Group was to make recommendations regarding the use of limited radio frequency spectra, taking into consideration the increase in commercial demands. The Working Group also discussed economic, technical, and policy issues related to spectrum allocation and have suggested how they might be regulated so that their use benefits all actors of the international space community.

# 2 INTERNATIONAL TELECOMMUNICATION UNION

The International Telecommunication Union (ITU) is an 35tandardized within the United Nations (UN) that governments and private sector need to coordinate with to resolve global telecom network and service issues. The organization was founded in 1865 and has its headquarters in Geneva. The main principle that governs activities of the ITU is that of the cooperation between governments and the private sector. Its membership includes 193 Member States, 548 Sector Members and 159 Associates (i.e., smaller companies, academic bodies) [1].

The ITU facilitates global operation of international radio systems, including satellite networks. It also works to improve telecommunication infrastructure in the developing world and establish worldwide standards. Decisions on spectrum allocations and procedures for coordination of satellite networks are made by Member States at treaty conferences [2].

## 2.1 ITU Missions

ITU's basic mission is to offer technical assistance to countries in the field of telecommunications and to promote the adoption of a broader approach to issues regarding telecommunications. In addition, it strives to extend and maintain international cooperation among all Member States with the hope of improving the rational use of telecommunications of all kinds. The ITU promotes constructive cooperation and partnership between Member States and their private sector actors. It also coordinates efforts to eliminate disruptive interference among radio stations of different countries, and facilitates improvement of the use of radio frequencies and communication services in geostationary orbit (GSO). In its simplest form, the ITU's mission statement is "helping the world communicate" [2] [3].

# 3 RADIO SPECTRA USE

There are many applications that make use of the radio spectra. Possible situations include but are not limited to [4]:

- more than one application working on any given frequency band;
- applications working on a range of different possible frequency bands ;
- different applications that require varying amounts of bands;
- applications requiring specific frequencies.

For the purposes of this report, the SGC Agency Working Group divided the applications in three main areas: navigation, communication and Earth observation (EO)/scientific use.

## 3.1 Navigation

The ITU allocates all Global Navigation Satellite System (GNSS) type applications a specific amount of bandwidth and frequency. These allocations are known as the Radio Navigation Satellite Service (RNSS) and the Aeronautical Radio Navigation Service (ARNS). The 1559-1610 MHz frequency bands are designated to ARNS/RNSS and include both the GPS L1 and L5 frequencies. The ARNS designation is critical for ensuring availability of these signals worldwide. It is important to preserve this spectrum because GNSS services provide applications that are essential for the global community. For instance, most modern emergency response systems rely on space-based navigation [5].

An example of GNSS is the American Global Positioning System (GPS), which consists of a constellation of 24 satellites. In 1983, the American government offered civilians access to the GPS and since then the use of satellites for positioning, navigation and timing has grown dramatically [6]. There is a wide variety of GPS applications. Everything from taxicab services to the 36tandardized363636 of huge communications networks involves the use of GPS. The use of GPS has become part of everyday life. However, the GPS community is presently concerned about communications companies transmitting signals immediately adjacent to the GPS frequencies [7]. Due to economic factors and lack of demand for spectrum in the past, GNSS receiving devices were not fitted with proper filters and may now be disrupted by interference from adjacent bands. The presence of harmonics between bands cause weak signals to be drowned out by stronger signals at other frequencies further complicating the structure of frequency band allocation.

## 3.2 Communication

Communication satellites are used for broadcasting TV and for mobile phone signals. They transmit information using the electromagnetic spectrum. Most of these satellites are in GSO and have omni-directional antennas and high transmission power that allow them to broadcast over large areas. The frequency bands commonly used in communication satellites are the L-band (1 GHz to 2 GHz), which is used for satellite phones and

WorldSpace satellite radio, the C-band (4 GHz to 8 GHz) and Ku-band (12 GHz to 18 GHz), which are used for satellite television distribution, and the Ka-band (27 GHz to 40 GHz), which is used for satellite phone backhaul [8].

Ground based mass communication is achieved using VHF (30-300MHz) UHF (300 MHz and 3 Ghz). These frequencies encompass television, radio, cellular & GSM as well as WIFI networks and Amateur Radio among other. Due to the transparency of the atmosphere in certain bands, ground based transmissions are detectable from space, as well as causing interference with signals originating from space.

### 3.3 Scientific/Earth Observation (EO)

EO satellites provide the possibility to observe the Earth from space. There are two types of EO depending on the sensors they use: passive and active. In the case of passive EO, the selection of frequencies for different applications is constrained by naturally-occurring fixed spectroscopic phenomena [9]. For this reason, there is a limited range of frequencies in which measurements have to be performed. Among the primary uses of the passive bands is the analysis of soil moisture, ocean salinity, sea surface wind speed, sea surface temperature, sea ice extent, surface rainfall rate, precipitation over oceans, surface snow cover, detection of strong convection (thunderstorms), and ice cloud detection.

Radio astronomy, which is affected by ground and satellite based transmissions, also requires the passive detection of frequencies that penetrate the atmosphere.

In the case of active EO, a sensor emits energy in order to sense objects on a specific frequency or band of frequencies. Depending on mission requirements, an active sensor may be selected to better detect certain physical conditions [9].

# 4 PROBLEMS

The use of the radio spectrum has evolved with changing demands. This evolution has left us with the burden of legacy when new technologies are developed and spectrum usage is not used optimally. Our experiences with satellite communication have given us a wealth of knowledge. Unfortunately, a great deal of this technology is not being or cannot be applied. Some key factors that contribute to this situation and were discussed by the working group include:

- allocation of radio frequencies (bandwidth);
- interference;
- inefficient use of radio spectrum; and
- technology implementation.

Each of these factors has national and international implications that are highlighted in the subsections below

## 4.1 Allocation of Radio Frequencies

Radio frequency spectrum is a limited natural resource. It is liable to be wasted if it is not used optimally and efficiently. Therefore, assignments of frequencies need to be undertaken to ensure an efficient, optimal, and economical use in conformity to bring the greatest social gain.

One of the biggest planning challenges facing spectrum regulators is the reallocation of spectrum. When frequencies have been 38tandard for one purpose, perhaps for decades, it is often problematic to reallocate these frequencies band for a different use. This can arise for example from the availability of new technologies that are more spectrum-efficient, allowing spectrum to be freed up either for the same use in the specific band or other uses; or by radio service that has not developed as expected [11].

The International Telecommunication Union at the World Radiocommunication Conferences allocates spectrum frequencies for the use of various countries; and The ITU Radio Communications Sector (ITU-R) is the coordinating body responsible for recommending frequency allocations. Allocations are made on a regional basis and for different types of services. It is stringently required for all administrations to stick to these allocations. For this purpose of spectrum allocation, each member state submits its proposals to ITU, based on their special needs and priorities for opening of the bands. During the conference all the proposals on spectrum allocations and procedures can be discussed and decisions are taken for opening of the band for new services. Hence, spectrum allocation is necessary to avoid any harmful interference to each radio services or communications of other member states, which operates in accordance with provisions of the radio regulations. These decisions are reflected in a table of frequency allocations which sets out the use of a given frequency for use by one or more radio communication services [10], [12].

## 4.2 Interference

Due to an exponential raise in the number of subscribers' additional spectrum is required by the operators (for example: mobile sectors). Serving a large number of subscribers means a larger amount of spectrum is needed, which lead to greater problems in monitoring and managing interference. More so, due to sharing of frequency bands, problem of potential interference is increasing. Hence, to avoid harmful interference, assignments of frequencies need to be undertaken and regulators have to consider precautions such as constrains on usage, i.e, restrictions on the direction of antenna, on power level, etc. It is therefore the main responsibility of the radio site operators to assure safe operation and installation of their radio systems. At the international and national level, ITU member countries work together to operate monitoring facilities and to coordinate efforts to prevent and control of harmful interference [12], [11].

## 4.3 Inefficient Use of Radio Spectrum

The effective and efficient management of the spectrum, though crucial to making the most of the opportunities that the spectrum resource represents, is growing more complex. Spectrum efficiency involves the arrangement of communication systems within the spectrum resource. In broader sense, spectrum is used inefficiently when system are not arranged as tightly as possible in frequency bands, or when parts of frequency bands are unused while other bands with similar physical properties are congested. So, 39tandardized39 spectrum and unoccupied spectrum that has been assigned is a wasteful uses of the resource.

The allocation of frequency bands and the assignment of frequencies to specific systems all affect spectrum efficiency. Therefore, the use of spectrum resource efficiently and effectively requires a coordination of the sharing of the available spectrum among users in accordance with international or national regulations. Furthermore, reallocating frequencies for bandwidths with little demand and introducing state-of-the-art technologies to reduce required bandwidth with high demand will improve efficiency and productivity in bandwidth usage. For certain radio frequency bands services for which the demand is high, e.g., high data video versus voice or multiple voice compression versus single, it will require to reduce the channel bandwidths for efficient management of the scarce frequency resources [11], [13].

### 4.4 Technology Implementation

The lack of availability of technology and equipment for different types of radio frequency applications can cause limitation of the use of the radio frequency spectrum, or harmful interference between different users. A current example can be seen by the risk of interference to millions of GPS users from broadband networks that rely on a high-density terrestrial network inside the Mobile Satellite Service (MSS) band, which is adjacent to the GPS L1 frequency band [7]; and which can be solved by applying innovative technologies such as band filtering or transmitter power reduction to reduce the interference to acceptable levels. Furthermore, the capability of emerging technologies designed to use spectrum in different ways is diminished, which increases the complexity and the cost for different applications. However, based on the fact that radio frequency spectrum is a limited natural resource, its equitable allotment for systems using different technologies would promote efficient use of radio frequency spectrum.

Nowadays, ongoing technological developments have opened the door to a diversity of new radio spectrum applications. These developments, though often making spectrum use more efficient, have encouraged greater interest in and demand for the limited spectrum resource. Spectrum managers need to consider the changing needs of society and ensure opportunities that match existing demands with new ones through innovative uses of technology e.g., band filtering, antenna design, and electronic. At the international/national level, plans and technical standards for spectrum use need to secure that applications of technology are done in a proper manner and that harmful interference is reduced to reasonable levels [12], [11].

# 5 RECOMMENDATIONS

After discussing the challenges of radio spectrum usage and allocation the SGC Agency Working Group decided on the following recommendations for promoting long-term, efficient, and socially valuable use of radio frequencies.

## 5.1 Consider Long-Term Implications Over Short-Term Tactics

With radio frequency being a limited resource it is vital that long-term strategies are established to guide short-term planning. This would allow for a more sustainable and efficient use of radio frequencies. Furthermore, it would increase the effectiveness of radio frequency 40tandardize by avoiding delays between allocation and usage. Applying advanced technology to ensure optimal use of frequency should also be implemented in such a strategy.

In order to design this long term strategy, there should be a mindset change to 40tandar that we are dealing with a limited resource, and we are approaching the limit.

## 5.2 Assess Emerging Capabilities Based On Experience

As the use of optical frequencies for satellite communications becomes feasible, it is important to evaluate the requirements and deployment of these frequencies [14]. Lessons learned from radio frequency management should be applied in developing a regulatory system for optical frequency (via fiber optics in ground based communications or laser based satellite communication). For example a regulatory system with long term considerations as mentioned above will help making efficient use of optical frequency. Problems like interference and efficient use of the spectrum need to be addressed now in order to be avoided. Furthermore, the international aspect of spectrum allocation is to be considered.

Another lesson is that when forward planning the allocation of bands, the impact that they will have on other bands must be fully considered.

## 5.3 Use Methods That Decrease Unintentional Upward Radiation

Due to the nature of radio transmitters, without 40tandardize antennae, the transmission is omni-directional, radiating in the desired direction and elevation as well as other directions.

Although the cost of this wasted radiation may be insignificant, it may cause effects on current and future Earth Observations from space. Techniques to reduce unintentional upward radiation should be 40tandard to decrease interference with space applications. These methods could take direction from the actions of the International Dark-Sky Association, which include avoiding light pollution and adapting to radio frequency applications [15].

The techniques should improve the radio quiet environment by reducing radio pollution through better transmitting practices that provide energy savings resulting in economic benefits, and safeguarding of scientific and educational opportunities, such as astronomy. Moreover, it is important to seek specific solutions that mitigate radio pollution, including reducing total transmission power through densities, controls (e.g., on/off capabilities), energy codes, shielding and directionality, and consideration of spectral distribution.

## 5.4 Coordinate Spectrum Allocation

One clear message that came out of the SGC Agency Working Group was to “think strategically, not tactically”. This means that all future activities should be strategically coordinated. Strategies should be carefully drafted, adopted and implemented. They should, for instance, include protection or 41tandardized4141 of non-commercial services (e.g., education and medical). Certain frequencies should be reserved for services with no direct economic revenue but high societal gain [16]. Countries with remote rural areas and developing countries would profit particularly from making use of such services.

The creation of a 41tandardized rating system, which is used to rank services competing for the same band, is desirable. Not only economic revenue, but also scientific and social benefits offered by the service need to be considered in this system. Standardised rating system should be created and used to rank services competing for the same band. The system should not only consider economic revenue, but also scientific and social benefits offered by the service. It would help to speed up and increase the transparency of the allocation process.

Furthermore, something crucial to consider when assigning frequencies, are those services that are essential for society in every part of the world such as disaster management. It is important to note that when a disaster occurs in one place, auxiliary support come from many other countries. Therefore, 41tandardized41 the frequencies in multiple bands and equipment for emergency services worldwide would make faster and more efficient disaster management and relief possible. The standards should be 41tandard on the international level.

Regarding interference, it can have a serious effect on weaker signals. Grouping strong signal to noise ratio signals together and with harmonic regularity will 41tandard the effects of harmonic interference in other bands and will be beneficial in protecting signals such as GNSS.

# 6 CONCLUSION

After evaluating different possibilities, the SGC Agency Working Group came to the conclusion that a strategic plan is needed instead of a tactical one. The plan should address both long and short-term considerations, and it should include management strategies. The creation of a 41tandardized rating system is also needed. Furthermore, where single point-to-point communication is required, use of the optical spectrum should be a priority. Moreover, the allocation and request for bandwidth should not be decided solely on the required frequencies. It should also be based on the transmission power, received flux requirements and the interference caused to other frequencies.

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# SOCIETY SESSION REPORT

THE 10TH ANNUAL SPACE GENERATION CONGRESS

SGC 2011

29 SEP - 1 OCT

CAPE TOWN

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SPACE GENERATION ADVISORY COUNCIL

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# SOCIETY SESSION REPORT

## Integrating Space Technology into Society

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Cape Town, South Africa, September 2011

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# 1 INTRODUCTION

Space products and services are increasingly important in terrestrial applications, as their uses have positive society-wise benefits. Space technologies are an important part of the proliferation of communications and data, which can assist in making the world a “global village”. Some examples of important space applications are crop monitoring, positioning, navigation, timing, mapping, tele-health and tele-education. Although these technologies can save and benefit human lives, there are many barriers: societal, economical, political, logistical and technological to their more rapid proliferation, which should be addressed by policy action.

What is stopping or slowing the greater proliferation of space technologies that benefit society as a whole? Some of these technologies proliferate as a result of normal market forces, and many others the result of coordinated political action. In each case, there are different kinds of tools available to policy makers for working to increase the speed of innovation and uptake. The goal of this report is to identify what barriers affect dissemination of these technologies, and provide actionable recommendations for increasing the speed of their adoption, for the good of society as a whole.

The Working Group’s goals were to recognise these influential barriers, and to provide recommendations to overcome them. The Society Working Group set the United Nations Millennium Development Goals as the basis for what it means to be beneficial to society. We also took current economic and political realities as given. It was identified that lack of awareness is one of the greatest barriers preventing space technologies from penetrating society, and that successful integration is heavily influenced by decisions made by the world’s policy makers.

# 2 AIMS, APPROACH AND METHODOLOGY

The purpose of this paper is to summarise the work performed by the Society Working Group in identifying barriers to space technology (societal, economic, political, logistical and technological) and proposing implementable solutions to overcome these barriers. The group aimed to harness the collective experience and perspective of the assembled members, using an analytic structure to root out undue bias and create meaningful results.

The first step was to identify and summarise current issues that hinder integration of space technology into society, and the above mentioned barriers. These are defined as issues that hinder the capabilities of space-based technologies, space-enabled technologies, and applications based on space capabilities. The second step was to focus on formulating strategies that directly addressed those barriers, which could be implemented by the audience of this report.

## 2.1 Analytic Structure

### 2.1.1 Ground Rules

In order to frame conversations appropriately, the group needed to agree upon ground rules for what we would consider a meaningful and appropriate dialogue. As an extreme example, the recommendation to eventually move to another planet as resources are exhausted on Earth is far too advanced and speculative to be of much use. Similarly, a proposal to raise taxes in rich countries to fund development efforts in developing countries would be insensitive to political and economic realities, and would not be implementable within the scope of influence of this report. The group needed to decide on what was considered a reasonable scope of effort, a reasonable timeline of action, and realistic technologies to that we would be accelerating.

The group agreed to apply a 2015 timeline, so that existing, near-term capacities could be embraced. That is to say, the group considered existing and relatively low risk technologies that benefit society. Precision agriculture was in, and helium-3 fusion power was out.

It was also agreed that all recommendations would work within existing political and economic structures and ideals. We would consider different arrangements that could be executed by existing bodies, and we would not consider proposals for alternative political or economic ways of doing business.

The group considered the world as a comprehensive whole. Benefit to society would not be biased towards developed or developing nations. We would consider the world as a global society, including the continuum of developing to developed countries.

Finally, in order to provide an objective mechanism to define what it meant to be "beneficial" to society, the group used the United Nation Millennium Development Goals as a guide to societal benefit in developed and developing nations alike.


**Figure 2-1. United Nations Millennium Development Goals. Credit UN [1]**

### 2.1.2 Process

In order to identify existing space-based technologies that are currently – or have the potential to – benefit society, the process began with an exhaustive list of space products and services compiled from *The Space Report*. [2] Using an existing, comprehensive list ensured that the group considered the full range of space products and services. New applications, devised since the publication of the report, were also added. Areas such as communications and satellites, telephony, data communications, satellite positioning, geo-informatics and converging media, satellite converged media and space infrastructure were investigated:

In analysing the aforementioned products, the following areas of application and services were subsequently devised:

**Disaster management**

**Weather**

**Resource management**

- Tracking shipment security
- Water resources

**Resource exploration**

- Using satellite imagery to observe fracture lines – where there is potential oil

**Safety and maritime**

- Remote tracking

**Agriculture**

- Where and when to plant
  Observing health of crop

**Indigenous capability development**

**Earth science**

- Weather
- Environmental monitoring

**Tele-presence / Instant infrastructure**

- Connecting a geographically-distributed population
  - Health
  - Education

**Humanitarian**

- Landmine detection
- Treaty verification
- Crisis management
  - Population tracking, refugee help, border control
  - Thermal sensing and tracking

**Navigation**

The group endeavoured to identify the most beneficial technologies, and then narrow down to applications from there. The group identified the following technologies as the most beneficial to society: (1) communication satellites, (2) remote sensing satellites, (3) geo-informatics and converging media, and (4) space infrastructure. This is due to them being more commercially viable and politically feasible, relative to other space technologies. Thus, they have a greater chance of benefiting society in general. The reasoning behind this opinion followed the areas in which these technologies can be applied, where the technologies aim to improve human life and communication within society. They were also chosen for their greater economic feasibility and likelihood of political support compared to other applications.

These applications were assessed by the degree of their benefit to society as a whole, using the MDG framework, and factoring in economic considerations and potential externalities. The group decided to focus on the following key applications: (1) disaster management; (2) Earth observation (EO) / Geographical Information Systems (GIS); (3) tele-presence / instant infrastructure. The last of the mentioned key applications is particularly important in the areas of health and education.

The above space applications were discussed at length to devise existing barriers that prevent their successful integration into society. Such barriers may include peoples' lack of awareness or scepticism regarding their usefulness.

# 3 SOCIALLY BENEFICIAL APPLICATION AREAS

## 3.1 Disaster Management

Humanity has faced a myriad of disasters, all of different nature and of varying severity, whether natural or caused by technology. Through the implementation of effective early-warning systems, appropriate emergency preparedness, vulnerability mapping, data collection and effective dissemination processes, it is possible to facilitate the reduction of negative impacts – as well as the mitigation of effects – caused by disasters.

Space assets themselves are normally unaffected by terrestrial disasters. That, in combination with their large terrestrial footprint, makes them very valuable in a disaster situation. Satellite phones will work when lines are down, and at any area on Earth. Some remote sensing satellites can relay images regardless of weather or ground conditions. The combination of these technologies, properly integrated and coordinated, is very powerful. This has the capacity to reduce mortality, economic loss from disaster, and response time.

## 3.2 Earth Observation and Geographical Information Systems

GIS are integrated data and mapping technologies that allow for the analysis of spatial relationships. They include computer-based mapping systems for capturing, storing, analysing, managing and presenting data that are linked to any given location. With space technology available in this area, it is possible to apply information layers over remotely sensed imagery to then assist with agriculture and weather monitoring, population and disease tracking, treaty verification, water quality and resource monitoring, climate change monitoring and maritime domain awareness.

## 3.3 Tele-presence – Instant Infrastructure

The setting up of a tele-presence instant infrastructure enables a virtual presence that utilises advanced audio-visual capabilities to create a live, “in-person” experience. Use of satellite communications to deliver public services, such as telemedicine and tele-education to remote locations, enables provision of access to information, services, and expertise to remote communities that would otherwise not have the opportunity to receive such professional guidance. For example, telemedicine allows expert doctors in urban areas reach rural patients across a wide swath of land. This is potentially very valuable in medicine, education, technical training, and any other knowledge-intensive professional arena.

# 4 BARRIERS BY AREA

## 4.1 Disaster Management

**Table 4-1. Disaster Management**

| | |
|---|---|
| Societal | Awareness of available technology, education of end-users, questions from people during disaster – procedural issues |
| Economic | Funding shortfalls for disaster agencies, such as those faced recently in the U.S. |
| Political | Not sensitive to political cycles – focussed more on immediate or short-term actions and benefits, distaste for public spending, sharing regulation, military regulation, awareness – political and public support |
| Logistical | Multiple technologies and standards available in multiple sources, access to data, lack of coordination – private and commercial entities do not work together but compete against each other, coordination of agencies – aid sector working with the space sector, competition amongst agencies – hinders coordination amongst space entities; lack of international cooperation amongst space agencies to work towards the same goal |
| Technological | Quality – low resolution images from public sources; expensive from private or military sources, usability of data – technology available to end-users, competition with ground systems |

## 4.2 Earth Observation and Geographical Information Systems

**Table 4-2. EO and GIS**

| | |
|---|---|
| Societal | Awareness of available technology, conceptual complexity, knowledge regarding its benefits, basic education regulations |
| Economic | Willingness-to-pay, substitute products, marginal value |
| Political | Data sharing regulations, military regulation, export control, awareness – political and public support, lack of prioritisation. |
| Logistical | Access to data, lack of expertise, lack of ground data – collecting the data itself, restrictions on technology for security reasons – security risks |
| Technological | Standardisation, required training, competing standards, integration complications |

## 4.3 Tele-presence and Instant Infrastructure

**Table 4-3. Health and Telemedicine**

| | |
|---|---|
| Societal | Awareness and education of the importance of technology, need to encourage communities and raise awareness of the benefits |
| Economic | The need for on-site technology, marginal cost of use and data costs, the costs of personnel off-site |
| Political | Need to educate the government and receive their support |
| Logistical | Need dedicated physicians, nurse practitioners, technicians and on-site support staff |
| Technological | Developing relevant on-site technologies – remote analysis of medical data; remote observation of monitoring equipment such as heart monitor, cost of on-site systems, surgical facilities may not necessary be available on-site |

**Table 4-4. Education and Tele-Education**

| | |
|---|---|
| Societal | Loss of a level of interaction – loss of learning community, existing stigma – reality of lower quality education, lack of awareness that education is important and that tele-education is available to them, encourage communities to benefit from this technology, cultural – language barriers, overcoming historical lock-in – being unaware of the existence of such technologies due to remote location and not being able to discover or learn about it |
| Economic | Lack of on-site technology, data costs |
| Political | Prejudice – control politics, less political weight leaning towards advocacy amongst targeted population – less political support needed from them as they are of a lower population |
| Logistical | Time zones and differences, loss of interaction and sense of community |
| Technological | Remote meetings – loss of a degree of interaction |

## 4.4 Key Barriers

From the above results, based on our discussions, the following barriers were identified as the most important:

### 4.4.1 Societal Barriers

Although it is believed that only developing countries struggle with lack of awareness of space technologies, also the developed ones struggle with this problem. As space technologies are already so heavily ingrained into communities, they are often taken for granted, such as cellular phones, television, radio and ATM access.

Developing countries often face difficulties due to their lack of capability in existing technologies, as well as training procedures in order for them to use said technology. This wide gap between the available technology and the end-user hinders coordination between the two, and consequently affects the overall effectiveness towards the application for which it can be used.

### 4.4.2 Economic Barriers

The cost of implementing and monitoring available space technologies is a major concern for both policy-makers and citizens alike. There are often funding shortfalls for agencies, which result in aborted and unfruitful projects. One way to solve this problem is to enable international cooperation so that developing countries could learn from developed ones. Furthermore, in some cases, not only is using space technologies the only available option, it is also often the cheaper alternative. For example, access to mobile networks in remote areas is more viable than building ground-based infrastructure, such as network towers.

### 4.4.3 Political Barriers

Decision makers and policy makers play a vital role for the development of their respective societies, countries and, ultimately, the world. Prominent issues with the implementation of space technologies for terrestrial uses are the existing import, export and military restrictions due to strong concerns regarding privacy and data sharing.

An additional barrier is an amalgamation of a lack of awareness and a lack of prioritisation. Due to the absence of public understanding of the capabilities of the space sector, there is no vision towards successfully mitigating future disasters; time and money are often committed to current disasters to ensure good quality of life to those affected. However, very little is being done with regard to addressing further, potential catastrophes. Thus, it is important to educate both politicians and the general public in the benefits of – as well as the necessity to – embrace space technology within society.

### 4.4.4 Logistical Barriers

Due to the multitude of technologies available, there are also a variety of standards. This multiple array of sources leads to difficulties in merging capabilities and using relevant space-based technology to the best of its abilities. Further issues relating to privacy result in roadblocks with regards to data access. This attenuates the effective use of respective space technologies. In other cases, a request for data access is not granted until days or weeks later – this is particularly adverse in cases of disaster management, where immediate access is imperative.

A final barrier for the use of space applications is a lack of expertise. People do not usually know where to get applications and how to use them. Even if they have access to data, they often do not know how to use them. For example, how one interprets photographs taken by satellites when working in crop management. There is a need to educate and train people on available space applications that may be of great use in their everyday life. If, for example, people knew how to use weather forecasts provided by satellites, they could prepare themselves for a forthcoming disaster. This may be particularly useful in areas prone to tsunamis or earthquakes.

### 4.4.5 Technological Barriers

It is not enough to simply attain a product – it is also important to take into consideration its quality and usability. At times, a community's ground-infrastructure may not be adequate enough to complement the space technology that is available to them. For example, it is not enough to have EO technologies in place, when there are no facilities to read the data that it collects. Therefore, it is necessary to bridge this gap between the technology and its end-users, and to develop a foundation of knowledge and ability that will enable sustainability of methodologies, the successful transfer of skills and the effective inheritance of existing technologies. During all the discussions carried out, it was concluded that a general lack of awareness amongst both policy makers and citizens alike has been observed. Both of these groups are not conscious of the benefits of space technology and are often disheartened, or made disinterested, by convoluted technical explanations. Otherwise, people are sceptical of the usefulness of space technology due to a perceived irrelevance and redundancy in their application. This derives from poorly constructed and ineffective communication between the scientific and layperson worlds, as well as a lack of coordination between end-users of respective technology. Therefore, postulation of development of strategies is needed that would enable both policy makers, as well as citizens or space-generations, to address these key issues so that it is possible to facilitate the integration of space technology to benefit society.

# 5 RECOMMENDATIONS

The four recommendations below are interconnected. They are proposed to allow a more application-focused use of technologies, and are compatible with helping commercial companies to gain incentives to enter a market for these applications. The recommendations are:

1. Civil space policies should be mapped to policy agendas in other governmental and international bodies. When deciding on a particular mission focus, space agencies should analyse on how their technology and application development activities can further the goals of, for instance, the United Nations or the World Health Organisation. This will frame the decisions of space agencies in a more integrated context, increase their own relevance, and help space remain grounded in terrestrial social issues.
2. Civil agencies should increase resources for application-focuses, in collaboration with the pure technology and capability-development that often characterises space programmes. That is to say, in addition to simply creating new technologies, civil programmes should devote development resources to integrated products and services that flow from these technologies. When new technologies are turned over to the private sector, there is often insufficient knowledge behind how they can be utilised. Space agencies would take this next step in application-focused development. Application development should be mapped to, and prioritised by, the potential economic impact of those applications.
3. The emphasis in public relation and outreach activities among space agencies should be outwardly focused, and come from a non-space perspective. Communications should be in a language and frame of reference common to other

agencies, and spoken about in terms of how space capabilities benefit the greater society. It should be clear to all constituents how space technologies are benefiting them in their daily lives. Space should be down to Earth, and reflect the daily societal dialogue.

4. In application areas, space actors should increase coordination to share best practices and standardise data and technologies whenever possible. Too often, in applications like disaster management, there are no standard methods for using technologies and products from the space arena. Too much technical ability is required of users, and not enough development work is invested in usability, standards development, and compatibility. This slows dissemination of important technologies.

In short, to better benefit society, space agencies should adopt as their own the goals of society-focused organisations; help develop end-products for needs that space technologies are uniquely positioned to solve; communicate in a common lexicon and orientation; and work within the space community to optimise and deliver best practices.

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# EXPLORATION SESSION REPORT

THE 10TH ANNUAL SPACE GENERATION CONGRESS
SGC 2011
29 SEP - 1 OCT
CAPE TOWN
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# EXPLORATION SESSION REPORT

## Robotic Exploration in Today's Evolving Global Space Sector

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Cape Town, South Africa, September 2011

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# 1 INTRODUCTION

Robotic exploration will play a major role in many future space endeavours. In a collaborative effort, space agencies around the world are currently developing the Global Exploration Roadmap in order to determine where meaningful investments should be made to enable a sustainable and progressive exploration of our solar system. [1] With exploration budgets dwindling, it is important to get an overall perspective of any future space exploration programme. Considering the development of assets and the subsequent utilisation of Low Earth Orbit (LEO) for different purposes, it has been commonly agreed among major international partners that our focus should return to the exploration of targets beyond LEO.

In order to enable future human missions to specific destinations in deep space, it is important to discuss the role of robotic exploration within any mission architecture. This includes both robotic precursor missions to human space programmes and robotic exploration missions to specific targets in order to enhance our scientific understanding of the solar system. This report from the Exploration Working Group summarises the benefits and drawbacks of robotic exploration and suggests potential future targets of interest for future missions. A focus on encouraging international collaboration is applied to these missions.

Firstly however, it is important to clarify the term “robotic exploration”. The Exploration Working Group developed the following definition of robotic exploration:

“Robotic space exploration is the usage of automated and/or tele-operated instruments as a platform to perform remote and in-situ science with the purpose of discovery beyond the Earth.”

In this definition a specific emphasis has been placed on the distinction between remote and in-situ science. There are several missions that can serve as examples for both categories. Robotic missions like the Mars Exploration Rovers Spirit and Opportunity are generally considered to be in-situ science missions, since they are performing scientific investigations directly in Mars environment. [2] Other examples include landers like the robotic probe Huygens from the Cassini-Huygens mission, which landed on Saturn’s moon Titan, or the robotic lander Philae from the Rosetta mission to comet 67P/Churyumov-Gerasimenko. [3] Another type of exploration includes robots that perform remote science from a certain distance with respect to the target of interest. This includes robotic probes like the Voyager or Pioneer spacecraft, which gathered data about the planets within our Solar System from afar.

These missions can be categorised within multiple scientific fields, including heliophysics, astrophysics and planetary science. It is important to note that all these robotic exploration missions are looking beyond Earth’s local environment and that Earth observation missions are not included in this definition. This is illustrated in Figure 1-1 below.


Figure 1-1: Space Exploration and Observation

# 2 MERITS AND ROLE OF ROBOTIC SPACE EXPLORATION

National and international space exploration programmes usually include both robotic and human missions in order to pursue common final objectives. The main advantages of each respective mission type can be summarised as:

**Table 2-1: Main features of mission types**

| ROBOTIC EXPLORATION | HUMAN EXPLORATION |
|---|---|
| Survivability in harsh environment | Human judgment |
| Long duration possible | High dexterity and flexibility |
| No need to sustain life | Autonomous decision |
| No need for return trip | Social value |
| Higher risks acceptable | High inspirational power for the public |
| Mass/Costs savings | |
| Predictable behaviour | |
| Scalable technical contributions | |

Undoubtedly the most evident benefit of robotic exploration is the possibility to reach targets, which are currently inaccessible to humans because of physical constraints, especially long distances and harsh environments. In fact, the current propulsion systems based on available technology, and even the ones of the next conceivable generation, will imply a very long time transfer between the Earth and desirable target sites. The other relevant technological constraint for human exploration is due to the environmental conditions that are experienced when the craft leaves the Earth's protection. Space environment is dominated by radiation in particular, which affects the biological processes of the human body more than the functions and performance of a robotic probe.

From the international cooperation point of view, robotic missions include the possibility to scale mission contributions, such as different components of a probe, much more than manned programs. This allows partners to have different levels of participation according to their individual capabilities.

Finally, the capability to accept higher mission risk levels is a good opportunity to implement a pioneering approach. Currently, the request for greater and greater reliability of space systems (often just to avoid the risk of unpopular failure) is making the costs of missions unjustifiably excessive. While for the Apollo program "failure was not an option", a new generation of cheaper and marginally less reliable space probes can easily lead to successful programs, though not always successful missions.

Given these strengths of robotic technologies, the main objectives of robotic exploration are:

- **Advancement of space science (planetology, space weather, search for life);**

Understanding of the evolution of the solid bodies in our Solar System is a very important input for all the scientific branches focused on our planet, like geology or ecology. Deep space itself can be considered as an environment to be analysed and characterised. Moreover, the current main goal of space exploration, mainly the search of extraterrestrial life, if fulfilled will change the human prospective forever.

- **Environment characterisation and technology validation as preparation for future human space exploration;**

During the preliminary phase of human missions, robotic probes allow for the characterisation both of the planetary and deep space environment where astronauts will be expected to live and operate, often for long periods of time. The validation of new technologies can be performed with robotics, before the involvement of astronauts and with a lower risk level; a typical example is a sample return mission, involving a goal of returning planetary samples to Earth while validating all the related capabilities of propulsion, navigation, etc. Moreover, precursor robots will be able to safely pre-deploy infrastructure in advance of any human crew arrival.

- **Support of humans during manned missions**

According to the basic task for which robots were conceived and are currently used on Earth, they will operate in space environment together with astronauts and execute dangerous or repetitive tasks. The first example of such kind of cooperation is currently being tested onboard the International Space Station (ISS), where Robonaut2 is being employed to perform standard and extravehicular activities in support or on behalf of the crew members. [4] The next generation of manned space missions, beyond LEO, cannot be conceived without using sophisticated and reliable robotic elements. This new approach requires strong technological support, especially for communications. Considering the unavoidable delays in the data and commands exchange over long distances, the explorative robots must also rely on autonomy and decision capabilities on board.

On the other side, humans are constantly improving their support and contribution to the success of the robotic missions. In fact, the recent advances in the field of tele-robotics enhanced the durability and reliability of machines with the typical human logic processes and capabilities of reaction to unpredictable and changing conditions.

The specific robotic exploration goals and the areas where robots can support and complement human exploration are depicted in Figure 2-1.

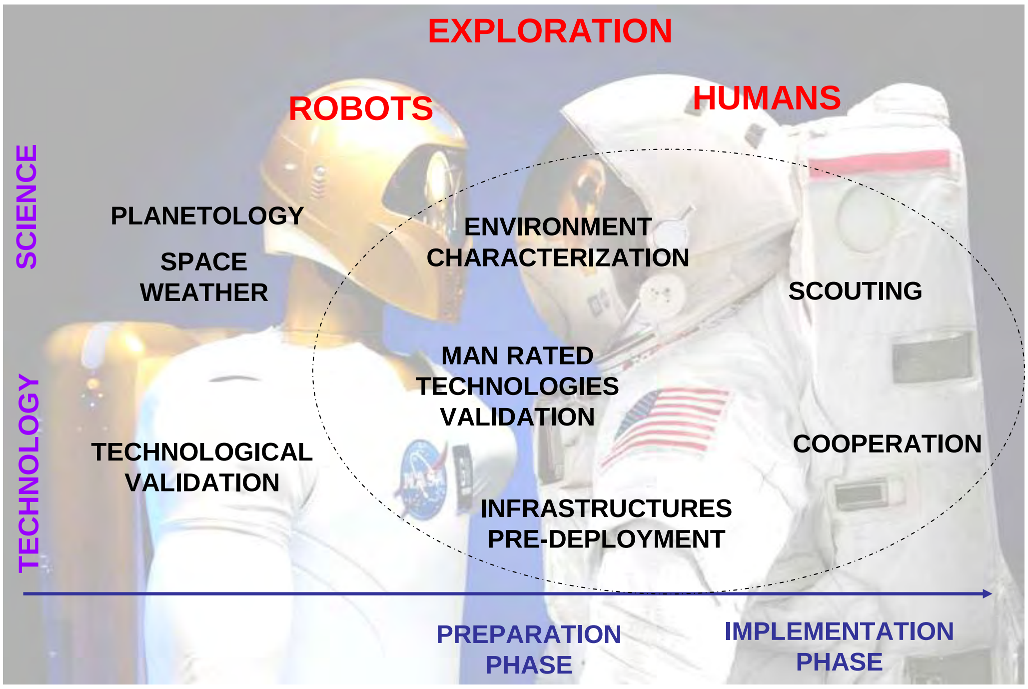


**Figure 2-1: Space exploration complementary areas for robots and humans. Background image credit: NASA**

# 3 PROPOSED MISSIONS AND DESTINATIONS

Space remains largely unexplored by humans, and thus there is no shortage of possible destinations for exploration missions. However, the strengths and characteristics of robotic exploration inherently favour missions and tasks that are currently too difficult or hazardous for completion by humans. Consequently, autonomous, unmanned space missions provide an ideal platform for an investigative and fact-finding role, acting as a precursor to future manned exploration. Robotic technologies are also well suited to substituting human involvement in exploring destinations that are either too distant or have too harsh an environment for current human exploration systems. Any proposal of future robotic space exploration missions should address both of these roles.

The Exploration Working Group concluded that a near or mid-term plan for a robotic exploration programme acting as a precursor to a future human mission, in combination with a longer-term exploration programme to a destination otherwise inaccessible to humans, provides the best utilisation of a robotic platform's unique capabilities. In this report the near to mid-term period refers to the next 10-15 years (2020-2025), while a mid to long-term time period corresponds to 15-25 years in the future (2025-2035 and beyond). A human precursor mission to a Near Earth Object (NEO) and a robotic exploration mission to Europa were the two target destinations selected for the mid- to long-term time frame considered in this report.

## 3.1 Robotic Exploration of NEOs

A robotic space exploration mission of NEOs provides an ideal means to survey possible human landing sites and test new technologies in a lower risk scenario than if a human payload were involved. This approach to preparing for human investigation and exploration of a NEO is also outlined in the "Asteroid Next" scenario of the recent International Space Exploration Coordination Group (ISECG) Global Exploration Roadmap. [5] Such an autonomous mission could include any combination of systems such as a space-based telescope to search for potential NEO destinations, robotic survey missions to investigate these destinations in more detail and a lander for in-situ measurements and technology demonstration.

A robotic mission preceding a manned mission to Mars, a destination considered by many to be our "final" exploration goal, may hold greater inspirational value for the public. However, the technology development required for a manned mission in the near- to mid-term time frame is currently unrealistic. Furthermore, robotic exploration missions lack the high profile public following often associated with manned exploration missions, along with other disadvantages of any mechanical and autonomous replacement for human presence. Yet despite these issues, an unmanned NEO mission does provide a strong and systematic foundation for any future human based endeavours to NEOs and beyond.

Using a robotic mission as a precursor to any human activity on a NEO allows for a simpler mission profile that does not necessitate any return of the space vehicle (although a sample return mission would be possible). It also provides an opportunity to test processes and technologies intended for human use in the target environment but with a lower associated risk, given the absence of supporting any human life. Robotic exploration of NEOs can also be easily scalable through the development of a standard or generalised spacecraft bus that lowers the cost of future missions with proven flight hardware. [6] Autonomous missions also involve less direct ownership of a programme that would otherwise be created from participant astronauts or cosmonauts representing a specific country, and therefore these programmes encourage greater and more diverse international and industrial collaboration. Furthermore multi-organisational cooperation also decreases the cost burden of the program on any single group. Robotic investigations of NEOs also provide an opportunity to gather information that may become useful in the need for planetary defence against a NEO impact.

## 3.2 Robotic Exploration of Europa

A robotic exploration mission to Jupiter's moon Europa offers a mid- to long-term goal for remote and autonomous investigation of a destination with an extreme environment that would be otherwise inaccessible to humans. Closer examination of the icy surface of

Europa, with a hypothesised ocean beneath, would provide an opportunity to undertake new science and further the search for extraterrestrial life. The ambitiousness of such a programme could also be easily scalable depending on the desired time frame for completion, either in the development of an observational orbiter, a basic surface lander or a complex landing mechanism to drill through the ice and investigate lower surface layers.

The challenges associated with providing the necessary budgetary planning for a long-term project and ensuring that a human-made lander does not contaminate Europa would need to be addressed before fully committing to this programme. However, such a long distance mission could only be realistically completed by a robotic system, and would stimulate and motivate the development of new technologies and public interest associated with the investigation of other life in the universe. The technologies developed to overcome engineering challenges such as survival in such a harsh environment and drawing power from the little available energy so far from the sun, makes spin offs to everyday technologies likely. Robotic space exploration missions of this scale and complexity cannot however be successfully achieved without international sharing of research, knowledge and resources.

# 4 INTERNATIONAL COOPERATION MECHANISMS

International cooperation is a crucial part of today's space activities. It allows very large and complex projects to be conducted, such as building the ISS. The ISS is a great example of how collaboration can be beneficial to all partners. International cooperation has the capacity to improve international relations, stimulate technology sharing, and enhance mission planning.

Another example of successful cooperation is the European Space Agency (ESA) with its 19 member countries. All of these countries have different backgrounds and fields of expertise, and yet, they are capable of efficient collaboration in order to build satellites, instruments, launch vehicles, ISS modules and more.

Cooperation among countries increases their mutual understanding of each other and helps to develop a platform for collaboration in other areas such as education, technology and science. Technology sharing allows countries with a less developed space sector to take advantage of the new technologies and expertise developed by their partners. Collaborative missions may help prevent overlap of space programme goals, which then translates to cost savings. A mission's output and results can be shared among participating countries as well. The ISS and ESA model show that the concept of collaborating works well. International collaboration, supervised by an international entity such as ISECG, seems like the best way to achieve synergy in case of collaboration among countries from different continents. Members would join on a voluntary basis and ISECG supervision would help strengthen national agencies.

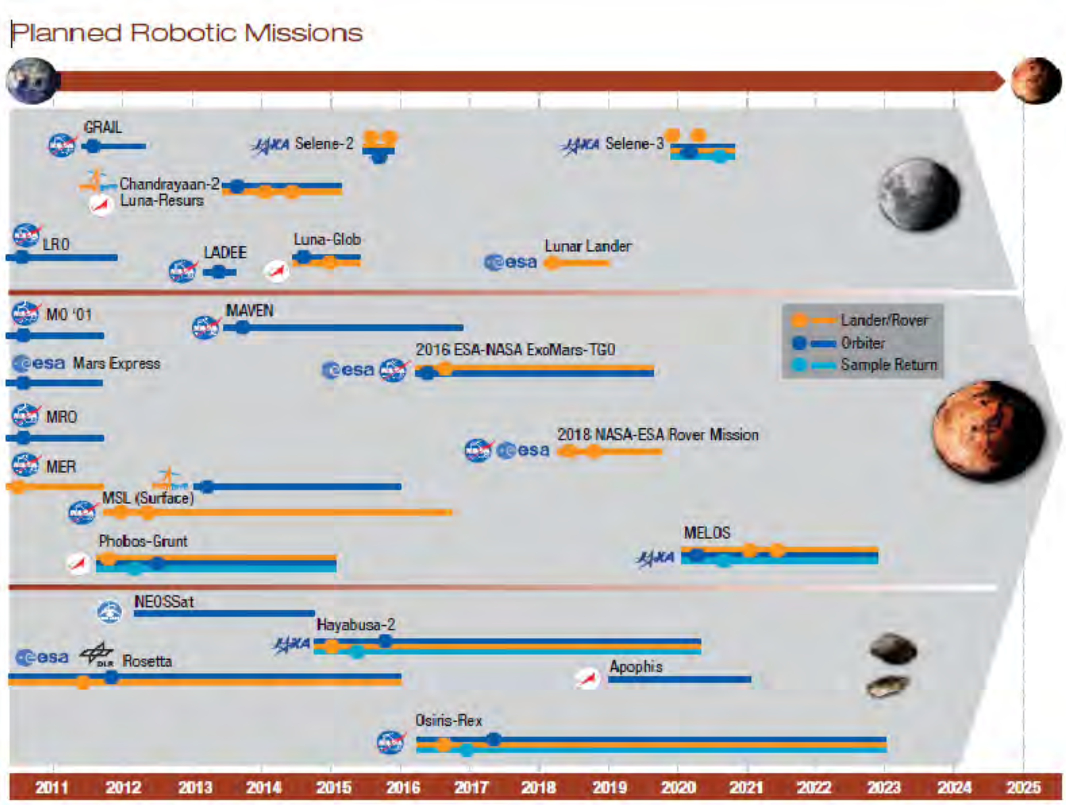


**Figure 4-1: Planned Robotic Missions. Credit: ISECG Global Exploration roadmap**

On the other hand, working with many different groups often leads to complications with tracking individual responsibilities and changes in a project's life, and the amount of paperwork usually increases rapidly. Other considerations should be also taken into account, such as who will be responsible for a project's funding, who is the owner of the product, how will product assurance and quality assurance be ensured. Despite some drawbacks, the Exploration Working Group believes that international collaboration is beneficial to all participating subjects.

Robotic exploration is a unique opportunity for any country to join space exploration efforts. The level of participation depends on a nation's field of expertise and technology readiness level. Modern robots are very complex with many different subsystems, including operations and ground systems. International teams can provide various sized pieces of the final project, from components to expertise for analysers, software, hardware, instruments, and facilities for testing (radiation, vibration, thermal, structural) or launch. Thanks to the diversity of systems, the level of participation can be determined according to skills of interested member teams and more skilled counterparts can mentor the less skilled national teams.

Robotic exploration provides an excellent opportunity for universities and other educational institutions to become involved in space exploration and to raise student interest and curiosity. More developed agencies might help emerging countries on their way "to space". Additionally, international collaboration could have a great outreach effect, although specifics to this end are beyond the scope of this report.

# 5 CONCLUSIONS AND RECOMMENDATIONS

Robotic space exploration is an important endeavour for mankind, improving the knowledge of our universe and paving the way for future human presence in the solar system. Robotic missions have specific advantages with respect to manned ones. A robust robotic exploration program on both national and international levels is more easily supported and accomplished.

The intrinsic human safety of remote robotic missions and the possibility to plan one-way trips to the planetary target enable greater risks to be taken, and this can also reduce the overall cost of these programs.

The architecture of spacecraft, with complex and scalable configuration, allows a good opportunity for wider cooperation with diverse levels of member contribution.

Two main types of missions are recommended: precursor missions to human exploration, for which Near Earth Objects are a good target for technological validation, and purely scientific missions, towards a destination like Europa otherwise inaccessible to humans with current technologies.

Although human exploration is the final dream (and target) and will always maintain a higher inspiration capability, robotic missions can be equally suitable to capture and maintain public attention by dedicated involvement of new media.

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# OUTREACH SESSION REPORT

THE 10TH ANNUAL
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# OUTREACH SESSION REPORT

## Space for Developing Regions

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Cape Town, South Africa, September 2011

***Members whose participation resulted in the final report.**

# 1 INTRODUCTION: SPACE FOR EARTH

"Space gives you a chance to dare to dream. It gives you expanded horizons, satisfies curiosity about the way the world – the universe – works. That's the kind of spirit that we need to spark in scientists, engineers and entrepreneurs. We need that culture to be pervasive in society. That's the catalyst that space can be!" [1] In the words of Sias Mostert, a space pioneer in South Africa, space has always represented a source of inspiration. The fact that “every culture has a link to the stars” has been noted by Dr. Kevin Govender, another South African representative and Director of the Global Office of Astronomy for Development (OAD). For Dr. Govender, astronomy represents a tool for creating a better society and a better life. It helps people understand how little and fragile Earth is. It educates children and young generations to better value our planet.

Studying outer space helps us become better citizens of the world by expanding our horizons. Space gives us inspiration and answers life’s most important questions – Why are we here? Where do we come from? Where are we going? Today space technology allows us to watch our planet from above and directly benefit from the knowledge we gain.

Today space applications have become an indispensable part of our everyday life. Satellite enabled telecommunications, remote sensing, and navigation allow us to live a better life by helping us address many of the challenges we face today. Space is considered among the best tools to spur scientific and technological progress in knowledge-based societies. If this is true for developed countries, where science and technology represent key factors of economic progress, it is true even more so for developing countries. In these nations, a high percentage of the population is still located in rural areas and the lack of terrestrial infrastructure sometimes makes satellite technology the only available option. Therefore, investing in space applications should be among the top priorities of developing countries.

Unfortunately, developing countries often view space programs as unnecessary, prestige-based, and only suitable or adequate for large, developed countries. This perspective is misleading. This report demonstrates that outer space is not only the domain of wealthy and technologically advanced nations. Space-based technology is in fact, currently one of the best tools to bridge the gap between developed and developing countries.

# 2 BENEFITS OF SPACE PROGRAMS TO DEVELOPING COUNTRIES

Communications, medical care, disease prevention, urban planning, agriculture, natural resource management, environmental pollution control, education, disaster prediction, disaster relief and meteorology are some of the important areas where space benefits society [3].

Communication satellites transcend traditional geographic barriers and limitations. They can provide data broadband services, enable tele-education, and allow doctors to provide medical information on demand to anywhere on the globe.[4] Remote sensing satellites can observe and monitor large areas. Other satellites can focus on specific territories. Radar technology can be used during the night and amidst heavy overcast. Radar is also used for prospecting water, oil and minerals. Remote sensing data can be used to predict outbreaks of many diseases and to identify conditions conducive to disasters. Remote sensing satellites are often the only available technological tools after a disaster occurs. Developing countries can also benefit from the use of navigation satellites, which can improve transportation systems, logistics, and security.

Space activities have shown a plethora of spin-offs that have improved our lives dramatically. Some of the latest spin-offs include water generation, which is based on recycling water technology developed for the ISS, as well as food management technology, which is based on the food processing and storage technology developed for the ISS. It is important that food storage and retrieval mechanisms be in place when natural calamities are about to strike.

## 2.1 Space Programs in Developing Countries

The best way for a developing country to benefit from space technology and space applications is to establish and implement a national space program. A national space program should stipulate short-, medium- and long-term goals of the country for the utilisation of space. The program should also state how the country wants to make investments – whether directly (creating and investing in a home grown space industry) or indirectly (focusing on space applications and services). Policymakers should select priorities and allocate resources based on the needs of their country. For the short and medium-term periods, focusing on basic space applications is a good starting point. This will enable the development of local space expertise. However, in order to obtain long-term benefits from space, focusing on a home grown space industry should be the most appropriate path to follow. Scientific and technological independence for developing countries means there is a possibility for those countries to tailor scientific research to their own needs. Presently, Algeria, Egypt, Morocco, Nigeria and South Africa already have space programmes. Nigeria and South Africa have national space policies, while only South Africa has a national space law.

A centralised strategy allows a government to implement long-term projects, which is critical for the creation of a space education curriculum and the establishment of infrastructure management (i.e., capacity building). It necessitates creation of jobs and helps address the problem of “brain drain”. Since many of the challenges that effect developing countries are common, a national space programme can foster international cooperation at the very least among them.

Many consider space technology too expensive and not a priority worth investing financial resources. However, as India has demonstrated when they started their space programme, satellites can provide developing countries with the opportunity to “catch up to more developed countries in communications and natural resource management without going through an initial stage of expensive infrastructure development” [5]. In the words of M. Mahmoud Ibrahim, Executive Manager of the EduSat Program the Egyptian National Authority for Remote Sensing and Space Sciences, “space applications are fundamental to solving many of the challenges that developing countries have to cope with space technology that really opens new dimensions for a country.”[6] A homegrown space industry means more control over and accessibility to space assets. In addition, it helps to provide something that developing countries are really in need of – self-reliance.

# 3 REGIONAL AND INTERNATIONAL COOPERATION FOR THE SPACE INDUSTRY

Given the challenges that a developing country faces when establishing a national space programme (lack of capabilities, expertise, basic infrastructure, capital, etc.), international cooperation is fundamental to provide expertise where needed. However, for better sustainability of space programmes, regional cooperation may be more important, necessary and meaningful. The incentives for regional cooperation include the following:

(i) *Common natural resources and disasters*

Countries in the same geographical vicinity share similar natural resources and are prone to similar natural disasters. It is, therefore, a good idea for them to come together and identify solutions that countries can cooperatively work on. Each country's benefits will be the sum of the contributions. A case to highlight here as an example is Lake Chad in Western Africa, which Chad, Niger and Nigeria border upon. Satellite images are being used to monitor the gradual drying of the lake as a result of desertification [7].

(ii) *Establishment of a regional structure for the larger international community*

Regional cooperation creates a strong basis for international cooperation [8]. It is culturally and logistically easier and therefore, more efficient. Regional cooperation should be encouraged before moving on to pursue larger collaborations.

(iii) *Improvement of indigenous capabilities*

Regional cooperation brings nations together and makes them self-reliant. It improves their indigenous industries, provides in-house jobs and makes for a more stable economy [10].

(iv) *Sharing of costs and benefits of new programmes*

Space is a new industry for most African nations. Embarking on the uncharted path together helps distribute the risks and costs, leading to more benefits. Building a larger project together also triggers the economies of scale so countries can gather more benefits for smaller shared costs.

*(v) Utilisation of existing infrastructure and expertise*

Some countries in Africa have underutilised space facilities, while others have a large skilled workforce. For example, South Africa and Kenya have launch pads which were used during early space missions, while Nigeria produces thousands of skilled professionals. Regional cooperation will enable the sharing of knowledge and facilities. This will ensure the retention of human capital within Africa. Furthermore, cooperating with nations that have already developed technologies allows emerging space nations to harness existing technology rather than to start its development from scratch.

(vi) *Financial security of a programme's sustainability*

Space programs are capital intensive. In several instances governments stop supporting space projects when there are more pressing national needs. However, sharing the cost of such projects will likely ensure that such projects continue.

(vii) *Unification of Regions – promotes communication and reduces conflict in other areas*

Collaboration in the space industry initiates communication and goodwill in other fields between the collaborating countries. It provides incentives for politicians to maintain good relations with each other. Citizens hold foreign citizens in good opinion and could even serve to avoid conflicts in other areas.

There are some apprehensions associated with international or regional cooperation. These includes misuse of information and shared resources; potential loss of power and influence of the stronger providers; and delays in implementation due to cooperation/communication requirements (logistics and coordination can be difficult). Despite these risks, the benefits from regional cooperation are more significant.

## 3.1 Example: The African Region

Currently, some collaborative space programs exist in Africa. Some of the examples include the African Resource Management Satellite Constellation (ARMC) Project, the African Leadership Conference on Space Science and Technology for Sustainable Development (ALC) and the Square Kilometre Array (SKA) [9].

ARMC is meant to be a constellation of Earth Observation satellites. Current participating countries include Algeria, Kenya, Nigeria and South Africa. Those countries contribute with a satellite to the constellation. These countries will have free access to data from any of the satellites. Presently, only Nigeria has contributed a satellite to the project. It is expected that more African countries will join the project.

ALC is a platform for space experts and professionals to come together to share knowledge, experience and to advise policy makers in Africa, so that they may make decisions based on satellite-derived data. The group holds a biennial conference. Past conferences were held in Algeria (2005), South Africa (2007), Nigeria (2009) and Kenya (2011). Efforts are being made to integrate the ALC into the African Union.

SKA is a project to set up the world's largest ground-based telescope. The bid for hosting the project is between Australia and South Africa. Eight African countries are supporting the bid of South Africa. If South Africa wins the bid to host the facility, the different participating countries will benefit in the utilization of the facility and sharing of data. Currently, young scientists from the cooperating countries are benefitting from a capacity development programme in South Africa.

# 4 BUILDING SUPPORT

As already mentioned, space programmes are often considered by developing countries as unnecessary, prestige-based, and only for large, developed countries. Thus, building support for space programmes and projects is as necessary as the identification of the different stakeholders. Potential stakeholders include taxpayers (who are also the people at risk), policy makers and governments, NGOs and other such volunteering organisations, students and the next generation of African nations, public (inclusive of children and unemployed citizens who are not likely to pay taxes), industrial sector, other countries (government and public), scientists and financial institutions.

Steps have to be taken to address the needs and different opinions of the different stakeholders. Below are some recommendations for gaining broader support for space programs in developing countries:

i. Inform, with the help of the media, all stakeholders about the benefits that come from space-based technology (use of brochures, conferences, debates, television, radio programs, children school books, etc.).
ii. Space science should be integrated into school curriculums. It is important to link the researcher with the actual educators in the field.
iii. National agencies should collaborate with other government departments and institutions. An office or point of contact should be set up to stimulate interaction with government institutions.
iv. Establishment of non-profit organisations, which liaise with the government and other organisations related to space applications. Examples of such non-profit organisations are the African Space Institute, the South African Space Association, and the South African Space Foundation.
v. Lobby the drafting and endorsement of a UN resolution that urges countries to focus on implementing space related products on education. For example, declare the year 2015 as the International Year of Space Science.
vi. Approach intergovernmental organisations to get the support from government and therefore, propagate the message of space applications and benefits.
vii. Create smaller, pilot programmes in schools and universities. Use the results from groundwork to show what results can come in the future. Apart from education, policy steps currently underway allow countries to gain greater benefits from space applications and national space programmes.
viii. Companies should create policies to encourage knowledge transfer.
ix. All policies should encourage local human capital development.
x. Create policy for productivity where researchers, operators and agencies have to showcase the outcome of programmes by publishing papers. Researchers need to make their knowledge and research results understandable by the general public.

## 4.1 Financing space projects

One of the benefits of building support is that space programmes and projects will receive more financing. Space programmes can be financed either through conventional or unconventional means. Conventional methods include giving tax breaks to new space-based companies and providing necessary infrastructure such as steady power supply, good roads and other utilities. Governments could also provide additional funds through grants and fund matching campaigns. Unconventional methods include government lotteries, crowd financing, donations from social media and websites, tapping from the budget of existing agencies, inter-agency collaboration and allocation of funds from private individuals or foundations [11, 12].

### 4.2 Involving students and young professionals

Students and young professionals are essential to the progress of the world and the general support is incomplete without their contribution. It is important to engage them in outreach activities so that they gain familiarity. On their part, they can increase the interests of various stakeholders to invest in space. The key is to work together rather than individually. The different ways in which students and young professionals can contribute are:

i. Direct involvement in teaching in schools.
ii. Organisation of workshops, games and competitions (e.g. SPHERES Zero Robotics and The Space Game).
iii. Form clubs/societies and organise events (e.g. Space Generation Advisory Council, SGC and Yuri's Night).
iv. Use social media or mobile phones to reach out to thousands or even millions of users.
v. Entrepreneurial start-ups for grassroots/field teaching, technology development and space advocacy think-tanks.
vi. Get involved in making policy.
vii. Space professionals can get their youngest employees involved in initiating and participating in scholarships and internships.

# 5 CONCLUSIONS

Space benefits Earth in many ways. Space-based technology has become indispensable to most countries today. Since space activities are not only the domain of the wealthy and technologically advanced nations, developing countries can directly benefit from space and actively procure those benefits for themselves. It has been observed that in countries where there is a lack of infrastructure or where a high percentage of the population is located in rural areas, spending on space technology applications is more beneficial than spending on terrestrial applications. Moreover, space science and space technology are among the best tools to spur development and help bridge the developed-developing country gap. This report identified the key stakeholders in the process of developing the space industry in developing countries. It goes on to assert that regional and international cooperation is the best way to initiate the process and foster growth in the industry. Investing in space applications, space technology and national space programmes should be among the top priorities of the governments of developing countries; in fact, several methods for building support have been identified among all age-groups and classes of stakeholders.

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THE 10TH ANNUAL

SGC 2011

CAPE TOWN

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# FINAL REPORT


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