SPACE GENERATION CONGRESS PRAGUE 2010

FINAL REPORT

SGAC
SPACE GENERATION ADVISORY COUNCIL
www.spacegeneration.org

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

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SPONSORS AND PARTNERS

The 2010 Space Generation Congress (SGC) would not have been possible without the generous support of our sponsors. This year our sponsors went further than before and provided 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.

PLATINUM

Anonymous

GOLD

SILVER

A.C. Charania

Peter Diamandis

James Moody

George Whitesides

Juergen Schlutz

ACRONYMS

CCSDS	Consultative Committee for Space Data Systems
COTS	Commercial Orbital Transportation Services
ESA	European Space Agency
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
IAC	International Astronautical Congress
IAF	International Astronautical Federation
MIT	Massachusetts Institute of Technology
NASA	National Aeronautics and Space Administration
NEO	Near-Earth Object
PR	Public Relations
SGAC	Space Generation Advisory Council in Support of the United Nations Programme on Space Applications
SGC2010	Space Generation Congress 2010
SFF	Space Frontier Foundation
SWF	Secure World Foundation
UN COPUOS	United Nations Committee on the Peaceful Uses of Outer Space
UNL	University of Nebraska at Lincoln
WSW	World Space Week
YGNSS	Youth Promoting Cooperation and Education on GNSS

LETTER FROM THE CHAIRS

It is with great pleasure that we present to you the report of the 2010 Space Generation Congress, held 23 – 25 September in Prague, Czech Republic. This year's congress was punctuated by some remarkable highlights for SGAC such as a speaker programme that included, Charles Bolden (NASA Administrator), Berndt Feuerbacher (President of the International Astronautical Federation, IAF), Dumitru Prunariu (Chairman of the United Nations Committee on the Peaceful Uses of Outer Space, UN COPUOS), and Jim Zimmerman (President of International Space Services and former IAF President).

SGAC strives to help more university students and young professionals participate in more space events, more often. This year we delivered on this with the most number of delegates ever assembled for SGAC and a record number of travel and registration scholarships delivered 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 2010 helped to foster new ideas and showcase the best of young, current thinking on space issues.

We would like to thank Ariane Cornell, SGAC Executive Director, and the team for their tireless efforts in coordination, thinking and planning. Without their efforts SGC 2010 would not have come close to being the event that it was.

We look forward to building on the success of this year's SGC and furthering our goals in the international space community. In particular, we welcome to our team new SGAC Event Manager, Filippo Menga, who will be leading the organisation of the biggest SGC yet in Cape Town, South Africa in 2011.

We hope to work with you all again next year and thanks once again for making SGC 2010 such a success!

Agnieszka Lukaszczyk

Chair

Michael Brett

Co-Chair

LETTER FROM THE CONGRESS MANAGERS

At the beginning of the planning of SGC 2010, the SGC 2010 organising team realised the task was going to be difficult. SGC 2009 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 2010 organising staff rose to the occasion. This year our organising team was comprised of 20 people from 15 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 SGC 2010 truly a historic event for SGAC. SGAC would also like to thank the Czech Space Office, in particular Jaroslav Urbář, Milan Halousek, and the managing director, Jan Kolář, for their support throughout the organising process.

The bar has been raised yet again for 2011 which just in time for SGC's 10th anniversary. We look forward to seeing you all back at SGC 2011, this time in Cape Town, South Africa, for what will be another historic Space Generation Congress!

Ariane Cornell

Executive Director and Congress Manager

Maria-Laura Voda

Executive Secretary and Assistant Congress Manager

SGC2010 CONFERENCE OVERVIEW

2010 Space Generation Congress delegates

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 2010 brought together both young and experienced players in the space sector from 40 countries for inspiring, resourceful engagement.

Young professionals and university students had the opportunity to discover the latest space programmes, technology and future exploration missions. Attendees heard perspectives on space issues from top space organisations, including: Arianespace, Inc., the Consultative Committee for Space Data Systems (CCSDS), the George Washington University's Elliot School of International Affairs, the International Astronautical Federation (IAF), International Space Services, NASA, Secure World Foundation, Space Frontier Foundation (SFF), and UN COPUOS. Conversely, leaders from these space organisations had the occasion to get an insight into the fresh, innovative and bold perspectives of the incoming space generation regarding the five main SGC 2010 themes: Industry, Agency, Climate, Environment, and Outreach.

SGC 2010 was held in Prague, Czech Republic from September 23-25, prior to the 61th International Astronautical Congress. The Congress sold out at 101 delegates which was a 33% increase compared to last year (75), a fact that demonstrates that SGC is becoming stronger with every year. Together, they shared their knowledge, gained intercultural experience, learned about international cooperation in the Space Age, created solutions for the challenges of tomorrow, and gained skills to help them in their pursuit of space development.

SGC 2010 was organised by a group of volunteers from around the world and supported by several sponsors. The 2010 Congress would not have been possible without either, and SGAC would like to express its appreciation and gratitude.

SPEAKERS

Barbara Adde	Policy and Strategic Communications (PSC) Manager for the NASA's Space Communications and Navigation (SCaN) Programme
Charles Bolden	NASA Administrator
Ben Corbin	Aerospace Engineering and Planetary Science Masters Student at the Massachusetts Institute of Technology (MIT)
Chris De Cooker	Head of the International Relations Department at the European Space Agency
Berndt Feuerbacher	President of the International Astronautical Federation (IAF)
Mike Kearny	Chairman and General Secretary of CCSDS
John Logsdon	Professor Emeritus at George Washington University´s Elliot School of International Affairs
Clayton Mowry	President of Arianespace, Inc.
Dumitru Prunariu	Chairman of the UN COPUOS
William Watson	Executive Director of the Space Frontier Foundation (SFF)
Ray Williamson	Executive Director of the Secure World Foundation (SWF)
Jim Zimmerman	President of International Space Services, Inc.

CONGRESS THEMES

At the core of SGC10 were the working groups, where delegates had the opportunity to discuss their views on the development of space. The themes of these discussions mirrored the five themes debated at the International Astronautical Congress (IAC): Industry, Agency, Climate, Exploration, and Outreach. Each theme working group produced 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, our anonymous donor and the SWF.

Industry: The New, Increased Role of the Private Industry in the Space Sector

Space is potentially on the verge of being driven by the private sector. From space tourism and the new generation of launching companies to continued growth of traditional large aerospace companies, industry's role is growing. The conference delegates discussed the prospects of, challenges and potential hindrances to the development of this new generation of commercial space activities.

Agency: Global Navigation Satellite Systems (GNSS) for Disaster Management

Our daily lives on Earth have much to benefit from international, collaborative space systems, such as GNSS, yet many challenges must be overcome to truly optimise their capabilities for the international community. Accessibility of technology, capacity building, and technical and political coordination are just a few of the issues that need to be addressed to allow for effective international collaboration, particularly in the case of disaster management. Delegates discussed these issues and suggested practice and policy changes to improve the effectiveness of these projects.

Climate: Enhancing Global Climate Data Exchange to Better Monitor Climate Change and to Empower Policymakers, Scientists, and the Community

Earth observation data has become an essential source of information for understanding climate patterns on the Earth. This data can help predict or follow climate's fluctuations and discover what can be done in order to prevent adverse its changes. Earth observation data are generated by different satellite systems which belong to different countries with different standards on the gathering and distribution of data. A new, innovative suggestion for data collection is the use of "community remote sensing" where smart phone (e.g., Blackberry and iPhone) applications harness the power of the public to record environmental data on the ground. This information is then combined with satellite data to create a more holistic picture. The participants of the group discussed the current challenges of Earth observation data collection – both top down and bottom up – and how the exchange of data can be improved.

Exploration: Examining the Feasibility of a Mission to Mars from the Perspective of the Young Generation

“Why explore space and send humans farther and farther away from our planet?” While this has always been an important question in space sciences, right now as the world’s top space agencies are reassessing their paths, this has become a critical question. This topic included a provision for opinions of the development of human space exploration and provides an in-depth analysis of what is necessary for a mission to Mars.

Outreach: Development of Science and Technology Education and Careers for the New Generation

Space activities are unthinkable without a well-trained technical workforce. Today, unfortunately, countries around the world are facing the challenge of motivating and inspiring young people to take on studies in science, technology, engineering, and mathematics. The working group will discussed how to improve space outreach, which includes changing stereotypes about space sciences.

CONGRESS HIGHLIGHTS & SPEAKERS

Day One

• Welcoming words from Ariane Cornell, SGAC Executive Director and SGC Congress Manager, and Maria-Laura Voda, SGAC Executive Secretary and SGC Assistant Congress Manager, who expressed their excitement and high expectations about this year's Congress.

• A welcome and short history of the organisation as well as the main activities of SGAC – networking, conferences and projects – presented by Agnieszka Lukaszczyk, Chair of SGAC.

• Dr. Dumitru Prunariu, Chairman of the UN COPUOS, set the tone of the Congress by addressing current global challenges and opportunities in the space sector from workforce issues to exploration. Most importantly, he emphasized the role of the youth in future space development activities.

Dr. Dumitru Prunariu,

Chairman of the UN COPUOS

• Project group work time.

• Climate Session speaker Dr. Ray Williamson, Executive Director of the Secure World Foundation, delivered a speech on the role of community remote sensing in climate change monitoring and mitigation.

• IAF Executive Director, Philippe Willekens, presented the International Astronautical Congress (IAC).

• SGC2010 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

• Premiere of a short movie, "Space Generations: From Sputnik to Today to Tomorrow," featuring key moments in space history. The movie was completed via a partnership between the Space Generation Advisory Council and the University of Nebraska at Lincoln (UNL). The idea behind the movie belongs to Prof. Dr. Frans G. von der Dunk, Othmer Professor of Space Law at the Space and Telecommunications Law Programme of the UNL. Art Anisimov, SGAC National Point of Contact of Belarus and space law graduate at UNL, and Andy Bacon, head of SGAC's Near Earth Objects (NEO) working group, led the effort of producing the movie.

• Move an Asteroid Competition Winner, Ben Corbin, gave a speech on "Implementing Advanced Technologies and Models to Reduce Uncertainty in a Global, Cost-Effective Asteroid Mitigation System." He addressed the need of increasing the accuracy and precision in tracking near Earth objects and the components behind an automated decision-making warning system.

• Agency spotlight speakers, Barbara Adde from NASA's Space Communications and Navigation (SCaN) Programme and Mike Kearny from the Consultative Committee for Space Data Systems (CCSDS). Ms. Adde stressed the importance of international cooperation in optimising the use of current and future Global Navigation Satellite Systems (GNSS). Mr. Kearny complemented Ms. Adde's presentation by pointing out that communication data systems enable most of this cooperation at the international level and affects all of our personal lives.

• Outreach spotlight speaker, Jim Zimmerman, President of International Space Services, Inc., stated that as individuals working in the space sector it is our mission to promote space and stimulate interest from the general public. From his point of view, outreach should focus on three key words describing space: international, glamorous and inspiring. He also pointed out that geography is a factor to take into account when doing regional activities and projects.

• Project group work time.

• SGC 2010 delegates attended the SGAC Project Team Info Session where they were introduced with the three main projects SGAC supports throughout the year: NEO Working Group, SGAC Group on Space Technologies for Disaster Management and Youth Promoting Cooperation and Education in GNSS (YGNSS).

Delegates discussing and debating the direction of space development

Day Three

- William Watson, Executive Director of the Space Frontier Foundation, informed SGC delegates of the advocacy work done by his organisation in support of the space strategy as proposed by the President Obama of the United States of America. Mr. Watson also premiered an SFF movie encouraging the expansion of the new commercial space sector.

- Berndt Feuerbacher, President of the IAF, delivered a technical presentation on the Rosetta mission. The presentation was followed by an extended round of applause by the audience which was filled with young space scientists, engineers, businessmen, lawyers, and politicians, alike.

- Industry spotlight speaker Clay Mowry, President of Arianespace, Inc., talked about the historic development and changing role of commercial space. Mr. Mowry emphasised that space is an application driven business, with satellites being today the major focus.

- The Exploration spotlight speech was given by John Logsdon, Professor Emeritus of the Space Policy Institute of the George Washington University in Washington, D.C. Dr. Logsdon reflected on past and present exploration issues and illustrated the unique conditions that allowed the Apollo programme to be successful.

- SGC delegates gave five 20-minute presentations encapsulating their fresh perspectives, in-depth analysis and innovative recommendations for issues connected with Industry, Agency, Climate, Exploration and Outreach. Youth perspectives on space will be gathered into a final report that during the following months will be presented to UN COPUOS and to industry, agency, and academic organisations that collaborate with SGAC. Results will also be shared at events where SGAC members participate, ensuring that the voice of the next generation of space leaders is being heard, listened to and integrated in today's space policies and decisions.

- Formal closing dinner held at the Charles University of Prague was attended by SGC delegates and prominent international leaders of the space sector. The featured speaker, NASA Administrator, Charles Bolden, addressed the audience and stressed the importance of youth for the future of space exploration. "If exploration is your passion, no one will stop you. You will make a difference, and I look forward to hearing your voices,"

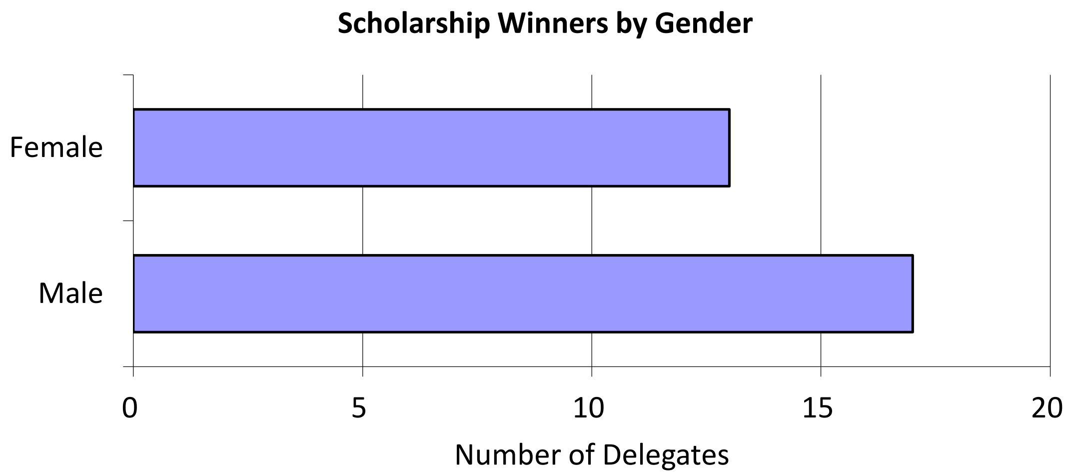
NASA Administrator Charles F. Bolden, addressing SGC 2010 participants during the closing dinner

Administrator Bolden declared. Also during the closing dinner, SGAC Young Leader Scholarships, funded by SGAC and its partners, were awarded. The 30 scholarships, a record-number for SGAC, sponsored the winners to participate in the Congress. As many of these winners are from developing nations, these scholarships enable SGC to truly be an international youth space forum.

SCHOLARSHIP STATISTICS

SGAC provided 30 scholarships to the organisation's top performing members to attend SGC 2010 – maintaining previous SGC scholarship record. 22 countries from five continents were represented in the winner pool. With support from our sponsors, SGAC covered the roundtrip travel, Congress fee, and room and board for the full conference for each winner. As one of SGAC's goals is to bring the youth international space community together to discuss space issues, SGAC sees the 30 scholarships as a key indicator of SGC 2010's success.

First Name	Last Name	Scholarship Title	Country (main)
Christopher	Vasko	Young Leader	Austria
Artiom	Anisimov	Young Leader	Belarus
Bernardo	Santos	Young Leader	Brazil
Hubert	Foy	UN/IAF Workshop	Cameroon
Mario	Ciaramicoli	Young Leader	Canada
Farnaz	Ghadaki	SGAC Event Manager Candidate	Canada/Iran
Bekele	Erko	Young Leader	Ethiopia
Catherine	Doldirina	Young Leader	Georgia
Andreas	Fink	DLR Delegate Assistance	Germany
Christian	Blank	DLR Delegate Assistance	Germany
Johannes	Weppler	DLR Delegate Assistance	Germany
Christine	Hill	DLR Delegate Assistance	Germany
Filippo	Menga	SGAC Event Manager Candidate	Italy
Israel	Ojeda	Young Leader	Mexico
Muhammad	Shafiq	Young Leader	Pakistan
Beata	Maihaniemi	Young Leader	Poland
Maria-Laura	Voda	Young Leader	Romania
Oana	Sandu	Young Leader	Romania
Ekaterina	Rezugina	Young Leader	Russia
Minoo	Rathnasabapathy	IAASS/ISSF	South Africa
Pierre	van Heerden	Young Leader	South Africa
Jessie	Ndaba	Young Leader	South Africa
Yohan	Ferreira	Peter Diamandis	Sri Lanka
Cem	Asma	Young Leader	Turkey
Ben	Corbin	Move an Asteroid	United States
Tabitha	Smith	Young Leader	United States
Stephanie	Wan	UN/IAF Workshop	United States
Victoria	Alonsoperez	Young Leader	Uruguay
Ana Alexandra	Perez	Young Leader	Venezuela
Prospery	Simpemba	Young Leader	Zambia

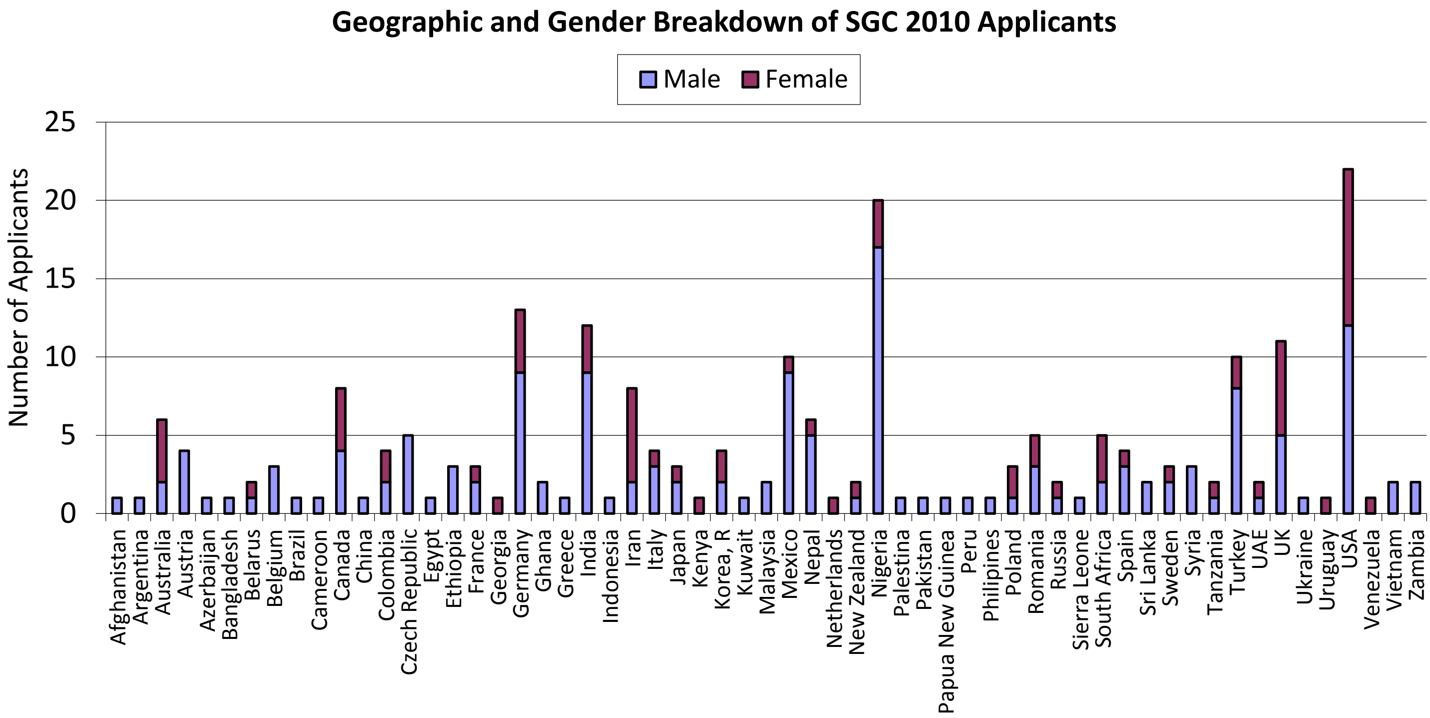

Scholarship Winners by Gender
Female
Male
0
5
10
15
20
Number of Delegates

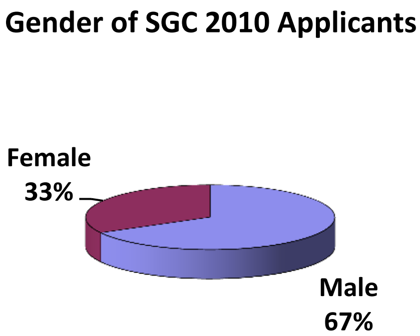
CONGRESS STATISTICS

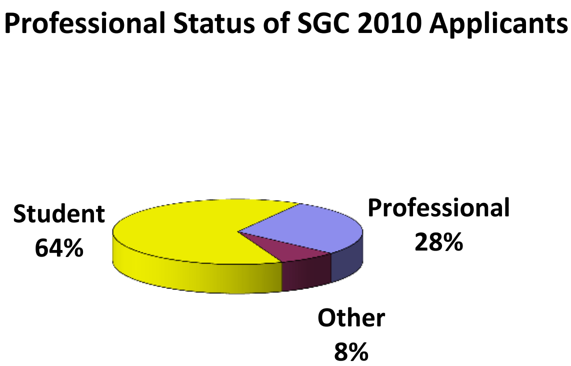
Application Statistics

As of the SGC 2010 signup closing date, July 8, 2010, 226 applications to participate in the Space Generation Congress 2010 in Prague had been completed through the SGAC website. This interest and the quality of the applications underlined growth and development in the quality of the event.

51% of the applications were undergraduate or masters students, 13% PhD students, while 28% were young professionals and 8% had other status. The applicants came from 59 countries, and 33% were female and 67% were male.







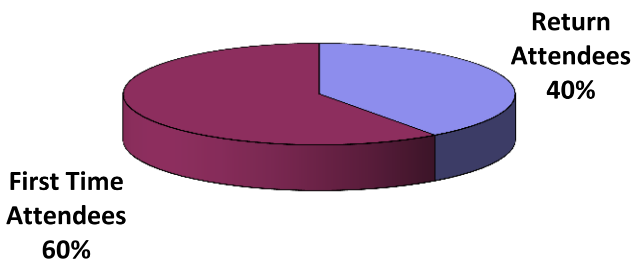
Final Delegate Statistics

After careful selection, a total of 101 delegates participated at the 2010 Space Generation Congress. Of those 101, a ground-breaking 30 participants from 22 countries were given full scholarships with help from SGAC and its partners to attend SGC 2010 in Czech Republic. Regarding gender distribution of the final delegates, there was a majority of men with 68 (67%) male participants and 33 (33%) women. As far as professional background is concerned, 61% of delegates were students, including undergraduate, graduate or post doc students. 33% of them were young professionals and the remaining 6% were guests. It gives us great pleasure also to announce that 60% of the applicants were not involved with SGAC until now. We believe this number to demonstrate how significantly improved SGAC's reach has become, and it gives us even more momentum to build a stronger and more representative network of young space professionals and university students.

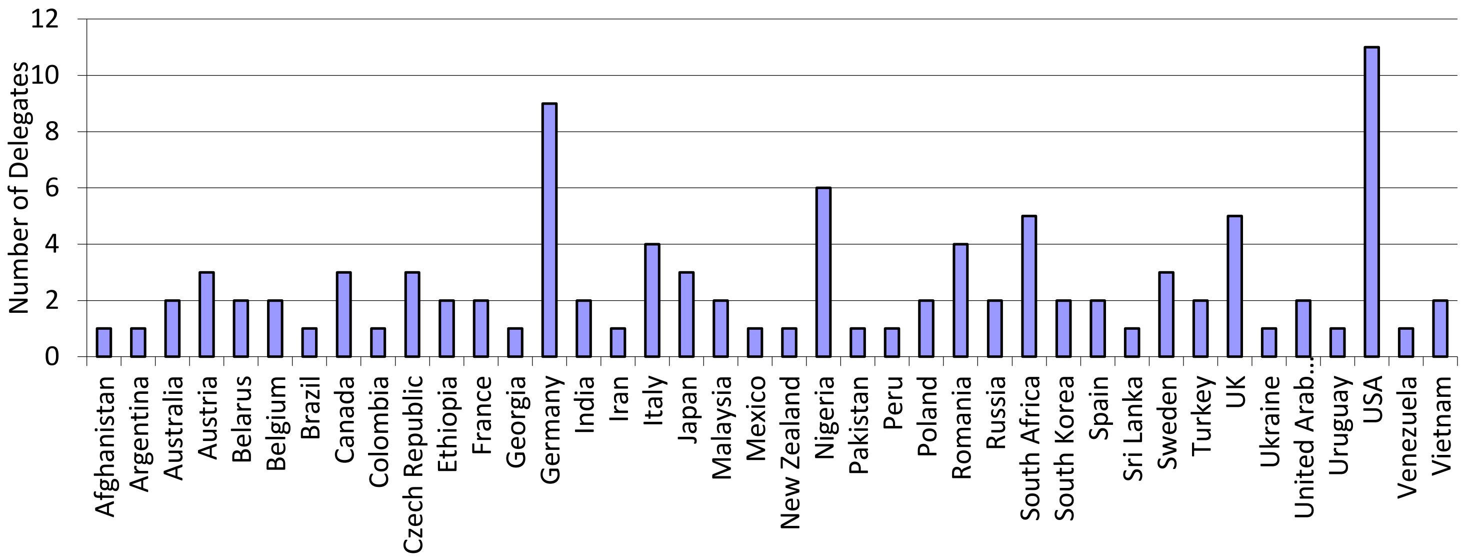
Finally, SGAC is proud to say that the SGC 2010 attendees came from 40 countries and six continents. This international diversity is the key to developing the international youth space voice for which SGAC strives.

At the closing dinner, from left to right: Alexandra Ruths (Austria), Athiye Jawad (India), Clay Mowry (President of Arianespace Inc. and SGAC Advisory Board Member), Catherine Doldirina (Georgia), Kai-Uwe Schrogl (Director of ESPI and SGAC Honorary Board Member) Ondrej Bruna (Czech Republic) and Justin Park (United States)

Prior Delegate SGC Participation

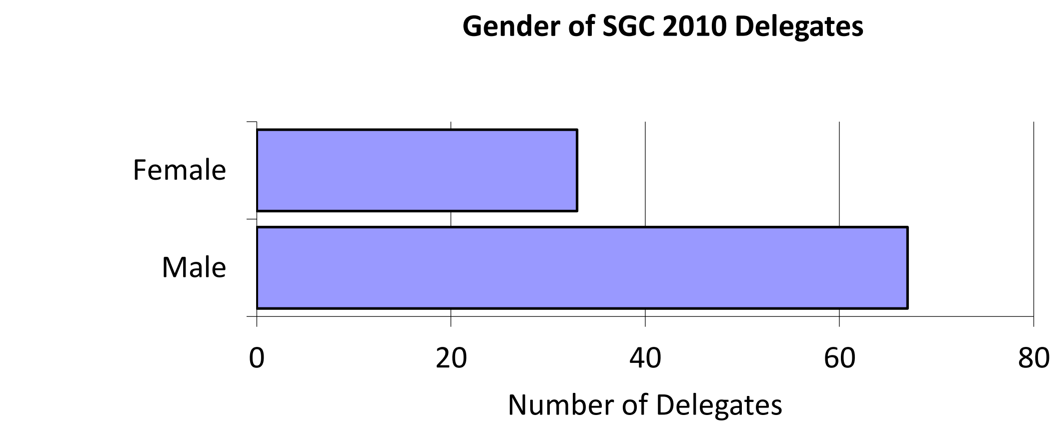


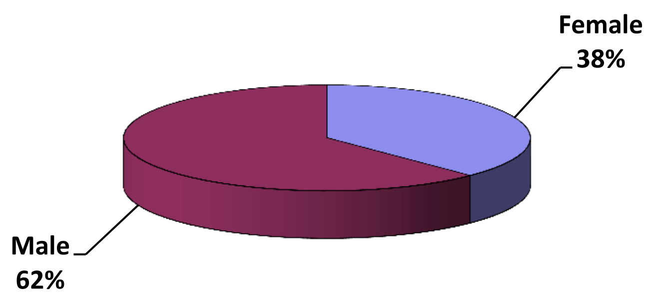
Citizenship of SGC 2010 Delegates

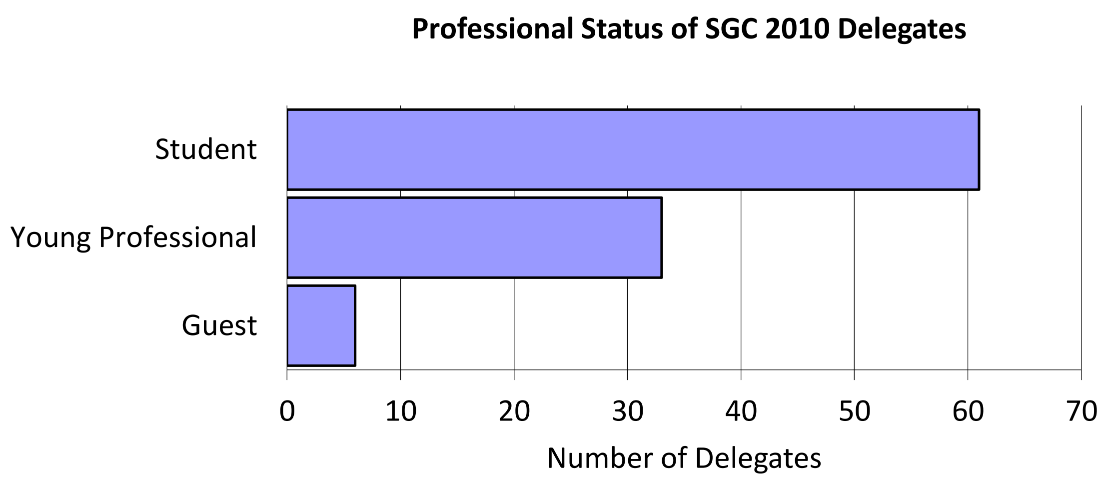


Afghanistan	1
Argentina	1
Australia	2
Austria	3
Belarus	2
Belgium	2
Brazil	1
Canada	3
Colombia	1
Czech Republic	3
Ethiopia	2
France	2
Georgia	1
Germany	9
India	2
Iran	1
Italy	4
Japan	3
Malaysia	2
Mexico	1

New Zealand	1
Nigeria	6
Pakistan	1
Peru	1
Poland	2
Romania	4
Russia	2
South Africa	5
South Korea	2
Spain	2
Sri Lanka	1
Sweden	3
Turkey	2
UK	5
Ukraine	1
United Arab Emirates	2
Uruguay	1
USA	11
Venezuela	1
Vietnam	2


Gender of SGC 2010 Delegates
Female
Male
0
20
40
60
80
Number of Delegates


Female 38%
Male 62%


Professional Status of SGC 2010 Delegates
Student
Young Professional
Guest
0
10
20
30
40
50
60
70
Number of Delegates

MEDIA COVERAGE

SGAC Public Relations (PR) Team's efforts lead to an excellent coverage of SGC 2010. 22 articles were written on different media channels.

The SGC 2010 had a communication strategy that focused on promoting the Congress in several waves, but with different targets. The first step was the communication done several months prior to the event, with the goal to increase SGC 2010 delegates' applications and therefore addressed directly to students and young professionals in the space sector. Announcements on the website and articles in the monthly SGAC newsletter resulted in a 25% increase in the number of applications compared to last year. Another communication wave was addressed to the media and focused on raising visibility of the top speakers coming to SGC 2010, among which NASA Administrator.

On the starting day of the congress, the SGAC PR Team sent out to the media a kick off press release, translated in multiple languages by the SGAC translation team. During the Congress, the team produced real time event updates via the SGAC Twitter account (#SGAC2010), daily summary, and SGC 2010 announcements on the SGAC Facebook group. Following SGC10, a complete summary press release was disseminated.

Several characteristics were specific to this year's coverage. First, the news items were spread over a longer period of time, covering topics prior to the congress such as winners of scholarships. Second, SGAC had news items on the websites of relevant and highly visible partners, including esa.org and checzspace.ch. The 2010 edition of SGC also had a reporter on site, covering the congress extensively for spaceref.com. Additionally, the France 5 television network was on site to interview Andrew Bacon, Co-Lead of SGAC NEO Working Group, about NEOs and SGAC's NEO work.

Press releases are available on SGC 2010 website (http://spacegeneration.org/index.php/activities/space-generation-congress/press-and-pictures), as well as a selection of professional pictures, credited to Julio Aprea/SGAC. (http://spacegeneration.org/index.php/activities/space-generation-congress/press-and-pictures/242-pictures-sgc-2010)

Participants at the closing dinner

Sample of SGC 2010 media coverage:

http://www.spaceref.com/calendar/calendar.html?pid=6065

http://spaceports.blogspot.com/2010/08/2010-space-generation-congress-draws.html

http://spacepolicyonline.com/pages/index.php?option=com_jcalpro&Itemid=109&extmode=view&extid=368&tmpl=component

http://spaceref.asia/news/viewpr.html?pid=31691

http://www.astronomy2009.org/news/updates/946/

http://www.free-press-release.com/news-high-level-space-leaders-and-young-professionals-start-debates-on-key-space-issues-at-the-space-generation-congress-2010-1285331296.html

http://spaceref.com/news/iac2010/

http://www.space.com/common/forums/viewtopic.php?t=26260

http://www.esa.int/esaMI/About_ESA/SEMWQJEODDG_0.html

http://www.nasawatch.com/archives/2010/09/sgac-at-iac.html

SPACE GENERATION CONGRESS 2010 SCHEDULE

Note: All events are at the SGC venue at Charles University except for the Optional and Opening Dinners

SGC Venue Address: Malostranské nám. 25, 118 00 Praha 1

	Wed., 22 Sep	Thu., 23 Sep	Fri., 24 Sep	Sat., 25 Sep
9:00	Delegate Arrivals	SGC 2010 Welcome	Movie on the Space Age	Space Frontier Foundation
		Featured Speaker: UN COPUOS Chair	Move An Asteroid Competition Winner	Outreach Session Speaker
10:00			Agency Session Speaker	Featured Speaker: IAF President
		Coffee Break	Coffee Break	Coffee Break
11:00 12:00		Working Group Time	Working Group Time	Working Group Time
13:00		Lunch	Lunch	Lunch
		Climate Session Speaker	Featured Speaker: Int'l Space Services President	Industry Session Speaker
14:00		Working Group Time	Working Group Time	Exploration Session Speaker
				Working Group Time
15:00				Group Presentations
		Coffee Break	Coffee Break	Coffee Break
16:00 17:00		Working Group Time	Working Group Time	Group Presentations
		Getting to Know the IAC (Optional)	SGAC Project Team Info Session (Optional)	Free Time
18:00		Free Time	Free Time	
19:00	Optional Dinner (Meeting location to be announced via email)			
20:00-21:30		Opening Dinner & Culture Night at Kolkovna Restaurant		Closing Gala Dinner Featured Speaker: NASA Administrator

SGC2010 ORGANISING TEAM

Agnieszka Lukaszczyk	Poland/USA	Chair
Michael Brett	Australia	Co-Chair
Ariane Cornell	USA/France	Executive Director and Congress Manager
Maria-Laura Voda	Romania	Executive Secretary and Assistant Congress Manager
Aziz Kayihan	Turkey	Logistics Coordinator
Athiye Jawad	India	Logistics Co-Coordinator
Zilin Elizabeth Tang	USA/China	Logistics Co-Coordinator
Jessie Ndaba	South Africa	Logistics Co-Coordinator
Pierre Van Heerden	South Africa	Logistics Co-Coordinator
Catherine Doldrina	Georgia	Project Coordinator
Victoria Alonsoperez	Uruguay	Project Co-Coordinator
Nicole Jordan	Colombia	Fundraising Co-Coordinator
Maryonsail Dong	China	Fundraising Co-Coordinator
Laura Drudi	USA	Delegate Coordinator
Ghanim Alotaibi	Kuwait	Delegate Co-Coordinator
Oana Sandu	Romania	Communications Coordinator
Diane Wong	Canada	Communications Co-Coordinator
Thu Vu	Vietnam	IAC Booth Coordinator
Ondrej Bruna	Czech Republic	Conference Venues and Fundraising Coordinator
Milan Vesely	Czech Republic	Travel & Lodging Coordinator
Martin Vondra	Czech Republic	Communications Coordinator

SGC 2010 Report Acknowledgements: SGAC would like to thank Victoria Alonsopereze (SGC Project Co-Coordinator), Cem Asma (SGAC Project Lead), Ariane Cornell (SGAC Executive Director and Congress Manager), Marc Cornwall (SGAC Graphics Lead), Catherine Doldirina (SGC Project Coordinator), Filippo Menga (SGAC Event Manager), and Oana Sandu (SGAC Communications and PR Lead) for the time and effort that they contributed to the development of the SGC 2010 report. Their hard work before, during, and after the conference both contributed to and helped SGAC document one of the most successful events in the history of the organisation.

Space Generation Congress

Prague 2010

INDUSTRY SESSION REPORT

INDUSTRY SESSION REPORT:

The New, Increased Role of the Private Industry in the Space Sector

Group Participants

Name	Position	Nationality
Artiom Anisimov*	Rapporteur	Belarus
Andy Bacon	Group Member	UK
Damian Bielicki	Group Member	Poland / UK
Foo Ye Chong	Group Member	Philippines
Israel Ojeda Coronado*	Moderator	Mexico
Farnaz Ghadaki*	Group Member	Iran / Canada
Chris Johnson*	Group Member	USA / UK
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Prague, Czech Republic, October 2010

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Cover Image: (front) VMS Eve and VSS Eve Π In flight during Captive Carry 03, Mojave, CA. Π Image Credit: Virgin Galactic/Mark Greenberg – modified Marc Cornwall; (back) VSS Enterprise Glide Flight Drop Shot Π VSS Enterprise moments after she is released from VMS Eve at 45,000ft. Π Image Credit: Virgin Galactic/Clay Observatory – adapted by Marc Cornwall

1 INTRODUCTION

Today's space industry is in the process of a shift from being driven by governments to being driven by the private sector. The private sector will be playing a larger and larger role and its involvement will range from running space tourism activities to developing a new generation of launching vehicles to conducting post-lunch space operation. During the Space Generation Congress 2010, a team of delegates came together within the Industry Working Group to discuss the prospects, challenges and potential hindrances to the development of the new generation of commercial space activities. This report summarises the relevant analysis and recommendations and represents the voice of the new generation of space professionals, advocates and leaders.

Figure 1-1. Launch of Ariane 5 ECA of Arianespace – the world's first commercial launch services company – with Arabsat-5A & COMS (June 26, 2010). Credit: Arianespace

2 OVERVIEW OF THE SUBJECT APPROACH

2.1 Categorisation

With the main purpose of developing a more effective analysis of the issues at stake, the following three categories were identified by the group as commercial opportunities where the private industry is already or soon will become involved in:

- Space applications:
    - Applications currently in place, such as remote sensing, microgravity technologies, utilisation of the International Space Station (ISS), satellite telecommunications, and Global Navigation Satellite System (GNSS)
    - New applications that include, but are not limited, to space tourism, space products and services, removal of space debris and on-orbit satellite servicing
- Launching:
    - Launching is a key factor for the success of a majority of all space applications, and the group decided that the report would benefit from an analysis focused on this strategic topic.

2.2 Methodology

After the subject matter was determined, the group found it was necessary to analyse this two key commercial space categories in great detail.

To ensure a well-rounded analysis of the launching industry and to identify how the new approach of having the private sector could transform the concept of “business as usual”, the group considered the following clusters of factors:

- Legal, public policy, ethics, and implications on space agencies
- Technical and engineering factors that include mobility, flexibility, and transferability to other non-space applications
- Economic and social considerations including capital, financing, profitability, employment, and resource management
- Marketability, competitiveness, public perception and media involvements
- Collaboration opportunities that encompass agencies, academia, and the symbiosis between industry and university research and development.

3 COMMERCIALISATION OF SPACE APPLICATIONS

3.1 Advantages/Strengths

Depending on the field where they are going to be used, there are some space applications that can be effectively commercialised. The group agreed on several factors that help determine commercial viability of an activity or application. Commercialisation of an activity leads to multiple suppliers offering more or less the same service, product or information.

This competition urges enterprises to differentiate themselves from their competitors by innovating and lowering prices. This is a big strength of commercialisation in general. Brainstorming by the group identified that in-orbit product manufacturing serves as a good example, and with on-going projects like in-orbit hotels in the near future,[1] commercial companies can successfully conduct manufacture and research of , say, pharmaceuticals.

Advantages of carrying out an activity commercial were also agreed upon by the members of the group. Innovation within the industry will likely lead to new space applications, some of which have yet to be invented or discovered. New markets might emerge, like in-orbit satellite servicing, where a service could extend the lifetime of satellites and lower the risk of losing an entire spacecraft from a malfunction that could be fixed. This would lower the threshold and invite more players to the space market. Furthermore, private entities lack the cumbersome bureaucracy of national agencies. This allows faster and more accurate decision-making and ultimately a more efficient enterprise. Commercial industry can help agencies make optimal use of existing in-orbit facilities, like the International Space Station. Companies could rent a spot in one of the laboratories to perform their own experiments, and if the economic case is well developed, it would be beneficial for the all the stakeholders.

3.2 Challenges

At the same time, the group agreed that commercialisation of space activities have to overcome some hurdles. Usually, space applications require large, risky and long-term investments, which make finding investors difficult. Unproven new technologies like the orbital clean-up might or might not find viable markets. Although undertakings like this could become indispensable in the future (especially if there are international or national laws enforcing a more responsible use of space) they would require some sort of government funding and support in general. Furthermore, there are also technological barriers to overcome.

Another potential threat for space applications could come from the need to generate revenue, which is in fact a commercial company's main interest. For example, what would happen if a private company becomes the sole provider of particular type of Earth observation data? Problems may arise when some countries might not be able to pay for data necessary for disaster management programmes, or the disaster response. However, regulation and international cooperation, such as the Charter on Space and Major Disasters and United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) have helped to mitigate this particular threat. Hence, regulation and cooperation should be used to avoid or mitigate future complications, which might arise when strictly commercial interests interfere with larger social needs.

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[1] Bigelow Aerospace LLC, availabe at: <http://www.bigelowaerospace.com/genesis-1.php>.

4 COMMERCIALISATION OF THE LAUNCHING INDUSTRY

Table 4-1. Advantages/strengths and challenges of the launching industry

Advantages/Strengths	Challenges
Sovereign right to access to space	Safety/Reliability in space transportation
Policy commitment	Import/Export control regulations
Steady growth	Lack of global space traffic management
Independence	Diverse global technological education
Public policies encouraging innovation through competition	Supply and demand issues
Financial transparency and accountability	Space debris
Advancement of mankind	Opposition to space commercialization

4.1 Advantages/Strengths

a) Sovereign right of access to space

Commercial launching is intended to provide less expensive access to space, which would enable more countries to become space faring. For example, if one analyses that SpaceX quotes a price of $50 million for a Falcon 9 launch compared to the United States' Federal Aviation Administration estimated price of $90 million to $100 million for the Russian Proton, which has a similar lift capacity.[2] If one takes into account that Russia with its Proton vehicles accounts for 43% of the world commercial orbital lunches in 2005-2009[3], it is not hard to see that private entities like SpaceX and Orbital Sciences (if proven to be reliable) could become dominant in the global market for launch service, with a more affordable prices.

b) Policy commitment

In the short-term, the global launching industry will be busting with private companies entering the market, the industry develop through competition. The US National Space Policy 2010, building on the 2006 US National Space Policy, further emphasises the importance of

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2 Space Foundation, THE SPACE REPORT 2010, 113.
3 *Id.*, 31.

the commercial sector.[4] This competition may lower the cost to reach space, and may even spur the development of new space applications.

c) Steady growth

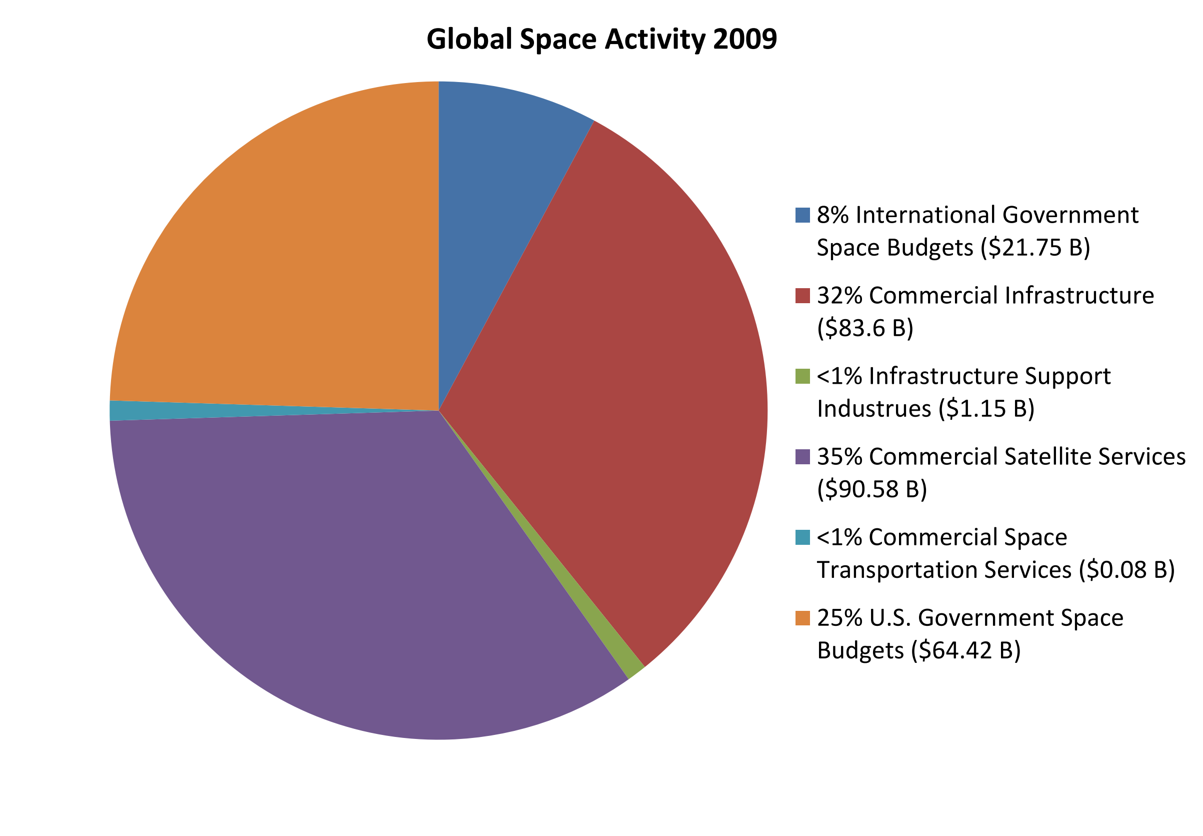

Figure 4-1. Global Space Activity, 2009. Source: Space Report 2010. Space Foundation

The research that the group has undertaken showed that while the ongoing financial and economic crisis continues to negatively affect economies and people around the world, the space industry has experienced steady growth. This growth can be explained by an increased role of the private sector through the development of commercial space technology. In fact, the best results were achieved in 2009 and the first half of 2010. According to the Space Foundation's Space Report 2010, aggregate 2009 revenue for commercial space infrastructure (representing 32% of the space economy) totaled $83.63 billion. This figure includes revenue from spacecraft manufacturing and launch services, as well as from ground stations and equipment (Figure 4-1). The private launching industry is expected to bring in larger revenue. Additionally, many unique products and services that private manufacturers and entrepreneurs might offer will be in popular demand.

4 John, M., United Nations Space Policy Comparison — Comparing the 2010 National Space Policy to the 2006 National Space Policy, SPACE FOUNDATION, available at: <http://www.spacefoundation.org/docs/USNationalSpacePolicy-2010vs2006.pdf>.

d) Independence

Instead of pursuing governmental space policy objectives as contractors and subcontractors to national space projects, private space companies are free to pursue whatever business endeavor they believe will become profitable. In addition to coming up with new technologies and hardware that are not anticipated by the governmental actors, entrepreneurs might manage to find new ways to extract benefits from the technology already in place. They may seek to develop and rent orbital labs, orbital hotels, satellites servicing facilities, or whatever else the entrepreneur might see as a possible success. This independence drives innovation faster and more forcefully than national space programmes, which must often have political will and governmental approval before governmental expenditures can take place.

e) Public policies encouraging innovation through competition

The essence of private activity assumes that the private sector is a self-sufficient, self-organised and self-healing mechanism, driven mainly by internal and natural market forces. Though some regulation of industry has proven necessary, private initiatives tend to flourish more with less government intervention. To date, governments for many decades had monopolised the launching industry. By holding a monopoly on the market, the government had not allowed real market forces to operate. Current commercialisation of the launching industry creates a new market system that is based on private property and freedom of enterprise and depends on competition. There are two main elements that are necessary for competition.[5] Firstly, it is the presence of two or more buyers and two or more sellers who act independently in a particular market. Secondly, it is the freedom of the parties to enter or leave this market as they pursue and further their self-interest. Those conditions, should be constantly enforced by governments to get all the advantages that competition offers.

Historically, most economists viewed technological advances as random, external forces to which economies adjusted. However, many contemporary economists now see technological advances as an internal element to a competitive market system, and which occur in response to profit incentives within the economy.[6] State of the art technologies give a company competitive advantage and product innovations encourage buyers to substitute a new product for an existing product, thereby increase the sales volume of the innovating entity. Additionally, by improving production technique, process innovation can lower a firm's production cost. This also increases a firm's revenue and profit. Consequently, the growth of a private launching industry will favor the competition and technological advance. For the optimal development of both, however, political support is important.

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5 McConnell, C. and Brue. S, ECONOMICS: PRINCIPLES, PROBLEMS, AND POLICIES, 16th ed. 2005., M.: INFRA-M, 2006, 74.

6 *Id.,* 608.

f) Shared liability with government

On the international level, the launching state of a private commercial endeavor is the ultimate responsible for irability.[7] When the government licenses and approves the commercial venture, the private company knows that its activity constitutes a "national activity" of that state. This is an opportunity in the sense that the company knows that, in the case of an event where liability arises, the licensing state will cover damages beyond which it requires the company to be insured for. Such allocation of risks creates certainty that the cost assessment of the cost of a potential commercial space ventures is correct and realistic. If one takes into account that currently there is no limit for liability for harm caused by space objects, the fact that an entity has the government to cover excessive costs associated with the damages is an assuring factor. Shared liability is also a factor that ensures safety.

g) Financial transparency and accountability

Another benefit of private sector involvement in space launching activities is that publicly traded and owned companies must conform to various state and national laws pertaining to corporate disclosure, such as the regular public reporting and disclosure of financial information to the US Securities and Exchange Commission or the Financial Services Authority in the United Kingdom. Publicly traded companies must report on regular basis specific information about the health of their company, so as to keep potential investors appraised and informed about the company. Strict enforcement of accounting rules and regulations promotes transparency and accountability of these companies. In combination, these activities contribute to the creation of a more mature and robust commercial space industry, where both investors and regulators can evaluate the state of the companies involved.

h) Advancement of mankind

Contributing affordable access to space that commercial launching may also help contribute to the advancement of mankind. Advancement of commercial launching will give mankind the means to do what we are known to do the best: explore and adapt. One can only imagine what effect stable, reliable and cheap access to space will do to the creative minds of entrepreneurs. Getting beyond Earth's gravitation well and back is the biggest obstacle on the way to the development of as-yet undefined markets, with unlimited opportunities

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[7] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, 610 UNTS 205 [herein Outer Space Treaty], *available at*: <http://www.unoosa.org/oosa/en/Reports/publications.html#treat>.

4.2 Challenges

a) Safety\Reliability in space transportation

The primary risk associated with commercial space transportation is safety, or, moreover the lack of an established safety record. Yes, there are successful *experimental* launches and impressive overflies etcetera. However, seen objectively, commercial space transportation cannot be considered safe. Quite to the contrary, this activity is seen (at least with respect to dealing with prospective commercial spaceflight participants) as extremely unsafe. This makes service providers ask their customers to waive any possible claims that may result from a private spaceflight. As some suggest, the period of at least fifty years will be required for commercial space transportation technology be proven safe.[8]

b) Import/Export control regulations

The mechanism of export control serves to prevent leaking of certain categories of technology and information to unauthorised parties, but it even has hindered but even from its transfer among trusted partners. Though designed to protect interests of its nationals, many would agree that current national export controls regulations found in many space faring nations overly burden the private sector while trying to provide to protect these. States with a strict approach to high tech security put their companies in a position where they cannot market their products or services internationally or are not able to reduce their costs by partnering with other nations or foreign companies of foreign nationality. This issue is most obvious in the United States where the ITAR (International Traffic in Arms Regulations) classify satellites and many of its components as subjects to export control and therefore exclude those items from international trade without prior, case-by-case verification and approval process.[9]

c) Lack of global space traffic management

According to the 2010 Space Report 2009, 78 orbital launches were conducted, carrying 111 payloads into space, including cargo, satellites, and other types of spacecraft. This marked a slight increase compared to 69 launches in 2008 carrying 106 payloads, and continued a five-year trend of annual increases in launch activity. Out of 78 launches in 2009, 24 were conducted by commercial launch providers from Russia, China, India, United States, Europe and multinational providers. With more launches performed each year and more payloads delivered to various orbits the lack of global space traffic management system is becoming a very serious problem. Such system is quintessential to ensure collision avoidance, improve utility of Geostationary Orbit (GEO), decrease congestion of other "popular" orbits, and last but not least to increase safety of human spaceflight missions.

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[8] Loizou, J., *Turning Space Tourism into Commercial Reality*, 24 SPACE POLICY 4 (2006), 289.

[9] Foust, J., *A Fading Opportunity for Export Control Reform?,* Space Review, Oct. 11, 2010, available at: <http://www.thespacereview.com/article/1708/1>.

d) Diverse global technological and education (un)readiness

Investment in space creates measurable benefits that flow across a wide spectrum of economic activity. The greatest investment that the space industry can make is human resources. The global space economy creates high-paying jobs and also stimulates demand for products and services in industries not directly linked to space. It promotes education in science and technology fields, creating a pool of talented professionals who support space enterprises and a broad range of other economic sectors.

By generating economic value, contributing to the growth of other industries, and enhancing the quality and availability of human capital, space activity tangibly benefits people's lives. In the United States, part of the economic value can be understood through a quantitative examination of workforce statistics, salary trends, and labour outlook. The benefits of space activity are increasingly recognised globally as well. Throughout the world, nations are responding to the economic and workforce benefits of space activity with investments in space-related education programmes reflecting both traditional and newer academic approaches.[10] However, there is still a considerable technological and educational gap that grows exponentially among the developed and developing countries. Lack of political vision, committed public budgets to develop the national intellectual capacity and the inexperience are among the problems that the non-space fairing nations are facing currently.[11]

e) Supply and demand issue

Though the data available shows a steady annual increase in demand for launch services over the last five years globally, demand in some ancillary markets (i.e., suborbital flights tourism and point-to-point transportation) is hard to anticipate. There is a possibility that the supply in the market of commercial spaceflight may far exceed the projected interest of the general public cannot be excluded. At the same time, it is hard to calculate what effect possible failures at early stages of establishing the service may have on the demand for it.

f) Space debris

The Kessler Effect is a scenario in which the density of objects (useful and space junk) in low Earth orbit is high enough that collisions between objects could cause a cascade. Each collision would generate debris which increases the likelihood of further collisions. This poses a real and considerable threat to the launching organisations commercial and government, alike space debris is a threat to exploration and stands to render space unusable for many generations to come.

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[10] Space Foundation, THE SPACE REPORT 2010, 87

[11] For a detailed discussion of these issues see Outreach Report.

g) Regulatory changes in international law

As much as international law has given strength and certainty to space exploration, it has also limited to some extent the development for the commercial space sector. The most critical reasons for this are international law norms regarding property rights and the issues of the jurisdiction and control over space activities. Prohibition of appropriation of celestial bodies by any means (e.g. claim of sovereignty, appropriation as per article II of the Outer Space Treaty) prevents ventures from being able to consider exploitation of resources of celestial bodies.

Another example is the issue of jurisdiction and control over space objects – both operational and non-operational. Current international space law delegates both of them to the state of their registry.[12] This legal ruling makes it difficult for any private organisation to clean up Earth's orbits and even eventually use space junk as material to use in assembling new structures in space. The biggest problem, however, is the fact that the international community is presently not addressing these issues effectively.

h) (Ir)Responsible use of space commercialisation

Some people in the space field, particularly those in the developed countries, are enthusiastic about the commercialisation of space activities. However, another view exists that space activities are the province of national activities and a source of national pride. Patriotism and even military interests drive the national space programmes and space aspirations of many countries. It is unclear to what extent cooperation, coordination and even the contracting for services is possible.

Would states really wish to see their hopes and dreams for their national space missions resting on the knowhow of foreign companies and personnel? The first half-century of space activities was led by national space agencies or the military, and it remains uncertain the extent to which private companies can successfully substitute them. Furthermore, space is regarded as the "province of all mankind" and celestial resources are similarly viewed as the "common heritage of all mankind" as declared at the United nations the exploration of outer space shall be carried out "for the benefit and in the interest of all States, irrespective of their degree of economic, social or scientific or technological development" and that "particular account should be taken of the needs of developing countries"[13]. Consequently, many feel that all space exploration should be in the interests and for the benefit of all, a requirement which may not always be in congruence with private, commercial enterprises.[14]

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[12] Outer Space Treaty, Art. VIII.

[13] Declaration of International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries, Art. I., UN GENERAL ASSEMBLY OFFICIAL RECORDS, 51st Sess. Supp. 20, 1996 (A/51/20).

[14] Lyall F., and Larsen, P.B., SPACE LAW — A TREATISE, 193 - 197.

5 RECCOMMENDATIONS

Intense discussions and the thorough analysis undertaken by the participants of the Industry Working Group resulted in the following recommendations for initiatives that SGAC should undertake or take part in to promote the development of private space industry.

- Establish or initiate the S-Pace Prize[15], a competition for the best new commercially viable space-related business plan

The value of the competition designed to foster innovation, in a particular sector, for a considerable monetary or otherwise valuable reward has been proven effective in many fields of activities. This method of encouragement became especially popular and effective with respect to various aspects of commercial space activities. SGAC should get involved into the process by creating the S-Pace Prize. The S-Pace Prize would be a reward for the best space-activity-related business plan developed and presented by a person/group under the age of 35. The prize, apart from public recognition, could provide the recipients with an opportunity to present their idea during one of the Space Investment Summits. The S-Pace Prize would be the first to date global initiative of this sort.

- Initiate the S-Pace Award, an award for the best advancement towards space utilisation

The premises are the same as with the S-Pace Prize. However, unlike the S-Pace Prize, which would be designed to stimulate future commercially viable ideas, the S-Pace Award would credit a person/group/project for the accomplishments that contribute to the advancement of commercial space activities.

- Sponsor pro-commercialisation of space event

A new international event should be organised under the auspices of SGAC. The sole idea and purpose of the event would be, to bring interested young professionals and students together to promote the advancement of commercial space globally. The event itself could be the forum for presently the S-Pace Prize and the S-Pace Award as well as other pro-commercialisation outreach activities and projects.

- Create a network to encourage retiring space professionals to consult and advise emerging space nations

Today, there are more and more experienced space professionals looking for retrieve. On the other hand, there are an increased number of developing states with means and ambitions to undertake space ventures of their own but no experience of actually doing so. SGAC should become a “bridge of knowledge” and facilitate the transfer of knowledge, skills and experience to countries and newly formed space agencies that are in such a need.

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[15] Play of words where ”S” - represents SGAC, “pace” – regular meaning: consistent and continuous speed in moving. Together cool Space Awards.

SGAC could do so by promoting the involvement of experienced managers from space-faring nations into day-to-day activities of emerging space agencies as expert consultants. A secured database of interested parties could be created and maintained.

- Develop a space media network

SGAC should take an active role in, the creation of an organisation dedicated to bringing together internationals media dedicated specifically to cover issues of space and the commercialisation of space.

- Support proactively "New Space"

"NewSpace" is a term used to describe approaches to space development that differ significantly from that taken by various space agencies and the mainstream aerospace industry.[16] SGAC should consider proactively supporting the promotion and development of commercial space as one of its primary activities for next years' strategic development plan. SGAC should be not only the voice of young people in the international arena but also be that of young, or to be precise, New Space itself.

6 CONCLUSIONS

Space Generation Congress 2010 gave the members for the Industry Working Group the opportunity to exchange ideas among other members of Space Generation from 40 different countries. Just the literature-review process itself (previous to SGC) allowed them to increase their awareness of the challenges and opportunities that the public and private space sectors are currently facing. In the upcoming years, the world will have the opportunity to evaluate and experience the new role of the private space industry in order to make significant leaps in space exploration. Fair to mention, that brave and objective political decisions had and will have to be taken (e.g., discontinuing NASA's Constellation program) in order to jump start smaller, but more budget-efficient, private companies. In the end though, these Space News could deliver technological solutions (orbital and sub-orbital) that could result in less expensive breakthroughs for the benefit of human space exploration.

[16] HobbySpace, New Space — An Alternative Route to Space, available at: <http://www.hobbyspace.com/NewSpace/index.html>.

Figure 6-1. Space X Falcon 9 vertical on launch pad. Credit: Space X

The recommendations drawn in this report are based in the spirit of encouraging all nations, whether large or small, to pursue social benefits through sustained political, economic and technological support to their civil space programmes. As a result, the group proposed tools, and activities, to support the continuity of and sustained commitment to space exploration. Hopefully, proper laws and regulations will be set to encourage international partnerships among space agencies and companies, in order to increase demand and new technologies. This will hopefully contribute to increased access to space for scientific, commercial or pleasure purposes. The new generation of space enthusiasts and professionals in one voice says – we hope that we all can reach space, and soon.

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SPACE GENERATION CONGRESS

PRAGUE 2010

AGENCY SESSION REPORT

AGENCY SESSION REPORT:

Global Navigation Satellite Systems (GNSS) for Disaster Management

Group Participants

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Prague, Czech Republic, October 2010

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Cover Image: Toxic Sludge in Hungary Π On Oct. 4, 2010, an accident occurred at the Ajkai Timföldgyar alumina (aluminum oxide) plant in western Hungary, when a corner wall of a waste-retaining pond broke, releasing a torrent of toxic red sludge down a local stream. Several nearby towns were inundated, including Kolontar and Devecser, where the sludge was up to 6.5 feet deep in places. Four people were killed immediately, several more were missing and dozens of residents were hospitalized for chemical burns. Π On Oct. 9, 2010, the Advanced Land Imager on NASA's Earth Observing-1 satellite captured this natural-color image of the area. Π Image Credit: NASA – adapted by Marc Cornwall

1 INTRODUCTION

As Earth's population continues to grow and influence the environment, the effects of climate change become more pronounced, and the effect of disasters on loss of human life and destruction of structures continues to rise. A disaster can occur in any area at any time. People's lack of awareness and time constrains are the essential factors that contribute to the ever increasing level of damage and loss. Various efforts to predict and mitigate disasters have been made in the past such as using ground, air, and sea based detectors for monitoring weather changes.

Since satellite technology has become more available and applications for their use are better understood, they have started to be applied to disaster management. The quality of data, in particular their precision and accuracy, has improved significantly over recent years.

This report presents the results of the Agency Working Group at the Space Generation Congress 2010 in Prague. This project group worked on issues related to the use of Global Satellite Navigation Systems for disaster management, including its current status, components, and steps for further improvement.

As in most of today's everyday life, space technology is more extensively used in the management of disasters, both natural (e.g., earthquakes, tsunamis, hurricanes) and anthropogenic (e.g., explosions, and contaminations). Fast and reliable communication is made possible by the capabilities of modern telecommunication satellites, and we all know the before-and-after remote sensing satellite imagery shown in our evening news to demonstrate the devastating effects of the disaster. The use of GNSS beyond the simple provision of a precise location for disaster management is still something that has to be expanded. As it is for all of space technology, the accessibility for those in need of it is, especially in less developed countries, a big issue to solve.

2 HOW DOES GNSS WORK?

For all GNSS, a constellation (see Figure 2-1) of satellites is necessary. Depending on the area the system is supposed to cover on the Earth's surface and the level of availability desired, these satellites have to be positioned in medium (MEO) or low Earth orbit (LEO), or use both in a combination. These satellites send a signal containing the time at which the message was sent and their position in orbit [1]. Generally a GNSS works by triangulating signals from four or more satellites, as shown in Figure 2-2.

With a compatible GNSS receiver and the signals of at least four satellites at a time, it is possible to trilaterate the position of the receiver. Signals from additional satellites or from ground based augmentation systems can enhance the precision of the location data.

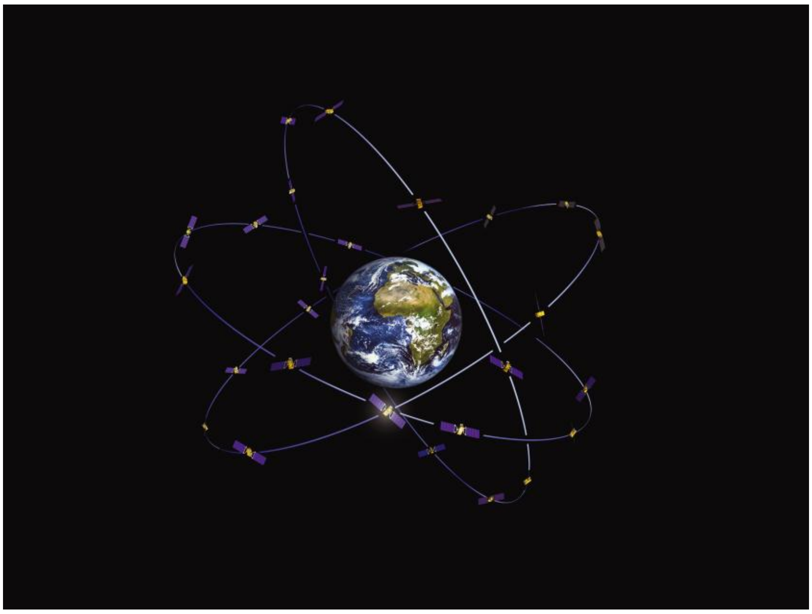

Figure 2-1. Galileo Constellation. Credit: ESA, J. Huart

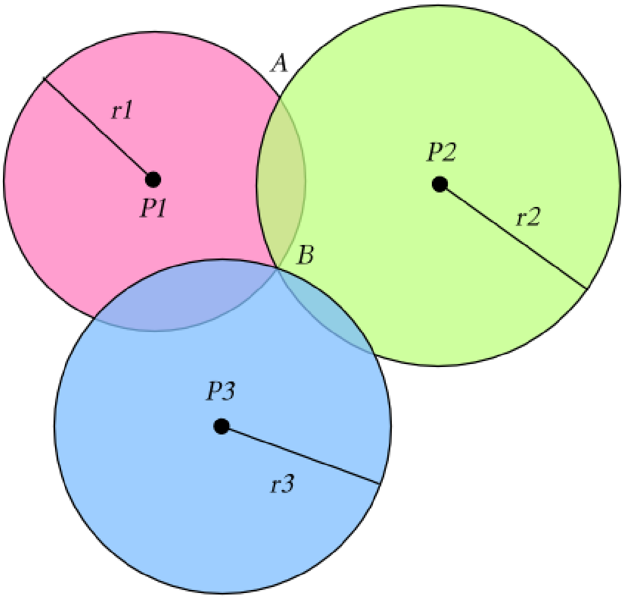

Figure 2-2. Trilateration of GNSS signals. Source: Wikimedia Commons

With growing interest in space technology, many countries want to have their own national satellite navigation systems.

The best known GNSS is the American Global Positioning Satellite (GPS) system. Originally built for military applications, it currently serves the general public. It provides global coverage, and the positioning information it gives is easily accessible as long as one has a GPS receiver. Currently, several other nations, and national groupings such as Russia, Japan, India and the European Union are developing systems of their own.

Table 2-1. Overview of GNSS. Source: InsideGNSS

Name	Country	Current/Final # of Satellites	Start of Operations	Comments
GPS	USA	31	1973	Fully functional
GLONASS	Russia	17/24	1976	Completion by 2010
Galileo	EU	0/27	2014	2 experimental satellites
Compass	China	3/35	2014 – 2020	2 phase implementation
QZSS	Japan	0/3	2012+	Regional & inter-operable with GPS
GINS	India	N/A	N/A	Still to be approved

3 INTERNATIONAL ORGANISATIONS WORKING WITH GNSS APPLICATIONS AND TECHNOLOGY

Currently, the main organisation that promotes disaster management using space-based applications within the United Nations is the UN-SPIDER – UN Platform for Space-based Information for Disaster Management and Emergency Response, which was established 2006 [4]. The UN-SPIDER group helps by providing universal access to, capacity building all types of space-based information relevant to disaster management. Their main activities can be grouped in the following categories: knowledge portal (web-based tool), technical advisory support**,** capacity building, and fostering cooperation.

Another important organisation that works with GNSS providers, regarding technical matters is the International Committee on GNSS (**ICG**) [5]. It was established in 2005 on a voluntary basis as an informal body for the purpose of promoting cooperation, compatibility, and interoperability among different GNSS. Its main activities include international training courses**,** workshops, expert meetings, conferences, and reports.

4 DISASTER MANAGEMENT CYCLE

For ease of analysis, disaster management can be divided into three stages [6, 7], which comprise the so-called disaster management cycle, as shown in Figure 4-1.

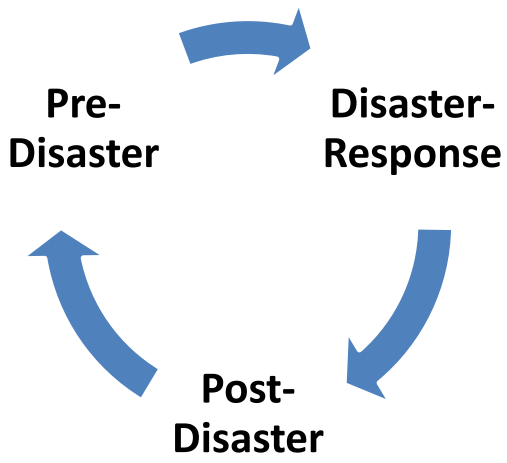

Figure 4-1. Disaster Management Cycle

The first, **Pre-Disaster Response**, includes activities, such as risk assessment, mitigation, prevention, and preparedness that are carried out by means of observation and monitoring, as well as by informing citizens and local authorities about the relevant events and their precursors. The second phase, **Disaster Response**, encompasses assessment of the damage and provision of help and all needed rescue services. Finally, the **Post-Disaster** phase concentrates on analysing possibilities to restore damaged infrastructures and to start reconstruction.

5 GNSS APPLICATIONS FOR DISASTER MANAGEMENT

GNSS can be used differently depending on the current situation needs in every phase. Since the application of GNSS is still under development, a number of issues should be solved on both technological and policy levels.

5.1 GNSS during Pre-Disaster Phase

What can GNSS do?

Before the disaster occurs, GNSS technologies can be used for monitoring sea level, ground profiles, and atmospheric composition (see Figure 5-1 & Figure 5-2) [8,9]. The measurements of these variables can lead to critical information such as impending tsunamis, earthquakes, and hurricanes. It can also be used for monitoring infrastructure stability and for the distribution of alerts to users in the affected area

Figure 5-1. Sea Level Monitoring Buoy. Source: NAVCOM

Figure 5-2. GPS Sensor for Monitoring Tectonic Movements. Credit: USGS

What are the technological challenges?

First, large networks of GNSS receivers are necessary especially in high risk areas (e.g. areas of high tectonic activities). A proper compatibility and interaction of these sensor arrays would also enhance their benefits, in preparing for disaster and post-disaster phases. Better interoperability and compatibility between different GNSS and software systems is not only needed for senor networks using GNSS, but also for better end user devices use of end user devices. The idea of a universal GNSS receiver seems very promising but also challenging, since having a uniform system of software for all communities and nations would require widespread, expensive, and synchronized efforts of cooperation and communication. Enhancing the precision of GNSS signals will be also beneficial. Both Earth and space based systems can be used for this purpose.

What are the policy issues?

Disasters are not limited to a country's borders. As mentioned above sensors networks will need multilateral efforts to be established in regions and countries of high risk to disaster. Often, the effects of disasters are more devastating in less developed countries because the necessary funds for a proper monitoring are not present. It will be necessary to provide these countries with the necessary equipment and development aid. The extension of Earth based GNSS augmentation systems is another idea that should be considered. Last but not least, higher level interoperability between various GNSS and a better cooperation between GNSS providers must be promoted in order to develop low-complexity multi-GNSS receivers that will deliver good position and timing performance. Standardization and international organisations to facilitate these changes are needed.

5.2 GNSS during Disaster Response Phase

What can GNSS do?

When a disaster occurs, very fast response must be provided. Good coordination of rescue efforts, precise information, and frequent updates can drastically enhance the efficiency of rescue operations and thus mitigate the suffering of the population. Integrating the data provided by Earth observation systems with GNSS data and the possibilities of Community Remote Sensing (CRS) can lead to a better damage assessment [12, 13]. In CRS, the GNSS data of personal mobile devices (the challenges of which are outlined below)can be used to monitor crowd movement and distress signals sent to GNSS satellites by effected persons can help to get a more precise picture of the situation during the disaster[17]. With this information rescue personnel and other aid can be coordinated more efficiently and the number fatalities in the aftermath of the event can be reduced significantly.

What are the technological challenges?

Common and user friendly interfaces and easy-to-use interfaces are needed to enable the optima use of CRS. The precise tracking of a large number of rescue crews is also challenging. In order to be able to use the GNSS equipment during this phase, it must be designed to be robust enough to withstand the harsh effects of most disasters. A technological challenge is the implementation of the Mid Earth Orbiting Search and Rescue (MEOSAR)/COsmicheskaya Sistyema Poiska Avariynich Sudov (COSPAS) functionality to current and future GNSS. This is a large challenge because this implementation would not only require orchestrated collaboration between various GNSS systems, and the MEOSAR/COSPAS systems would also undergo some adjustments for compatibility to GNSS systems.

What are the policy issues?

An organisation or centralised system is needed to collect and process the data of CRS. Easy, timely and universal availability of this information will be integral to the success of this idea. The misuse of personal GNSS data and pictures may invoke privacy issues. There may also be issues of false alarms. Those have to be addressed in a satisfactory manner by the organisation in charge of collecting and processing the data. Efficient cooperation between GNSS providers implementing MEOSAR will also be a key element.

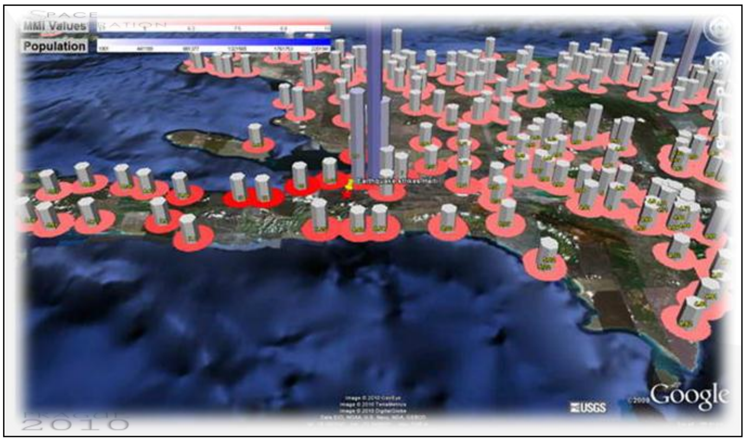

Figure 5-3. Visualization of geotagged information following the Haiti Earthquake

5.3 GNSS during Post-Disaster Phase

What can GNSS do?

After rescue operations begin when immediate threat to affect the population has been eliminated. The analysis and reconstruction can then commence. For this, pre-disaster GNSS data can be used to assist reconstructing damaged buildings and other infrastructure [14, 15]. The data from aerial and space based Earth observation systems can complete the before and after image of the disaster area. As during the immediate disaster response phase, reconstruction crews and materials can be coordinated for better utilisation of resources. An important part of the post-disaster phase is the analysis of the GNSS data gathered before and during the disaster. The retrieved data of ground movements can lead to a better understanding of geological processes, such as earthquakes or volcanic activity that may have caused the disaster. These data enable development of better geological models and prediction methods. Analysis of the ways GNSS data are used in rescue operations can assist in developing improved procedures for future events (e.g. by preventing bottlenecks in crowd movements).

What are the technological challenges?

Most technological challenges have already been addressed during the first two phases (pre-disaster and during-disaster) Once those aforementioned challenges have been met, the pressing challenge facing the GNSS systems in the post-disaster phase is the impairment of the GNSS ground segment during the disaster. One must develop the physical and technological resilience to these disasters to ensure their availability after the event.

What are the policy issues?

Archiving the collected data and making it available to all interested organisations, governments and persons are the main policy issues at this stage of disaster management. There needs to be laws developed for the collected information so that it is not distributed for purposes that violate personal rights.

6 CONCLUDING RECOMMENDATIONS

After discussing the current issues that various actors might face when using GNSS for disaster management, the working group developed a number of recommendations. For the international organisations in general and the community of GNSS providers in particular, the group offered the following as concluding recommendations:

- Create a universal GNSS software system.
- Distribute a ground-based network to high risk regions and countries.
- Develop a mobile GNSS device to track and monitor crowds during a disaster.
- Encourage ICG to have discussions on disaster management using GNSS applications regarding, for example, unification of types of receivers and GNSS system design (MEOSAR) [16]).
- Make GNSS data more available via a centralised database.
- Promote CRS

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SPACE GENERATION CONGRESS

PRAGUE 2010

CLIMATE SESSION REPORT

CLIMATE SESSION REPORT:

To Enhance Global Climate Data Exchange to Better Monitor Climate Change and Empower Policymakers, Scientists and the Community

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Prague, Czech Republic, October 2010

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

Cover Image: The dramatic retreat of the Aral Sea Π These Envisat images highlight the dramatic retreat of the Aral Sea's shoreline from 2006 to 2009. The Aral Sea was once the world's fourth-largest inland body of water, but it has been steadily shrinking over the past 50 years since the rivers that fed it were diverted for irrigation projects. By the end of the 1980s, it had split into the Small Aral Sea (north) and the horse-shoe shaped Large Aral Sea (south). By 2000, the Large Aral Sea had split into two – an eastern and western lobe. As visible in the images, the eastern lobe retreated substantially between 2006 and 2009. It appears to have lost about 80% of its water since the 2006 acquisition, at which time the eastern lobe had a length of about 150 km and a width of about 70 km Π Image Credit: ESA – adapted by Marc Cornwall

1 INTRODUCTION

Climate change is considered to be one of the greatest global challenges humanity is currently facing, and its nature, processes and consequences are not yet fully understood. The gaps in the knowledge and understanding of the science of climate change are significant because of the complexity of the phenomena affecting the climate system. Furthermore, the dynamic nature of the system in the terrestrial, oceanic and atmospheric environments makes it increasingly difficult to characterize. The use of space science and technology has enhanced understanding of these processes and offers great potential for a range of climate research and related applications. Earth observation data can help in monitoring and predicting climate fluctuations, as well as exploring what can be done to prevent adverse consequences as a result of these fluctuations. Data and information exchange and communication are the key issues to address in order to enable participation of all countries in these processes. The step is particularly important given that Earth observation data are generated by different satellite systems that belong to different countries and operate, gather and distribute data using different standards.

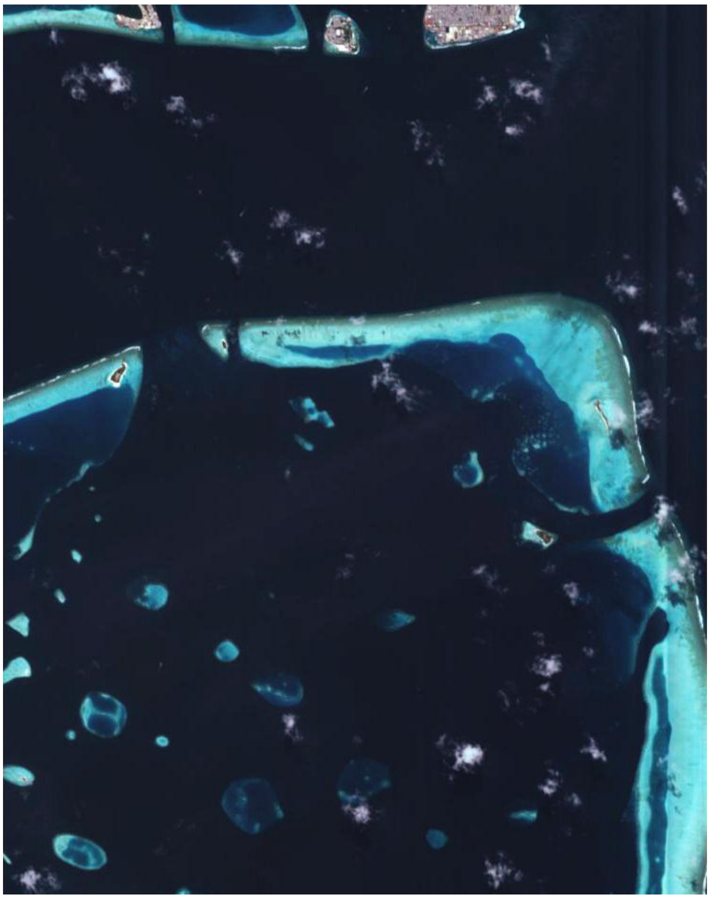

Figure 1-1. The Maldives as seen by CHRIS in the Proba satellite on July 05, 2005. It is the flattest country in the world, with altitudes no greater than 2.4 metres above sea level. The country sustained serious damage during the Indian Ocean tsunami on 26 December 2004 where around a hundred people were killed or reported missing. Credit: ESA

The delegates of the climate group were invited to discuss the current challenges facing Earth observation data exchange, and how the exchange of data can be improved. Looking into the future, the group came to the conclusion that both responsible political action and research require access to comprehensive long term Earth observation data. In addition, during the deliberations of the climate working group, the delegates identified that parameters used in monitoring climate change are often different from those used, for instance, in reconnaissance and meteorological applications. Similarly, data used for fundamental scientific research has different requirements than data needed for political or economic studies. The delegates agreed that individual countries or other actors will decide in favour of data policies promoting open access and sharing, if specific needs of the various user groups are clearly identified. Once these needs are established, a comprehensive data sharing regime is more likely to be achieved, and the objective of a global data sharing community (including many more than just established space faring nations), may become a reality.

2 BACKGROUND

As climate change is a global problem, a global response is needed. There are approximately 20 countries[17] which have their own Earth observation satellite technologies, but most of these use different data policies and standards. Each year, more countries either substantially invest in or develop their own space Earth observation missions and systems, which signifies increased interest and concern regarding the issue of global climate change. The reasons for new actors to get involved in satellite Earth observation include national pride, international prestige, optimisation of data for one's specific requirements, and control of data concerning specific territories.

A major problem for climate research and policy is that relevant and complete data are not always available or accessible. This is due to fragmented climate data collection methods and poor standards for sharing and interoperability that are partly caused by financial and political constraints. This often creates obstacles for use of data by professionals in academia, think tanks and decision making institutions. The lack of cooperation between institutions and nations, as well as the absence and inadequacy of consistent and reliable metadata are major reasons of the aforementioned problems. This is not only true for primary data but also for processed data and added-value data products. The working group finds that the recent efforts like the Global Earth Observation System of Systems (GEOSS) and the China-Brazil remote sensing programme are trends that signify the change in the way satellite data are archived, distributed and used.

Scientific models have to consider economic models. One relevant example is the Montreal protocol for coping with the problem of the ozone hole over Antarctica; the observation of which was enabled by satellite data. Each nation had to identify the production and usage of

[17] USA, Japan, India, Russia, Nigeria, Europe (France, Italy, Germany, and United Kingdom), Israel, Canada, United Arab Emirates, China, Algeria, Argentina, South Korea, Egypt, Turkey and Brazil

chlorofluorocarbons (CFCs). The reporting mechanism was supposed to be delivered annually, and the damaging capacity of CFCs was eventually identified as too high. Consequently, all nations agreed to ban them. The whole process was enabled by an industrial substitute which could be introduced into the market within a timeframe that caused no major losses to either consumers or industry.

3 TECHNICAL AND POLITICAL ISSUES

Various space assets are used for climate change monitoring and research. Satellites have provided considerable benefits in monitoring glaciers, CO_2, methane, ozone and aerosol concentrations, ocean and vegetation parameters, land use, deforestation, vegetation monitoring, and natural disasters. Each of these phenomena is best observed through specific spectral bands, identifying the need for optical, radar or LIDAR instruments. Productive academic research requires use of the most diverse range of the Earth observation technologies that can provide data regarding similar phenomena at differing spectral, spatial, and temporal resolutions. However, it is important to note that the parameters and resolutions of data appropriate for scientific studies, to be utilised on detailed climate models, are not necessarily the same as those needed for commercial, industrial or political applications.

The delegates identified three main areas of concern for climate studies and policy. The first one is the scientific understanding of natural phenomena and processes, such that these may be modeled and predicted. The second one is monitoring, which includes compliance to international agreements. The third one is preparation and mitigation of climate change effects including the adaptation of infrastructure. As present understanding of climate change is still limited, scientists struggle to offer conclusive results of their observations and studies to society, which contributes to the unfortunate situation where we lack adequate preparation and mitigation measures. This has direct implication in achieving political consensus on many environmental topics, causing international actions to fail more frequently than to succeed [1].

In order to establish proper dialogue between the scientific community and policy-makers, both have to provide long-term support to one another. The scientific community must provide robust studies on climate, and policy-makers must provide a comprehensive cooperation framework. To enable productive interaction, policy-makers need to be certain of which parameters – including their spatial, spectral and temporal resolution – will serve the scientific community without overlapping with other sensitive issues like long term strategies and national security. Interdisciplinary consultations are a prerequisite for achieving this goal.

On the political level, the United Nations Committee on Peaceful Uses of Outer Space (UN COPUOS) developed several principles to regulate the practices of imaging each other's territories [2]. The decision was made, that no previous consultation was needed, but the data have to be shared ex post. Unfortunately, these principles did not unify national data policies. Climate change is quickly becoming a national security issue because it is likely to affect food production, access to drinking water and, in the case of the arctic countries, redesign of the national maritime claims. This situation also contributes to the motivation to increase and improve data exchange – the issue gains political momentum. [3]. Climate change now occupies a central place on the global political agenda and countries are more inclined to adjust their space policies to reflect it.

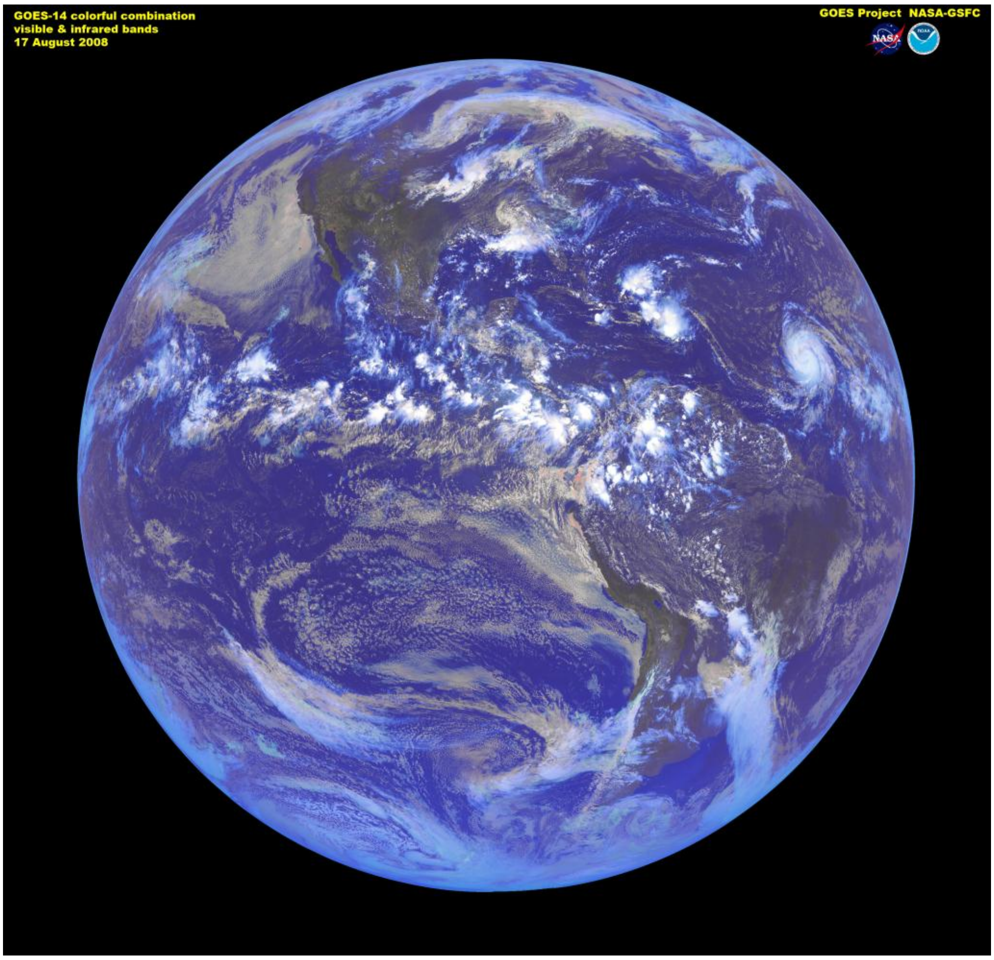

Figure 3-1. On August 17, 2009, at 1:31 p.m. EST, the latest NASA/NOAA geostationary weather satellite, called GOES-14, returned its first full-disk thermal infrared (IR) image, showing radiation with a wavelength of 10.7 micrometers emanating from Earth. Credit: NASA GOES Project, Dennis Chesters

Nevertheless, the acceptance of principles among nations to share data remains a challenge. The Group on Earth Observations (GEO) was organised in response to calls for action by the 2002 World Summit on Sustainable Development and by the G8 (Group of Eight) leading industrialized countries. These high-level meetings recognised that international collaboration is essential for exploiting the growing potential of Earth observations to support decision making in an increasingly complex and environmentally stressed world. Ensuring that these principles are implemented in an effective and flexible manner remains a major task for the international community.

3.1 Concerns with Data Sharing

The SCG Climate working group came to the conclusions, based on the review of the current research and the discussions during the congress, that countries operating satellite systems generally have legitimate concerns regarding sharing their data. They are mostly of economic, strategic and political nature. Sharing data may, in some cases, be precluded by the demand of the data generators to receive financial compensation. Satellites are very expensive and governments are often unwilling or unable to invest in their development or purchase. Sharing data may also provide strategic information, usually very difficult to obtain from a competing sector or government and, politically, countries may feel they have more bargaining power if they keep certain information to themselves.

3.2 Benefits of Data Sharing

The group is of the opinion that the incentives to overcome hurdles of data sharing lie in the benefits of their use that should outweigh the concerns that exist among states and other actors. The main focus of data sharing is to maximise the benefits for mankind of understanding the effects of climate change at large that include forecasting of extreme climate events and disasters, with the goal of improving mitigation. Another significant benefit is the improved modelling capability. Furthermore, making this information accessible for a wide range of users in a shorter time enables creation of a pool of global research resources.

More data sharing translates into quicker and better research, in terms of coverage and the number of scientists working on climate issues. The consequence of more stakeholders involved in climate research is the gain in awareness about the issue, which enhances global responsibility. It is the agreed understanding of the group that climate change is a global problem and the benefits of understanding it are global too. It is relevant for all countries, societies, as well as directly involved professionals, all the stakeholders should participate in the initiative to draft and adopt data sharing agreements. Those actors who advocate for a comprehensive data sharing agreement would not only enjoy international prestige, but also be positioned on a moral high ground to strengthen their global leadership.

4 WAYS TO STRENGTHEN CAPACITIES

4.1 Recommendation one: global agreement on data acquisition, continuity and exchange

The main key to strengthening the capacities is coordination. It enhances mutual knowledge about the parties' activities, as well as prevents unnecessary duplication of work and, in some cases, capabilities. A resolution to provide guarantees for data availability and data continuity, to agree on the parameters and to identify standards of use, long-term storage and metadata is essential.

Accuracy and reliability of collected data are vital, along with accompanying metadata. While the leadership lies with the developed countries that produce the most CO_2, which contributes to global warming, the responsibility falls on all involved actors – developed and developing countries alike [3]. The countries proficient in space technologies, though, should have additional responsibility for data acquisition and exchange, with all actors expressly willing to partake. All actors should be given the opportunity to sit at the table from the beginning of the process so the results can be as democratic as possible. The voice of those who display political will to see such an agreement until its conclusion would gain respect among global leaders.

4.2 Recommendation two: involve new stakeholders and raise awareness

The most important objective for dealing with climate change is to have people take it in their own hands and responsibly act upon it. Approaches like Community Remote Sensing, capacity building partnerships in the development of ground and space segments, and competence centers for data analysis are only a fraction of resources that can be used by globally involving communities of citizens, amateurs and scientists. Community Remote Sensing can play an important role in both providing inputs to climate change policy, and raising awareness. CRS is a relatively new field of activity that combines Earth observation, grass-root actions of citizens and social networks, to enhance the data obtained from traditional sources and to augment the observing systems [4]. CRS can for instance lead to improved weather data collection by gathering inputs from local populations. An aspect to consider about CRS is the balance between quality and quantity. There are many variables affecting CRS data quality which are difficult to control. However, wide participation will increase statistical reliability of data and give local communities a sense of awareness and responsibility – enhancing their understanding of the fragile environment in which they live.

Another discussed recommendation for providing data access was for space-faring actors to help space-aspiring ones building their own satellites, rather than selling or helping to build ground stations in other countries. This support would be contingent upon a global need for more satellites, a geophysical specificity of the country or region that would own a satellite, and new research and data this equipment would bring to the global community. The increased awareness, data resources and the capacity of a growing constellation of Earth observation systems capable of providing better spatial resolution and continuity over time outweigh many of the political concerns.

Capacity building is essential, but it may be too costly for some actors to endeavor in it alone. Regional centers can be a good starting point to set activities in motion, assisting other small actors in the region to start working with satellites. Another option is to use low cost space technologies that offer a novel solution to monitor and manage sustainable urban and territorial development, conservation of forests and valuable biodiversity habitats for example. Their data may not be as accurate as the highly sophisticated systems built by agencies, but their complimentary function is of great value. The CRS option can be combined with any of the other proposed here.

4.3 Recommendation three: implement a system providing easy data access

Two common models have been used to exploit satellite data from third parties. The first model sees interested actors buying satellite data from a producing agency or company. The major problem identified was that the buyer has to submit to whatever decision the technology owner had taken concerning the volume of satellite data acquisition, their availability or price. According to the second model, interested governments can acquire data from third party providers through ground stations that they establish and operate within their territories. The advantage of this model is that the owner of the ground station may have more rights over the acquired data, often with the ability to resell them. The major difficulty lies with the investment in training personnel to operate ground stations and to add value to primary data that is sometimes expensive for many countries.

One of the most important examples of policy pushing a different concept of satellite data business is the CBERS (China Brazil Earth Resource Satellite) model. Images are given for free for anyone in Brazil, China and now for several African countries. Brazil and China decided share the cost of project and supply the interested public in those countries with the needed initial knowledge for adding value to the free raw data and selling these services. The business model goes similar to the successful Global Positioning Satellite (GPS) model, in which market innovation builds upon the initial public investment. Long term data archives are another important factor to consider. A remarkable example is the current Landsat model, in which a large amount of Earth observation data is provided free of cost and without any restrictions to the global research community.

Finally, the group considers Global Earth Observation System of Systems (GEOSS) as an initiative worth investing in and implementing. It aims at providing improved scientific understanding, modeling and prediction of climate change as well as the accessibility to all Earth observation data and enhanced efforts for data rescue and digitisation. It also aims at achieving effective and sustained operation of the planned global climate observing system. It is expected to provide reliable data and information of sufficient quality to predict, mitigate and adapt to climate variability and change, as well as to better understand the global carbon cycle [5]. GEOSS is a framework that could provide the technical support for global data sharing initiatives, dispensing the need to reinvent the wheel and thereby achieving desired results in a reasonable timeframe. The delegates reiterated the importance of the creation of a permanent SGAC working group on climate which will act as an SGAC platform contributing to the GEOSS framework as well as for further climate discussions.

5 RECCOMMENDATIONS AND CONCLUSIONS

Climate change is a global and complex problem, therefore a global response is needed. Countries need to make existing data sharing policies more cooperative and open. Space technology is a very important tool being used and can even be more effectively used for future climate research. All types of available Earth observation methods and techniques should be considered in the climate research, not only highly calibrated and sophisticated ones. This implies including all the data ranging from high quality/expensive to low quality/inexpensive. Small and low cost satellites, much as CRS, offer great value for their function as complimentary data collection for calibration and validation, as well as unprecedented power to aggregate and involve communities inside and outside laboratories.

Figure 5-1. Envisat radar image of the Tanezrouft Basin in the Algerian Sahara. Stone and pebbles make up most of the Sahara surface in Northern Africa. Erosion – first by water, now by wind – has created this landscape of hills, basins, steep canyon walls, stone plateaus and multi-storey sand dunes. Credit: ESA

In summary, the climate working group recommendations are:

- Earth observation data should be shared with everyone who wishes to engage in climate and environmental research. This implies common standards for metadata and data sharing, as well as global coordination of how to ensure access to data and their continuity;
- Capacity building should also be used as an awareness tool by including information about and developing low cost and small scale initiatives;
- New business models favouring a more cooperative approach to the sharing of data, especially for those countries lacking the proper regulatory framework, should be explored;
- As many stakeholders as possible should be involved in acquiring, processing and interpreting Earth observation data. This will enhance knowledge, lend legitimacy and strengthen the way for taking effective actions on a global scale.

The delegates of the climate session recognised the importance of giving institutional opportunity and a voice to any space-aspiring actor to develop their own capabilities. It was a consensus that such concepts should be debated at COPUOS as the international forum able to serve as a forum to include all nations with space interest. It is a strong hope of the

2010 SGC Climate working group hope that this work can help to enhance global climate data exchange to better monitor this phenomena and empower policymakers, scientists and the general population.

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Space Generation Congress

Prague 2010

EXPLORATION SESSION REPORT

EXPLORATION SESSION REPORT:

Examining the feasibility of a mission to Mars from the perspective of the young generation

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Prague, Czech Republic, 23-25 September 2010

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

Cover Image: Mars' moon Phobos Π This image was obtained by the High Resolution Stereo Camera (HRSC) on board ESA's Mars Express on 28 July 2008 (orbit 5870), at a distance of 351 km from the moon's centre. Π The origin of Phobos is debated. While its density, lower than the density of the Martian surface rocks, make it appear to belong to D-class asteroids, the moon appears to share many surface characteristics with the class of carbonaceous C-type asteroids, which suggests it might have been captured from this population. However, it is difficult to explain either the capture mechanism or the following evolution of its orbit into the equatorial plane of Mars. An alternative hypothesis is that it formed in its present position, and is therefore a remnant from the planetary formation period. Π Image Credit: ESA/ DLR/ FU Berlin (G. Neukum) – adapted by Marc Cornwall

1 INTRODUCTION

“Twenty years from now you will be more disappointed by the things that you didn't do than by the ones you did. So throw off the bowlines. Sail away from the safe harbor. Catch the trade winds in your sails. Explore. Dream. Discover.”

Mark Twain (American Humorist, Writer and Lecturer. 1835-1910)

“Exploration is really the essence of the human spirit.”

Frank Borman (American, NASA Astronaut and Engineer. 1928 - Present)

The primary goal of the Exploration Working Group was to discuss aspects of a manned mission to Mars – the technical, social, legal and political challenges involved. In the context of the discussions, both short-term and long-term missions as well as a permanent settlement were considered. The question of whether or not it is advisable, or perhaps even necessary, to send people to the Moon again before a manned mission to Mars is attempted, was raised many times in different contexts.

The discussions started in very broad terms – the primary, general difficulties associated with a manned mission to Mars were identified during this time. As these ideas were developed and their finer details considered, it became necessary to divide the group into three sub-groups that would discuss (in greater detail) the obstacles to be expected during the three phases of a manned mission to Mars: Lift-off from Earth, the flight to Mars and life on the Martian surface.

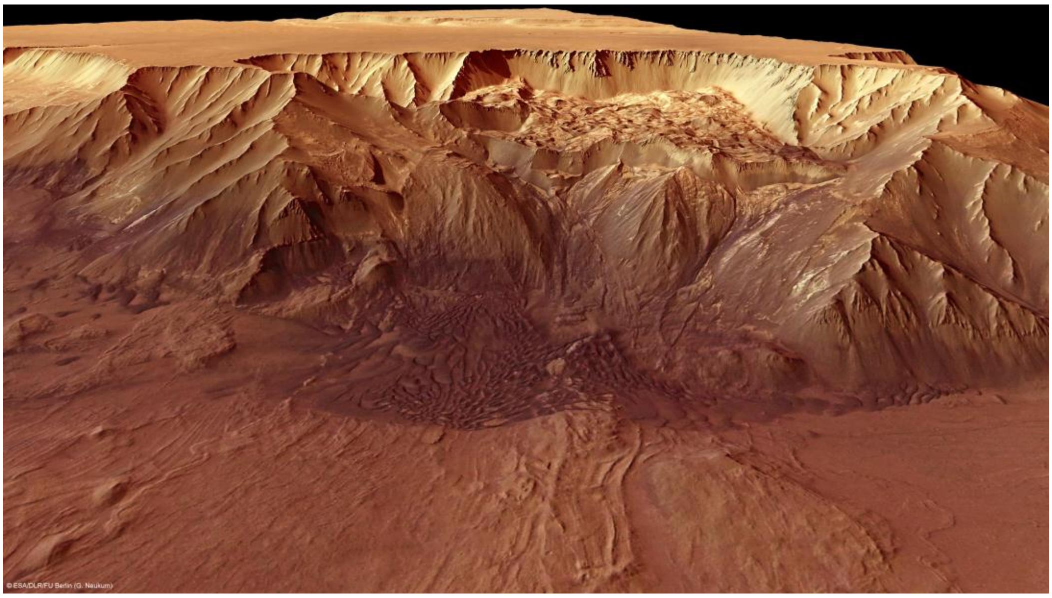

Figure 1-1. Melas Chasma is part of the huge Valles Marineris rift valley on Mars. Melas Chasma itself sinks 9 km below the surrounding surface, making it one of the lowest depressions on the planet. Landslides have created huge fans of rubble at the base of the cliff. Credit: ESA/DLR/FU Berlin (G. Neukum)

2 GENERAL OBSTACLES

It was unanimously agreed that any attempted mission to Mars should be an international, collaborative effort. There are many existing and potential future obstacles and pitfalls associated with this approach, but there are also many advantages. They include sharing of knowledge and technology, reduced risks of loss of life and financial resources, profits from spin-offs of shared technology etc. A summary of the general obstacles to be expected during a manned mission to Mars is presented in the next section.

3 OUTREACH

SGAC should stimulate public opinion in order to gain support for a manned mission to Mars. Such a global awareness campaign should cover education and capacity building, as well as public outreach and reach alignment of conflicting interests. In order for a manned mission to Mars to be successful, development and implementation of educational and professional programmes to develop required skills are essential. In particular, interest in careers in the natural and physical sciences (e.g., mathematics, physics and chemistry), engineering, social sciences (e.g., sociology, psychology and law) and medicine should be stimulated. Details as to the process of promoting such education can be found in the report of the Outreach working group.

An international, collaborative effort to send people to Mars may capture the hearts and minds of the world community in the same way that major space exploration endeavours captured the hearts and minds of the citizens of the country or countries that attempted them. In this context, precursor missions intended to test particular systems or technology readiness levels could be used to stimulate public interest. Another manned mission to the Moon could possibly generate much interest in a future manned mission to Mars. Although, as mankind has already landed on the Moon, it's debatable exactly how much positive public opinion for a mission to Mars this would gain. For a cooperative effort to be a success, existing and potential future conflicts of interest and opinion are to be anticipated and resolved in a timely fashion. International organisations, such as SGAC, should be prepared to mitigate and alleviate such conflicts in the context of a manned mission to Mars.

4 INTERNATIONAL COOPERATION

When discussing long-term, complex and expensive projects, the working group looked at other examples of international cooperation in space. For European states, participation in the European Space Agency is one such example. It is an international organisation separate from governments of its member states that has capacity to make its own decisions. At the same time, it leaves its member states the autonomy to decide their individual degree of involvement.[18] The International Space Station is yet another international undertaking in space created and maintained under an international convention between its partners that just recently celebrated its ten-year anniversary of operations.[19]

These successful projects in international cooperation serve as pertinent role models for a manned mission to Mars. It was decided that the establishment of an international consortium, through an international treaty or convention similar in form to the ESA convention and ISS agreement, is best suited for a mission to Mars. Such a consortium must define the different players in the project (agencies, governments, industry, universities, laboratories, etc.), delineate funding and create a managing body, perhaps similar to ESA's governing council. However, as problems related to these aspects may be difficult to anticipate, there is no utility in forecasting the precise framework or timeline for the creation of such a consortium, whose details must be drafted and negotiated on an inter-governmental diplomatic level. As SGAC is an international body of motivated young individuals, its members are ideally placed around the globe to foster the capacity building and public awareness for this grand project.

5 LEGAL ISSUES

Several legal aspects of high relevance to the process of setting up an international consortium and its internal functioning, as well as legal aspects of the mission itself (both immediate and remote), were identified during the discussions held by the working group.

5.1 The Consortium Framework

- *Allocation of risks:* The international agreement creating the consortium must allocate the risks involved to the most appropriate state parties on a pre-determined contractual basis with the help of mandatory insurance provisions. Each state must negotiate the extent of its possible liability in detail in case of occurrence of damage.
- *Cross-waiver of liability:* Following the ISS model, the consortium agreement should contain norms regarding cross-waiver of liability, where partners agree not to make any claims against other partners regarding damage caused to them during the implementation of the project.
- *Governmental indemnification:* Under the existing space law regime, state parties are responsible for the authorisation and supervision of national activities in outer space,

18 Convention for the Establishment of a European Space Agency, May 30, 1975, 1297 U.N.T.S. 161, 187, 14 I.L.M. 864.

19 Agreement Among the Government of the United States of America, Governments of Member States of the European Space Agency, the Government of Japan, and the Government of Canada on Cooperation in the Detailed Design, Development, Operation, and Utilization of the Permanently Manned Civil Space Station, Sept. 29 1988, 1989 U.K. Misc. Ser. 9, U.S. Dept. of State 92-65 (1988); See also Logsdon, J., Together in Orbit: the Origins of International Cooperation on the Space Station, NASA Monographs in Aerospace History no. 11, 1988, available at: <http://history.nasa.gov/monograph11.pdf>.

whether by governmental agencies or by non-governmental entities,[20] and thereby ensure their compliance with international law.[21] Since any mission involves actors from across the globe, including public and private entities, commercial contractors, universities, and national space agencies, it is imperative that the indemnification

5.2 The Mission to Mars

- *Non-appropriation principles*: While the Outer Space Treaty allows that outer space and celestial bodies are free for exploration and use by all states,[22] it also explicitly prohibits national appropriation, by "claim of sovereignty, by means of use or occupation, or by any other means."[23] Cognizant of the explicit prohibition on property rights in outer space, legal certainty and clarity regarding the exploitation and use of celestial resources must be built into the framework beforehand. The Treaty's mention of freedom of scientific investigation and the encouragement towards international cooperation[24] and mutual assistance[25] further mitigate the possible violation on the non-appropriation principle by the consortium's use of celestial resources, and the international character of the mission prevent the possibility of national appropriation.
- *Jurisdiction and control*: The Outer Space Treaty confers legal jurisdiction and control to State Parties over those space objects which they register on their national registry.[26] Legitimate exercise of authority over both the personnel and the space objects should be negotiated and specifically laid down in the agreement, and be in compliance with the existing registration practices of space fairing states.
- *Identification of the launching state*: Since a launching state bears international liability for any resulting damage,[27] the question of which state (in the case of a single, collaborative launch between multiple states) is of paramount significance. However, there is a long history of space-faring nations successfully negotiating apportionment of possible liability issues arising from launching. For instance, Russia and Kazakhstan use a lease agreement for launches conducted from the Baikonur cosmodrome in Kazakhstan.[28]

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[20] Art. VI, Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Jan. 27, 1967, 610 U.N.T.S. 205 [herein Outer Space Treaty]; *See also* BROWNLIE, I., PRINCIPLES OF PUBLIC INTERNATIONAL LAW 255 – 258 (7th rev. ed. Oxford 2008).
[21] Art. I, para. 2, Outer Space Treaty.
[22] Id.,
[23] Art. II, Outer Space Treaty.
[24] Art. I, para. 3, Outer Space Treaty.
[25] Art. IX, Outer Space Treaty.
[26] Art. VIII, Outer Space Treaty.
[27] Art. VII, Outer Space Treaty.
[28] Bjornerud, M., *Baikonur Continues: The New Lease Agreement Between Russia and Kazakhstan*, 30 J. OF SPACE LAW 13.

- *Other issues*: Other related issues which might give rise to disputes include product liability issues, intellectual property rights, tortuous liability for negligence, and even criminal jurisdiction.

6 TECHNICAL DIFFICULTIES

Not least of all the problems that will need to be solved before a manned mission to Mars is attempted, are the technical difficulties involved. Members of the working group identified several key issues that would have to be addressed and technologies that would have to be developed. Given the sheer number of systems, devices and components that even a short-term mission to Mars would require, as well as the cumulative cost of their launch, it may be wise to further develop launch vehicles and to investigate alternate means of propulsion during transit. The possibility of refueling in orbit (around the Earth) before the transit to Mars and again before the return journey, as well as the notion of manufacturing fuel on Mars from local resources should be investigated.

The recycling and/or production of human necessities, such as food, water and air, during the mission will likely be essential. The notion of an extraterrestrial farm was suggested to produce food and oxygen. As it is difficult to simulate the Martian environment on the Earth, some means of simulating the conditions and testing the effects of prolonged exposure to the elements on the Martian habitat and other exposed systems on the Martian surface would have to be devised.

The effects of long-term isolation of the crew would also have to be tested – the Mars500 mission is a good start.[29] Nevertheless, a more thorough investigation is advised, particularly taking into account the fact that the test subjects taking part in the Mars500 mission are aware of the fact that in case of an emergency assistance is a moment away.

7 EXPLORATION OF THE MOON

The issue of lunar exploration prior to the exploration of Mars was identified and discussed at the very beginning. No consensus was reached in this respect but several important points were raised in the discussion. First of all, a new mission to the Moon should not be an imitation of the Apollo programme, and new reasons for exploring the Moon along with new solutions to the challenges of getting humans there should be found. Only through innovation can we attract the attention of the public. Successful completion of a flight to the Moon would certainly gather more support for a mission to Mars. The question of whether critical technologies needed for the exploration of Mars can be tested on the surface of the Earth (e.g. Antarctica) or if going to the Moon is the only viable solution should be discussed in further detail. Several science missions to the Moon may be considered which could then be used to test new technologies relevant to a Mars mission; examples include an

[29] Mars500 mission: http://en.wikipedia.org/wiki/MARS-500

astronomical telescope on the dark side of the Moon and studies of the geologically pristine surface of the Moon.

8 IN-DEPTH DISCUSSIONS ON ISSUES OF A MANNED MARS LANDING

Following the initial discussions, during which potential problems in an attempt to land people on Mars were identified, mission was divided into phases. The first phase is the launch from Earth of all components and systems that would be required during the mission, either in transit to Mars or on the Martian surface. The second phase is the transit from Earth to Mars. The third phase is the exploration of the Martian surface and may be short-term (approximately two weeks), long-term (approximately two years) or permanent.

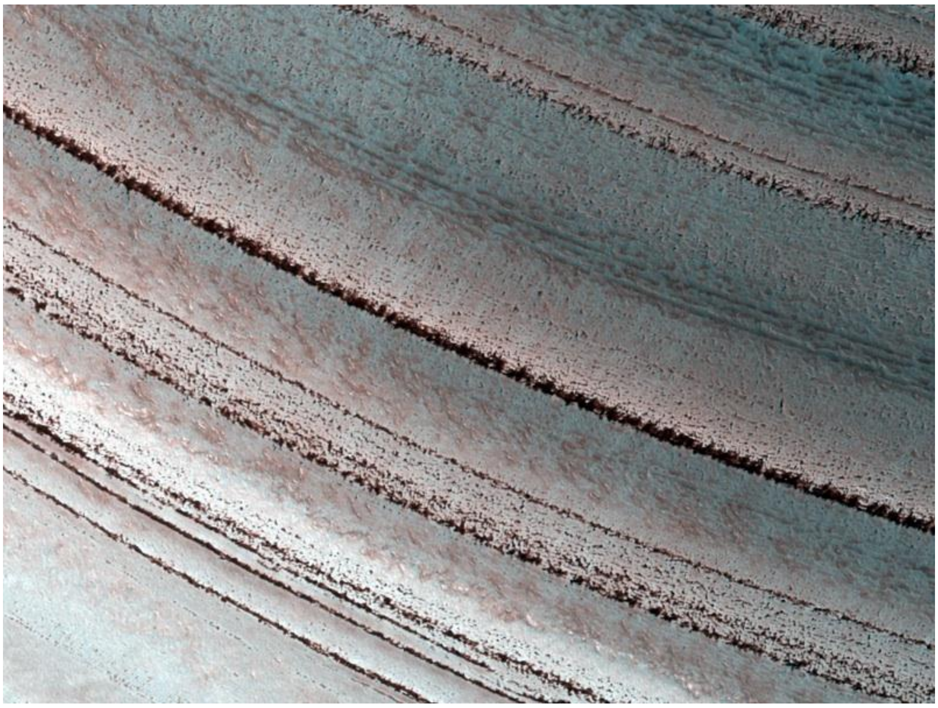

Figure 8-1. Icy Layers and Climate Fluctuations near the Martian North Pole. The High Resolution Imaging Science Experiment (HiRISE) camera on NASA's Mars Reconnaissance Orbiter recorded this image of north polar layered deposits on March 11, 2010. Credit: NASA

The main group was divided into three sub-groups to investigate and address various issues related to each of these phases. There is obviously a significant amount of overlap between the three phases (for instance, where the components for the transit vehicle and surface habitat should be assembled), consequently some matters were discussed in more than one of the sub-groups.

9 LAUNCH

Estimates of human missions to Mars envisage spacecraft that weigh in the order of several hundred tons.[30] [31] The launch and assembly of such a system would require several years to complete using today's launchers and methods as proven by the ISS programme. Several key technological issues need to be addressed in order to reduce the period needed to assemble the transit craft and facilities required on the Martian surface and to reduce the overall mass that has to be transported into orbit.

A new generation of heavy-lift launch vehicles would have to be developed to allow bigger payloads to be launched at lower prices. Although this area is of fundamental importance, the capability to launch larger and more massive objects into orbit has not changed fundamentally in the past few decades. As such, the group believes that a more significant reduction in cost of a Mars mission can be made in the area of emerging and hypothetical propulsion technologies. Furthermore, new methods and technologies related to Earth-transfer orbits and injection into a Martian orbit should be developed.

10 TRANSIT

10.1 Mission Architecture

A mission as complex as an exploration mission to another planetary body requires an efficient and well thought architecture. Issues such as the assembly strategies necessary to construct a large complex in orbit, refueling and disassembly upon reaching the destination must be considered. Contingency scenarios need to be properly identified as they will have great influence on the overall vehicle design and resulting strategies.

10.2 Transit Vehicle Design

A vehicle designed to transport the necessary exploration systems to Mars would have to meet several technical challenges. The development of new upper stage propulsion systems aimed at injecting the spacecraft components into transfer orbits to and from Mars is critical. Refueling in space, innovative in flight maintenance technologies (such as self-replicating and self-healing systems) and vital power generation systems will provide new directions of development for design.

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[30] "Reference Mission Version 3.0 Addendum to the Human Exploration of Mars: The Reference Mission of the NASA Mars Exploration Study Team", Bret G. Drake, editor Lyndon B. Johnson Space Center, NASA/SP—6107–ADD, June 1998.

[31] "Human Exploration of Mars Design Reference Architecture 5.0", Bret G. Drake, Lyndon B. Johnson Space Center, February 2009.

10.3 Life-support

Sustaining human life in the vacuum of space has been the emphasis of studies since the beginning of the space age. However, sustaining human life during a space voyage to Mars would be more cumbersome than a mission in Earth orbit or even to the Moon. Discussions on this topic were focused on sustaining the life of the crew by the use of a regenerative (closed loop) life support system and new methods of maintaining crew health, such as telemedicine.

A closed loop life support system would offer major advantages in terms of oxygen generation, water and waste management, and food production along with the provision of vital nutrients. A balance between stored food and food grown on board must be maintained. Just as important are the cultural and personal preferences related to food and its preparation. The vital factor of radiation shielding was not overlooked. New technologies and mission strategies must be developed to shield the astronauts during their transit.

10.4 Crew Operations

The subject of crew operations is very important and often under-appreciated. Group cohesion, cultural awareness, command hierarchy and the use of artificial intelligence are all fundamental subjects when dealing with long term confinement particular to an interplanetary transit period. Group cohesion monitoring can yield important information and warnings regarding the psychological health of the crew and of the team in general.

A mission to Mars will most likely be the result of an international, collaborative effort involving individuals from all over the world with radically different cultural backgrounds, habits and dietary preferences and requirements. Cultural awareness would have to be stimulated amongst the crew and methods aimed at minimizing the impact of historical and cultural differences would have to be developed. So far, missions have relied mostly on archaic command hierarchies inherited from the early space age. Future exploration missions will likely be manned mostly by civilians. A strong command hierarchy would still be necessary to help crew moral and streamline operations on board.

The possibility of cross-training among crew-members en-route to Mars should be considered. This would facilitate the exchange of knowledge between crew-members with different fields of expertise. Additional training could be supplied in the form of training material stored on-board. The initial flight could involve the assembly of certain non-critical systems by the crew. This would both reduce the time required to construct the spacecraft and keep the crew occupied. Educational time can also be allocated where crew members can remotely participate in classes for school children.

11 ON THE MARTIAN SURFACE

The hardware challenges of a surface system were discussed in depth and important issues were identified, including life-support, housing, infrastructure, contamination and transport to and from the Martian surface.

Figure 11-1. Image of a meteorite found and examined by NASA's Mars Exploration Rover Opportunity in September 2010. Opportunity's cameras first revealed the meteorite in images taken on Sol 2363 (Sept. 16, 2010), the 2,363rd Martian day of the rover's mission on Mars. This view was taken with the panoramic camera on Sol 2371 (Sept. 24, 2010).

11.1 Life-support and Housing

In terms of life-support, issues regarding the production of water and oxygen and the management of waste would have to be addressed and key technologies developed in order to meet the demands. The crew would also require a suitable habitat which would provide shielding from elements on the Martian surface, such as temperature extremes, dust storms and harmful radiation. Although some of the systems and technologies designed to address these issues could be tested during a Lunar mission, it is questionable whether adequate (albeit less robust and extensive) testing could be done on Earth or in orbit around Earth to reduce the cost of testing.

11.2 Infrastructure

The infrastructure on the Martian surface would also have to be developed, likely before manned missions are considered. Some means of sustained communication both between systems near Mars and within the solar system would have to be established. Such a communications network would be a major milestone in terms of any manned or unmanned mission beyond the Earth-Moon system. The habitat will require a sustained source of electrical power and vehicles will be required to transport astronauts on the surface. All these systems have to be reliable and should preferably be self-maintained or maintained automatically. In this regard, testing on the Moon will perhaps be more insightful and worth the added cost. Technologies based on the notion of *in situ* resource utilisation (ISRU) would have to be developed in order to achieve the infrastructure requirements as well as many of the other points mentioned. For example, a frequently addressed topic is that of fuel for a return journey, which would potentially involve ISRU to produce fuel on the surface before any astronauts arrive.

12 EDL and AER

The crew's safe arrival on the planet (entry, descent and landing – EDL) is as important as the crew's safe return to Earth (in terms of the scope of the group's discussions – ascent, exit and return or AER of the crew capsule). In both cases, technologies to build these complex systems must achieve a high technology readiness level (TRL). In order to gain experience and identify further technological challenges, robotic precursor missions preceding manned missions beyond and on the Moon should be considered.

12.1 Dust Mitigation and Contamination

Dust from the Martian surface could have a negative impact on systems within the habitat, on systems fully exposed to the Martian atmosphere and potentially on the crew itself. Thus, dust mitigation mechanisms should be developed to ensure hardware reliability and crew health. Dust mitigation strategies are also required for lunar missions, therefore testing on the Moon should be considered. It is of paramount scientific importance to ensure that nothing from the habitat or any other item of terrestrial origin contaminates the Martian surface in order to conserve pristine conditions for geophysical and microbiological investigations and studies concerning the long-term impact of systems of terrestrial origin on a potential Martian biosphere.

12.2 Automation and Modularity

Special emphasis on the importance of modularity and automation was made, as many mission aspects are related to and connected with them. For instance, the in-situ assembly of a modular habitat prior to the arrival of the crew would require a high level of automation.32 Equally challenging are the proposed farming system to build up oxygen and food reserves and the system to produce and store fuel for the crew's return journey.

[32] Revolutionary Concepts for Human Outer Planet Exploration (HOPE). Space Technology & Applications International Forum (STAIF - 2003) February 2-6, 2003 Albuquerque, New Mexico. Page 9. http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20030063128_2003072427.pdf

13 A LOOK FORWARD

Further research regarding surface systems is needed. This would include research and development of technologies related to automated assembly and interoperability to enable precursor missions and lower the cost of subsequent missions. Furthermore, the development of inflatable or collapsible modules for initial missions (especially short-term missions and precursor missions), the development of subterranean habitats for long-term missions, which would require further developments in terms of modular design, radiation protection and habitat design, is vital. Extra-terrestrial agriculture with an emphasis on automated, sustainable systems, possibly combined with *in situ* resource utilisation would also be required. Creation of standards for data formats, engineering standards and communication protocols to give mission crews the highest possible flexibility to ensure forward and backward compatibility of systems for future missions and increase redundancy is required.

14 CONCLUSION

“We shall not cease from exploration; and the end of all our exploring will be to arrive where we started. And know the place for the very first time.”

T. S. Eliot (American-born English Poet, Playwright and Literary Critic. 1888 – 1965)

There are several ideas and themes that recurred frequently throughout discussions and brainstorming by the delegates of the group. Most notably, the question was often raised as to whether another manned lunar mission is necessary in order for a manned mission to Mars to be safe and successful. As discussed in the preceding sections, there are many advantages and disadvantages to the testing of systems and technologies intended for a mission to Mars during a lunar mission. It was concluded that the Moon is not a necessary stepping stone for getting to Mars, and that aiming for Mars directly can have large benefits in terms of budget expenses and international cooperation, but that the costs of certain lunar precursor missions may be justified by the potential gain in terms of knowledge and experience.

14.1 Future Activities

The analysis of the issues involved and the exchange of opinion among the group members led to the decision that issues identified and outlined in this document need to be expanded upon, further investigated and potential solutions sought in order to produce a “Roadmap to Mars”. Such a roadmap would consist of a prioritised list of obstacles (in terms of technology, policy, law etc.) that would need to be overcome. For instance, many technologies and design philosophies were mentioned that could be used and tested in other terrestrial and extra-terrestrial contexts and may even yield profitable spin-offs. More extensive international collaboration during upcoming space missions could simplify the matter of devising and implementing a plan to send a manned mission to Mars.

14.2 Contact

Since the group members are spread worldwide, an online group was established to facilitate the exchange of ideas, archive them for later reference and work towards creating the road-map. Please send an e-mail if you have any comments, suggestions or questions:

Yahoo! Group link is: http://tech.groups.yahoo.com/group/SGC2010_Exploration

Please contact via e-mail: SGC 2010_Exploration-owner@yahoogroups.com

Ms. Kat Coderre (Moderator): kathleen.coderre@gmail.com

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Space Generation Congress

Prague 2010

OUTREACH SESSION REPORT

OUTREACH SESSION REPORT:

Development of Science and Technology Education and Careers for the New Generation

Group Participants

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Petr Pulc	Video Team	Czech Republic

Prague, Czech Republic, October 2010

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

Cover Image: Build the Future Π Students used LEGOs to 'Build the Future' at NASA's Kennedy Space Center in Cape Canaveral, Fla. on Wednesday, Nov. 3, 2010. The 'Build the Future' event was part of pre-launch activities for the STS-133 mission. Π NASA and The LEGO Group signed a Space Act Agreement that features educational games and activities designed to spark children's interest in science, technology, engineering and math. Π Image Credit: NASA/Bill Ingalls – adapted by Marc Cornwall

1 INTRODUCTION

Space technology has become an indispensible component in today's information society. From precision agriculture to remote health services and education, space applications now serve key roles in many areas of today's society. Countries around the world are facing the challenge of motivating and inspiring young people to pursue studies and careers in science, technology, engineering, and mathematics to foster further development of space activities. As a result, space education and outreach programmes aimed at the next generation of space industry experts have to be established and developed.

Recent studies[33] have shown a decline in young people pursuing studies and careers in science, technology, engineering and mathematics (STEM). The key to fighting against this trend is building on the enthusiasm of young people in an engaging learning environment. Hands-on learning, for instance, teaches one to be a maker of things rather than a consumer. By providing innovative approaches that support science and technology education in schools, outreach efforts should aim to spark interest in space related activities among students. Current and future outreach programmes should enable critical thinking, problem solving and support innovative learning.

This report is driven by the mission of the 2010 Space Generation Congress' Outreach Working Group which was to break the myths regarding space in general and technical and scientific education in particular. Further, the group aimed to provide outreach recommendations from the young space generation for programmes that can increase awareness and understanding of space and make technical and scientific careers in space industry more appealing to students in both developed and developing countries. With an emphasis on breaking stereotypes, the report highlights the key challenges we face in the development of science and technology education. Moreover, it recommends a strategy with the main objective of making technical and scientific careers in the space sector more appealing. Finally, the report makes several suggestions for outreach efforts to easily reach students of all ages from different parts of the globe.

2 CURRENT STATE OF SPACE EDUCATION AND PUBLIC OUTREACH

This section highlights the current state of space education and public outreach, as well as the challenges faced by both developed and developing space-faring nations. Figure 2-1 shows the influences on today's children development and it is explained in detail in the following section.

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[33] 2010 Report from DARPA, the Pentagon's research agency and 2009 Study by researchers at Rutgers and Georgetown universities

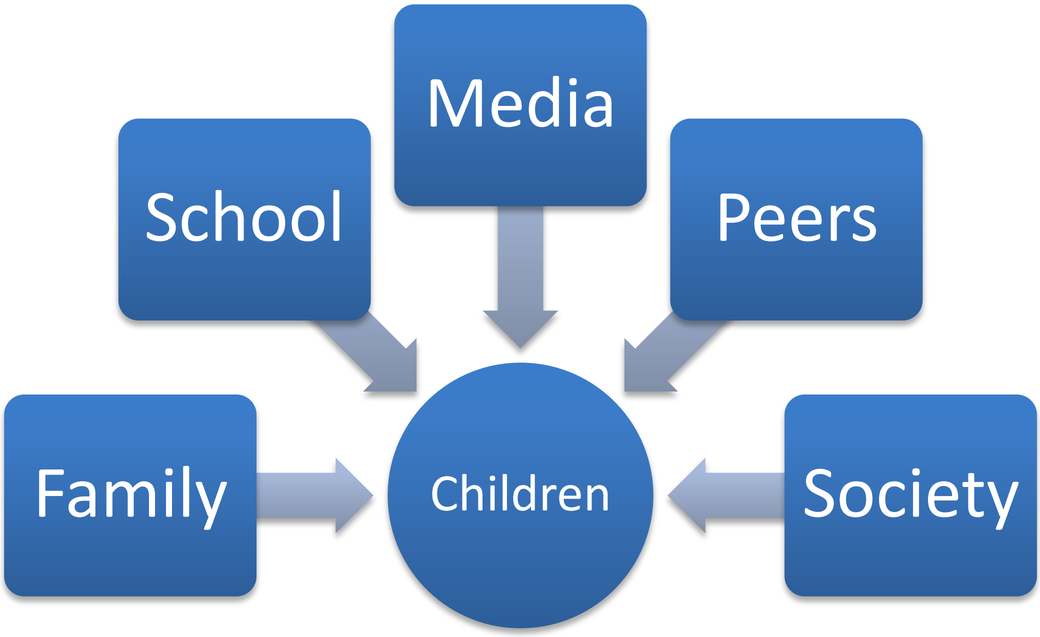

Figure 2-1: Influences on children's development.

2.1 Children's Natural Curiosity and Interest in Space are Not Cultivated

Many children that may wish to pursue their dreams of a space career grow up to lose interest in space. There are several reasons that lead to this situation. First, not many of kids study space science in school. Media products targeted at children, such as television shows, games and comics, do not approach space and technology themes. In addition, parents, educators and society in general do not encourage the young generation towards space, because they do not see it as an opportunity for a career. As a result, while children may have a natural curiosity for space, the environment in which they grow up discourages them from pursuing a career in this field.

Furthermore, STEM subjects are not emphasised in schools' curricula and teachers themselves are often not inspired or inspirational. This situation results in a lack of enthusiasm from students to study and focus on these subjects. But students spend an average of four to six hours per day at school, which makes the classroom the optimal environment to generate and cultivate enthusiasm for any field of knowledge, including STEM. Therefore, it becomes vital to have educators taking part in training programmes that provide them with the knowledge about their subjects, as well as formal and informal educational mechanisms and tools to help them share a passion for science with their students. This can make learning STEM subjects a fun adventure for students. Educational and outreach programmes that encourage participation from schools will help support the classroom experience for both teachers and students.

2.2 Stereotypes: Space is Not for Everyone

Society perpetuates stereotypes about space that influence its perception by the general public. One of the main stereotypes is that space is “rocket science”. This leads to the belief that space activities are only for only an elite group. The ever expanding activities and achievements of the private space sector are in fact evidence to the contrary. Space is becoming more accessible and benefits from its use are felt more and more by people in their daily lives around the world. Further, suborbital spaceflights and competitions like the Google Lunar X-Prize are allowing the public to be actively involved in evolving space technology.

Another stereotype associates space-related activities only with the work of scientists and engineers, leaving out a wide range of space careers available to lawyers, biologists, architects, etc. Additionally, society’s preconceived image of a space engineer or a space scientist is also out-dated. The space industry once involved mostly men, but it has evolved and expanded in scope and scale, leading women to join the space community. All these stereotypes lead to a situation where space, despite its importance for the development of society, is not treated as a priority by authorities, mass media, general public, and parents. This eventually leads to a lack in funding, education, media coverage and choices in favour of space-related careers.

2.3 Lack of Public Awareness and Positive Messaging

The lack of public awareness about the impact of space applications on our daily life leads to the perception of space being intangible. The general public links the space sector to exploration and other activities that actually happen in outer space, rather than with everyday technologies derived from space applications, such as weather forecasting and satellite global positioning systems. Therefore, journalists should provide for broader and better media coverage of “spin-off” space technologies and their benefits to people that will emphasize their immense contribution to solving the problems of the world. Such a step, if effectively executed and pursued, will bring space closer to the public, as it will show its relevance for our everyday life, as well the importance of our involvement in its further successful development. This will inevitably contribute to increasing the interest of young people for space science and technology. In addition to this issue, all members of the SGC Outreach group agreed that media coverage of space-related activities tends to focus on the negative aspects and associated costs of space missions, perpetuating the stereotypes that space is only a waste of money.

Another issue with the message about the space sector is regarding the image of the workforce. Society’s image of “success” is often associated with athletes and entertainers. The successes of scientists and engineers are often under-represented in the media. As a result, young people do not feel inspired in pursuing a career in space as they do not see the opportunities that could make them successful. The achievements of the space industry and the people behind it need to be highlighted. Scientists and engineers need to stand side-by-side with actors and sportsmen as role models to generate enthusiasm for space and inspire the next generation of explorers.

2.4 Lack of Resources and Opportunities

Training and maintenance of the workforce is a key issue in developing the future of the space industry. Employment security is rarely guaranteed, and job prospects from wealthier nations may result in "brain-drain". Additionally, an increasing number of developing space-faring nations are becoming involved in space activities, allowing these countries to enter previously not developed area of science and technology. New space-faring nations' programmes may encounter difficulties, though, in pursuing this activity, as they compete with foreign companies, receive limited funding, and often lack the necessary infrastructure. Consequently, space is often placed low on priority lists and sometimes is not even an option of programmatic development by the government and society.

Apart from actual space activities, space education itself often lacks the necessary support to provide young people with adequate education and training. Although some space agencies have limited educational and outreach programmes in their respective countries, these resources are not being widely made available in schools. Underdeveloped space-related curricula, especially prominent in developing space nations, result in a lack of understanding of and enthusiasm for space activities. Given the opportunity, students will rise to the challenge, and it is therefore necessary to work in cooperation to not only create educational opportunities, but see that they are put into practice by schools and educators.

3 PROPOSED FRAMEWORK FOR OUTREACH RECOMMENDATIONS

3.1 Strategy

The strategy identified by the SGC 2010 Outreach Working Group focused on promoting a set of outreach guidelines to dispel misconceptions, stereotypes and myths about space with the aim to raise the visibility of role models and positive beliefs about space and STEM in return.

3.2 Tactical Objectives

An important objective of outreach efforts is to inspire and engage people. The importance of space for humanity should also be presented together with the complexity and beauty of the universe.

Another important aspect to consider is how information is handled. One way to inform the youth about the range of opportunities available in the space sector is to identify and promote individual success stories so as to position prominent and worthy people involved in space activities as role models. Another approach is to connect people with these successful individuals (and their projects) in the region, and through international resources, such as social networks, make the stories broadly available.

3.3 Methods

As previously outlined, people's perceptions of space need more realism. Outreach programmes should take this into account to be successful. Children should be inspired through engagement, for example with sounding rocket launches or nano-satellite launches, among other possibilities. Another important point is that outreach programmes should be designed in such a way that they can be easily adaptable for different regions according to different cultures and geographic needs. These programmes should also be flexible, and they should focus on encouraging reuse and further improvement.

4 EXAMPLES OF EFFECTIVE SOLUTIONS

In order to tackle all of the issues raised by the SGC 2010 Outreach Working Group, several recommendations are introduced below.

Videos: space is for everyone

The SGC 2010 Outreach Working Group produced a video during SGC to serve as the starting point for effective outreach material. It can be accessed at:

http://www.youtube.com/watch?v=3w1Q1NECBEM

Figure 4-1. YouTube movie: "Space is not just rocket science"

The idea of making a video came from the fact that people are often more responsive to visuals. The proposed video shows people from various places in the world who work in different fields but have one thing in common – they all work in space sector. The most important aspect of this video is the impact factor when viewers watch real people from different countries working together. Viewers more easily can relate to them better than to politicians or celebrities.

Space as a social network

The number of social networks and their popularity are increasing today. People interested in space could stay better connected if a dedicated global community were initiated. This network, an enhanced SGAC, perhaps, will provide exchange of knowledge and solutions. It would enable people from different parts of the world to communicate and exchange ideas on space related subjects. People would also be able to find solutions to possible problems they might be having with their own space projects by turning to enthusiasts who had already done a similar project.

Furthermore, social media channels such as YouTube, Facebook or Twitter could be used as a learning channel. Since their use is fun and interesting, it reaches many people and it is also engaging and very easy to use. Furthermore, once a group of people, starts using it, it will spread fast since it is contagious and popular. For example, a "Mars Farmville" application could be developed on Facebook, challenging people to think of ways to survive on Mars.

Active training

In order to inspire teachers about space, "targeted lesson plans" should be developed so that teachers can further inspire their students. These plans should contain educational material and practical science activities. It is recommended that these lessons are planned taking into account local resources to make them feasible to implement when the teachers return to their classes.

Break myths and stereotypes about space field jobs and people who work in the space sector

First, efforts should be made to dispel the current stereotype of scientists being only nerdy. TV shows, for example, can be created to show that by scientists and engineers are in fact, cool. Secondly, more TV shows regarding science should be produced following popular formats. A current popular example is "Myth Busters". More cartoons with space themes that do not show doctors as evil or scientists as crazy should be encouraged. Furthermore, in order to break the myth that space is difficult, more practical exercises should be done for children to see that "space" is within their capabilities.

Finally, to break the myth that space is not suitable for girls, women from the space sector should give talks in schools and encourage both girls and boys to study space. Also, it would be interesting to see interviews with women who have a career in space in glossy magazines or on lifestyle websites.

Figure 4-2. Space Barbie. Credit: Mattel

A rather negative stereotype regarding the image of people from the space sector should also be changed for the better by promoting local role models that people can relate to or identify with. Outreach programmes should show that anyone could have a space career regardless of age, gender or race. They should also aim at making members of the community familiar and involved with local space heroes that can encourage and inspire others.

Media engagement

Media should be encouraged to focus on promoting the benefits of space to the general public. Local activities of people involved in space should also be brought to the attention of the journalists, by stressing their contribution to the region, as well as by encouraging a feeling of local or national pride. In order to achieve better outcomes and a higher involvement, a close relationship with relevant media representatives should be cultivated. For example, journalists could be invited to space events with their families, particularly if they have children.

Competitions

Different types of competitions can be done that can be adapted to the resources available in the specific country. The aim of these competitions would be to encourage learning and creativity through simple, but exciting activities. A competition that combines sports with technology such as Robo Cup could be an example. Another competition could have children build a spaceship with Legos.

Already recognised outreach events

Through global outreach events people that otherwise may not be interested in space could get involved and further inspired about space. Among currently global projects are Yuri's Night, the Blue Marble Project and World Space Week. These programmes have the advantage of increasing space awareness in a fun environment.

5 CALL FOR ACTION

Analysis of and debates regarding the space education issue is not enough. Keeping in mind that there are countries where space is not an even an issue on the public or political agenda, action is needed. Actions are more effective than words. This section deepens the understanding of the ways organisations can help by getting more involved in educational and outreach efforts that encourage young people to follow STEM education and careers.

5.1 SGAC Role in Promoting STEM

The creation of a permanent Outreach Working Group to promote STEM is the first recommendation of 2010 SGC Outreach Working Group. The discussion of new ideas on how to improve space education programmes will be publicised on the SGAC website and can therefore be seen and used by all the interested people all over the world. The bases of the SGAC Outreach Working Group were established during the Space Generation Congress 2010 held in Prague, Czech Republic, with a recommendation addressed to SGAC to integrate this group into its structure. The group's first objective is to work on the discussed issues during 2011 to get positive results for the upcoming Space Generation Congress 2011, Cape Town, South Africa.

The second recommendation is to develop working plans that can be used by the interested people in both developing and developed countries in order to generate new space education activities and ways of their realisation. These working plans can also be integrated into already existing space education programmes of cooperating agencies (e.g., ESA), but also possible new partners. Current and potential partners in space education could be asked for financial or promotional support to help improve space education programmes across the globe. Experts from the named cooperating organisations could be consulted for further guidance. For this purpose, contacts with them should be established and maintained.

5.2 The Role of other Agencies and Organisations

Not only SGAC, but also other agencies and organisations from the space sector should help improve space education programmes. The first step could be an update of already existing educational programmes. Ideas coming from the young generation could be useful (seen from a different point of view) for improving "old" space education programmes. Other organisations and agencies should create an archive of lessons learned from the implementation of educational programmes in order to pass the knowledge to the young generation and interested educational personnel. Teachers in schools, but also space enthusiasts, who dedicate their time to improving the public perception of space, could make good use of these already tested educational materials.

6 CONCLUSION

"We *can* do space!" – with this phrase the SGC 2010 Outreach Working Group concluded its last session at the Space Generation Congress 2010. "We have to inspire this attitude in all people out there!" was the main message.

Active and engaged discussions and debates about space education, stereotypes about space related professions, relevant differences in developing and developed countries, as well as about new ideas regarding the improvement of the current situation took place in Prague, Czech Republic. Space outreach is a complex issue that encompasses many aspects of the society, with a number of different stakeholders involved. In some countries SGAC is the only organisation where people can get information about space and space activities. The understanding of what space is and what activities it encompasses starts to change with the involvement of the Space Generation activities. People get involved in space activities on their own, for example by participating in balloon experiments or Yuri's Night all over the world. But it is still necessary to make clear that doing space is not as difficult or as exclusive as it is generally thought. Methods by which the idea that space can be accessible were discussed and developed. Based on this, a strategy and a framework for implementing outreach programmes across the world were designed with the aim to inspire students to pursue a career in a STEM-related field and particularly in the space sector. Examples included a wide range of opportunities from making space activities part of social network websites to organising workshops for teachers in schools. Emphasis on the values and benefits of space activities for developed and emerging space nations was considered to be essential.

The Outreach Group' movie "Space Is Not Just Rocket Science" was a first sign from the young generation that meaningful work can easily be done to encourage young people to become part of the big space family, not necessarily as scientists and engineers, as well as a fashion designers, lawyers, researchers and many more occupations.

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FINAL REPORT

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