SPACE SECURITY 2003
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A Research Report Prepared for the

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Preface

This discussion paper draws upon research commissioned by the International Security Research and Outreach Programme (ISROP) maintained by the Department of Foreign Affairs in cooperation with the Eisenhower Institute. The purpose of this research effort was to explore the concept of space security, but it does not attempt to establish new policies for the Department or the Government. **Thus, the views and positions stated in this paper are solely those of the contributors to this research project and are not intended to reflect the views and positions of the Department of Foreign Affairs or the Government of Canada.**

ISROP would like to express its gratitude to partners at the Eisenhower Institute: **Ms. Susan Eisenhower; Dr. Roald Sagdeev; The Honorable Thomas Graham, Jr.; Mr. Ryan McFarland; Mr. Tyler Nottberg; Mr. Andrew Park; Ms. Olga Prygoda; and Ms. Suzanne Vogel**. It would also like to thank the team of Research Associates for their leadership in developing this discussion paper: **Mr Phillip Baines, Mr. Michel Bourbonnière; Ms. Sarah Estabrooks; Ms. Theresa Hitchens; Dr. Andrew Latham; Dr. Robert Lawson, Dr. David Mutimer**; and **Mr. Gabriel Stern**. ISROP would also like to thank the team of research assistants which worked on this project: **Ms. Jessy Cowan; Dr. William Marshall; Mr. Robbie Schingler;** and **Mr. George Whitesides**. Finally, ISROP would like to thank research intern **Maciek Hawrylak**, MA student, Norman Paterson School of International Affairs, Carleton University, for his assistance. More details on the contributors to this project are included in the Annexes attached to this paper.

Introduction

Space is an environment in transition.[1] At the hands of a growing number of civil, commercial and military actors it is being transformed into a new political, economic, and military centre-of-gravity. It is home to unprecedented achievements of international scientific cooperation, and it generates tens of billions in revenues for the private sector. It also provides an unrivalled panoramic observation of and communication with any location on earth at any time in any weather—capabilities becoming increasingly essential to modern societies. Space-based assets are rapidly becoming part of our critical national and international infrastructure.

As our dependency upon space-based assets has grown, so too have legitimate concerns about the security of these assets—stimulating an important debate about the nature of space security. How can we assure the security of our space assets? How do the unique physical parameters of the space environment affect space security considerations? How are the intentions and capabilities of various space security actors affecting trends in space security? How can we most effectively balance civil, commercial and military space interests against the need to ensure that our activities in space today will not threaten our secure use of space for tomorrow? How can we be assured that space is maintained for peaceful purposes as defined by our collective obligations under the Outer Space Treaty?

The following discussion paper is motivated by these concerns, and is the product of a research partnership between the Eisenhower Institute and International Security Research and Outreach Programme (ISROP) maintained by the Department of Foreign Affairs.[2] Since December 2002, through a jointly established Space Security Working Group, ISROP and the Eisenhower Institute have undertaken a detailed examination of the concept of space security. This discussion paper provides an overview of this work, describing the two phases of this project that have been completed thus far:

> **Phase One: Defining Space Security** - The development of a working definition of space security and a set of 12 indicators of space security (December 2002-August 2003).
>
> **Phase Two: Evaluating Space Security for 2003** - An evaluation of the status of space security in 2003 using this definition and indicators to assess the utility of this research approach to inform debate on space security issues (September 2003-November 2003).

The third phase of this project, extending to June 2004, will bring the results of this research effort to the attention of a broader community of experts as a contribution to the emerging debate on space security issues, and will seek their views on ways to address space security challenges identified by this research.

Defining Space Security

The objective of the first phase of this research project (December 2002-August 2003) was the development of a working definition of space security and a set of indicators capable of providing a comprehensive vision of the key influences on space security. This work was undertaken by a Space Security Working Group (SSWG) convened by ISROP and the Eisenhower Institute.[3] Between December 2002 and March 2003, the SSWG used a Delphi research methodology[4] to develop a working definition of

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[1] 'Space' has no agreed definition in international law. For the purposes of this research , it is understood to begin at an altitude of 100km above the surface of the Earth and to mean primarily orbital space, ie the region of near-earth space above 100km that includes low earth orbit (100-1,500km) and extends to medium earth orbit (5,000-10,000km) and geo-stationary earth orbit (36,000km).

[2] The International Security Research and Outreach Programme, Global Security Bureau, Department of Foreign Affairs, Canada, and The Eisenhower Institute, Washington, DC, USA.

[3] This 18 member SSWG included individuals with a broad range of expertise on space issues: legal (4), scientific/technological (2), political/policy (7), civil/commercial (2) , and military (3) dimensions of space security relevant issues. Participants in the SSWG meeting in March 2003 are listed within Annex A.

[4] The Delphi technique is a group process which employs a mix of iterative quantitative and qualitative questionnaires designed to assess expert views in fields where no clear answers exist. In this case the technique was used in an attempt to provide greater focus of expert views on space security issues. Participants completed two sets of questionnaires, the first following the review of a discussion

space security and (initially) 17 indicators of space security. This work was reviewed by a second group of space experts in April 2003.[5]

As a new concept, there exists no broadly agreed definition of "space security" and various possible approaches were considered. In order to proceed with the research project, however, it was necessary to adopt a working definition of some kind. By August 2003 the research partners had reached agreement on the following definition of "space security" for the purposes of the study: ***Secure and sustainable access to and use of space, and freedom from space-based threats.*** The key elements of this working definition were informed by a range of considerations including consistency with relevant major international legal instruments such as the United Nations Charter, the Outer Space Treaty, the Liability Convention, and the Environmental Modification Convention. Also considered were relevant United Nations General Assembly resolutions, the laws of armed conflict as well as key elements of selected arms control and disarmament treaties.

This working definition provides a vision of space security that has proven to be useful in guiding our collective consideration of space security relevant issues. Space actors have been able to access space and use space for a wide variety of civil and military applications without having significant negative impacts on the access to and use of space by others or without importing terrestrial conflicts into space. This particular point of reference was also critical in order to seriously address the concerns some have expressed about space security, for example a growing dependency upon space assets critical to national security functions combined with a growing sense of the vulnerability of these same assets.[6]

These considerations informed the development of three types of ***space security indicators***: environmental; intentions of space security actors; and capabilities of space security actors.[7]

The Space Environment – The environmental conditions of space have a direct impact upon our secure access to and use of space. Orbital space is highly sensitive to debris. Some orbital locations with physical characteristics valuable for certain specific applications are becoming crowded. The SSWG identified two environment related space security indicators:

- **Space Debris: Production and Mitigation** – Amounts of debris at various orbits, both naturally generated and man-made. Trends related to the mitigation of the impact of space debris, including efforts to reduce the production of man-made debris, reduce existing debris and reduce the hazards which debris presents for the uses of space.

- **Space Resource Allocation** – Trends in conflict and/or cooperation in the allocation and use of orbital slots and radio frequency spectrum by space actors, including compliance with existing norms and procedures developed by the International Telecommunications Union.

The Intentions of Space Security Actors – At the national level, one indication of the intentions of space security actors can be found within national security policies and doctrines. At the international level, these indicators of intentions can often be found within each actor's record of engagement with international law and the international institutions relevant to space security issues. Intentions are relevant to space security because they provide important indicators of how actors perceive the opportunities and challenges of the space environment, as well as possible threats to their secure access to and use of that environment. The SSWG reached agreement on two indicators of the intentions of space security actors:

- **National Space Security Policies and Doctrines** – Trends in national space security policies and doctrines.

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paper and the second following the discussions at a meeting in Washington which reviewed the results of the first questionnaire. See for example Ludwig, http://www.joe.org/joe/1997october/tt2.html .

[5] A list of participants in this meeting is included as Annex B.

[6] For example, USA, "Report of the Commission to Assess National Security Space Management and Organization," June 11, 2001.

[7] By 'space security actors' or just 'actors' we mean institutions, firms or agencies which have a direct interest in space, and a potential impact on space security. While states *qua* states are the most prominent such actors, the term actor also includes, but is not limited to, civil space agencies, militaries, international organisations, and firms.

- **Legal, Normative, and Institutional Developments** – Trends in multilateral space security norms and compliance with space security relevant international legal obligations. Developments with respect to space security relevant international institutions.

The Capabilities of Space Security Actors – Capability indicators provide an evaluation of who can access and use space, and who can affect space assets from the ground. These indicators are particularly critical because they evaluate who can affect space security and how they can potentially do so. The SSWG reached agreement on eight capability indicators:

- **Space Access** – Trends in the number of actors with access to space through an indigenous launch capability or through the launch capabilities of others.

- **Civil Space Programs and Global Utilities** – Trends in civil space programs as well as the development and management of global space-based utilities (e.g. Global Positioning Systems).

- **Space Industry** – Trends in the space industry sector related to the builders and users of space hardware (e.g. rockets, satellites, etc.), information technologies (e.g. software applications), and space products (e.g. remote sensing data).

- **Space Surveillance** – Trends in capabilities to track, identify, and catalogue significant objects in earth orbit, including functional satellites and space debris.

- **Space and Terrestrial Military Operations** – Trends in the development of space-based assets providing support to terrestrial military operations, including their vulnerability to attack.

- **Space Protection** – Trends in the development of capabilities related to the protection of space assets including trends related to the research, development, testing and deployment of systems designed to protect military and non-military space assets from potential interference by others.

- **Space Negation** – Trends in the development of capabilities related to space negation, including trends related to the research, development, testing and deployment of systems designed to negate the use of space by others.

- **Space-Based Strike Weapons** – Trends in the development of operational military doctrine related to space-based weapons, including trends related to the research, development, testing and deployment of space-based weapons.

Evaluating Space Security for 2003

As noted above, the objective of the second phase of this project was to complete an evaluation of the status of space security in 2003 using our draft definition of space security and its 12 indicators to assess the utility of this research approach. Using an enhanced Delphi methodology, the Space Security Working Group (SSWG) met in Washington in late November to complete a systematic evaluation of the status of space security for 2003.[8] This was an enhanced Delphi approach in two key respects. First, like the initial phase of this project, SSWG members were asked to complete a pre-meeting questionnaire designed to evaluate their views on the space security issues. This Space Security Survey was also completed via the web by a larger group of space security experts and the results were used to inform and/or challenge the

[8] This 26 member SSWG included individuals with a broad range of expertise on space issues: legal (4), scientific/technological (4), political/policy (9), civil/commercial (4), and military (5) dimensions of space security relevant issues. A list of participants is included in Annex C.

views of the group itself.[9] Secondly, SSWG members were also provided with a series of draft 20-30 page research papers which examined each of the 12 indicators in some detail based on unclassified materials.

Following a review of the Space Security Survey results, research papers and a round-table discussion, SSWG members were asked to complete another Space Security Survey designed to assess the status of each space security indicator for 2003. At the conclusion of this process the Group reviewed these results and members were asked to provide an overall assessment of the status of space security for 2003.

Space Security 2003: Key Assessments

The following discussion paper provides an overview of the early results of this evaluation of space security for 2003 -- described within this project as ***Space Security 2003 Assessments.*** A summary of the key assessments of this discussion paper is provided within this introduction. Following the introduction this paper provides a 3-5 page summary of the key research results for each of the 12 space security indicators including: a working definition for each indicator and an analysis of how developments with respect to the indicator impact space security; a brief review of key background information and historical developments relevant to the indicator; an overview of key developments with respect to the indicator during 2003; an integrated evaluation of the status of space security for 2003 with respect to the indicator drawn from documentary research efforts as well as the quantitative and qualitative results of the two Space Security Questionnaires completed by the larger space security expert group (October 20 to November 14, 2003 and the SSWG November 24-25, 2003). Key background information for this project is attached to this paper as a series of annexes, including lists of SSWG participants and a working bibliography.

I-The Space Environment

1-Space Debris

A majority (19) of SSWG members assessed that there had been little or no effect upon space security with respect to this indicator, while 6 members of the Group assessed that space security had been somewhat enhanced with respect to this indicator during 2003. A significant number (53) of Space Security Survey respondents assessed that there had been little or no effect upon space security. A total of 24 Space Security Survey respondents that assessed space security had been somewhat enhanced, and 33 Survey respondents assessed that space security had been somewhat reduced (28) or reduced (5).

The SSWG assessed that developments with respect to this indicator were consistent with the contradictory trends of previous years. Space debris was a serious concern related to the secure and sustainable access to space -- particularly with respect to MEO and GEO. While amounts of debris continued to increase in absolute terms over 2003, the rate of this increase was declining. The UN-mandated Inter-Agency Space Debris Coordination Committee was successful in developing voluntary international guidelines for debris mitigation, which was expected to be endorsed by the UN Committee on the Peaceful Uses of Outer Space in 2004. Compliance with these voluntary guidelines remained a concern as most mitigation measures require additional fuel to maneouver satellites into graveyard orbits and/or greater launch costs associated with added weight which are significant considerations for commercial actors or newer space security actors. China's commitment to space exploration raised questions about how an enhanced Chinese space program might affect debris creation. **In view of these developments, it was assessed that there had been little or no effect upon space security during 2003 with respect to this indicator.**

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[9] An invitation to participate in this Space Security Survey was provided to over 400 individuals with expertise in the legal, scientific, technological, political, civil, commercial, and military dimensions of space security issues. Participants were asked to provide both quantitative and qualitative judgements and were assured anonymity of their responses. They were also asked to self-identify their level of expertise with respect to specific issues and, on a voluntary basis, indicate their country of origin. A total of 115 respondents completed some parts of the survey. A total of 87 respondents indicated their country of origin with a clear majority from Canada and the United States. Other countries represented were Australia, China, France, Germany, India, Japan, Netherlands, New Zealand, Poland, Russia, Sweden, Switzerland, and the United Kingdom. **[BOB TO RESPOND TO DND REQUEST FOR DETAIL]**

2-Space Resource Allocation

A majority (16) of SSWG members assessed that there had been little or no effect upon space security, six members of the Group assessed that space security had been somewhat reduced and one member of the Group assessed that space security had been somewhat enhanced with respect to this indicator for 2003. A majority (56) of Space Security Survey respondents assessed that there had been little or no effect upon space security. A total of 18 Space Security Survey respondents assessed that space security had been somewhat enhanced (16) or enhanced (2). A total of 23 of Survey respondents assessed that space security had been somewhat reduced (17) or reduced (6).

The SSWG assessed that demand for radio-frequency spectrum allocations and orbital slots in GEO continued to experience dramatic growth, largely related to competing commercial and military demands for bandwidth. However, space security stakeholders undertook important steps to address these challenges by reforming procedures within the International Telecommunications Union (ITU) for the allocation of GEO radio-frequency and orbital allocations. SSWG members and Survey respondents expressed concerns about the potential for future conflicts over space resource allocations. The US-EU dispute over Galileo spectrum allocation provided a current example of this type of conflict - although there was optimism that the parties to this dispute could find a satisfactory resolution. The Group noted that as societies become increasingly dependent upon space-based systems, thus increasing the demand for bandwidth for multiple applications, the potential for intense competition and even disputes over spectrum allocation could increase. **In view of these developments, it was assessed that there had been little or no effect upon space security during 2003 with respect to this indicator.**

II-The Intentions of Space Security Actors

3-National Space Security Policies and Military Doctrines

A significant majority (21) of the SSWG members assessed that space security had been somewhat reduced (20) or reduced (1) with respect to this indicator for 2003. A minority (4) of the Group assessed that there had been little or no effect upon space security, and 1 SSWG member assessed that space security had been somewhat enhanced. A significant majority (73) of Space Security Survey respondents also assessed that space security had been somewhat reduced (42) or reduced (31) with respect to this indicator. A minority (14) of the respondents assessed that there had been little or no effect and 15 respondents assessed that space security had been somewhat enhanced (13) or enhanced (2).

The SSWG assessed that there were contradictory indicators of the intentions of key space security actors during 2003 which raised concerns about the sustainability of space security over the longer term. Although longer-range planning documents originating within services and agencies of the US military have recommended that the US seek offensive counter-space capabilities, current official US space doctrine emphasizes reversible and non-destructive means of pursuing space control. While the announcement of the US Missile Defence Agency's intention to place on orbit a 'test bed' for space-based ballistic missile interceptors no earlier than 2012 represented a delay from previous estimates, it still raised concerns among some analysts, as did the announcement that the Indian Air Force has started conceptual work on anti-satellite weapons. Although the Indian announcement was later officially retracted, concerns remained about the intentions of these and other actors. For example, US defence officials have assessed that China was likely working on anti-satellite weapons. **Notwithstanding certain positive developments that occurred with respect to the policies and doctrines of certain states, therefore, it was assessed that space security had been somewhat reduced during 2003 with respect to this indicator.**

4-Legal, Normative, and Institutional Developments

A majority (15) of the SSWG members assessed that there had been little or no effect upon space security with respect to this indicator during 2003. A minority (6) of the SSWG assessed that space security had been somewhat reduced and 1 member of the Group assessed that space security had been somewhat enhanced. A majority (47) of Space Security Survey respondents also assessed that there had been little or no effect upon space security with respect to this indicator. A total of 32 Survey respondents assessed that space security had been somewhat reduced (22) or reduced (10). A total of 18 Survey respondents assessed that space security had been somewhat enhanced (16) or enhanced (2).

The SSWG assessed that the institutions charged with space security relevant issues such as debris, radio spectrum and orbit allocations were taking what appeared to be effective steps to deal with these challenges. The adoption of the annual UN General Assembly resolution calling for progress within the Conference on Disarmament (CD) to prevent an arms race in space provided a good indication of the continued strength of the norms supportive of the peaceful uses of outer space. However, the CD remained deadlocked throughout the year on this issue. The Chinese move within the CD to accept a compromise formulation of the mandate for an ad hoc committee on the prevention of an arms race in outer space raised hopes that work might begin on this issue within the CD in 2004. **Overall, it was assessed that there had been little or no effect upon space security during 2003 with respect to this indicator.**

III-The Capabilities of Space Security Actors

5-Space Access

A majority (16) of the SSWG members assessed that space security had been somewhat enhanced (15) or enhanced (1) with respect to this indicator during 2003. A minority (6) of the SSWG assessed that there had been little or no effect upon space security. A total of 5 SSWG members assessed that space security had been somewhat reduced (4) or reduced (1). A large proportion (38) of Space Security Survey respondents also assessed that space security had been somewhat enhanced (35) or enhanced (3) with respect to this indicator. An almost equal proportion (35) of Space Security Survey respondents assessed that space security had been somewhat reduced (31) or reduced (4) while 18 assessed that there had been little or no effect upon space security with respect to this indicator.

The SSWG assessed that China's first manned space mission and India's successful test of its GEO-launch capability suggested that space access developments during 2003 should be judged in a fairly positive light. A greater number of actors having access to space had the potential to enhance space security by providing competition, access to space for actors without a dedicated launch program and redundancy in the case of system failures. The Brazilian and U.S. civil space tragedies in 2003 underscored the risks associated with space access as well as the corresponding value of a growing diversity of space access capabilities. However, as indicated in both the quantitative and qualitative results from the Space Security Survey, there is also a level of concern that more actors with access to space could increase the threat to space assets, undermining space security over the longer term. **Overall, however, it was assessed that space security had been somewhat enhanced during 2003 with respect to this indicator.**

6-Civil Space Programs and Global Utilities

A significant number (11) of SSWG members assessed that there had been little or no effect upon space security with respect to this indicator, while eight members assessed that space security had been somewhat enhanced with respect to this indicator during 2003. A total of four SSWG members assessed that space security had been somewhat reduced. A total of 27 Space Security Survey respondents assessed that there had been little or no effect upon space security with respect to this indicator. A total of 23 Survey respondents assessed that space security had been somewhat reduced (21) or reduced (2). A total of 38 Survey respondents assessed that space security had been somewhat enhanced (33) or enhanced (5).

SSWG assessments were mixed regarding developments within this indicator and their implications for space security during 2003. The importance of international cooperation within civil space programs was underscored by developments during the year - in particular Russia's agreement to continue servicing the International Space Station following the *Columbia* tragedy. China's entry into manned space flight was also an important civil space development which appeared to stimulate the civil space activities of others. The continued dispute between Europe and the US over *Galileo* spectrum allocation was highlighted by many SSWG members and Survey respondents as a source of concern regarding global utilities. **Overall, it was assessed that there had been little or no effect upon space security during 2003 with respect to this indicator.**

7-Space Industry

A majority (15) of SSWG members assessed that there had been little or no effect upon space security with respect to this indicator, and 8 members of the Group assessed that space security had been somewhat reduced with respect to this indicator during 2003. A total of 23 Space Security Survey respondents assessed that space security had been somewhat enhanced (21) or enhanced (2) with respect to this indicator. A total of 24 Survey respondents assessed that there had been little or no effect upon space security and 37 respondents assessed that it had been somewhat reduced (29) or reduced (8).

There were somewhat mixed views within the SSWG on developments within this indicator and their implications for space security. The over-riding feature of the space industrial sector in 2003 was a ongoing economic downturn. While governments and militaries turned increasingly to commercial space services to meet their needs for space services, the space industry sector remained burdened by overcapacity. This overcapacity was viewed by some as having a negative impact on space access, and thus on space security itself. However, this overcapacity also tended to increase competitive pressures and contributed to pressures for lower space access costs. **In view of these developments, it was assessed that there was little or no effect upon space security during 2003 with respect to this indicator.**

8-Space Surveillance

A significant majority (17) of the SSWG members assessed that space security had been somewhat enhanced with respect to this indicator during 2003. A minority (4) of the Group assessed that there had been little or no effect upon space security. A significant number (37) of Space Security Survey respondents also assessed that space security had been somewhat enhanced (34) or enhanced (3) with respect to this indicator. A minority of Survey respondents assessed that space security had been somewhat reduced (15) or reduced (4). A total of 28 Survey respondents assessed that there had been little or no effect upon space security with respect to this indicator during 2003.

The SSWG assessed that space security actors have shown increased interest in and some increased capacities to support cooperative space surveillance capabilities. An experimental space-based optical sensor, in particular, suggests the potential for improvements in the capability of the U.S. Space Surveillance Network to detect smaller objects. Space surveillance capabilities were also critical to collision avoidance and protection against orbital debris. Space surveillance capabilities are generally based on dual-use technologies, and there were indications of U.S. interest in developing these technologies in support of space control and ballistic missile defence missions. The SSWG assessed that it is the positive contributions of these capabilities that, on balance, supported an increase in the transparency of space activities and efforts aimed at the management of space for peaceful purposes. **In view of these developments, it was assessed that space security had been somewhat enhanced during 2003 with respect to this indicator.**

9-Space and Terrestrial Military Operations

A significant majority (14) of the SSWG members assessed that space security had been somewhat reduced (13) or reduced (1) with respect to this indicator during 2003. A minority (4) of the group assessed that there had been little or no effect upon space security while five assessed that space security had been somewhat enhanced. A significant majority (58) of Space Security Survey respondents also assessed that space security had been somewhat reduced (37) or reduced (21) with respect to this indicator. A minority (13) of respondents assessed that there had been little or no effect upon space security, or that space security had been somewhat enhanced (13) or enhanced (4) with respect to this indicator.

During 2003, the US launched a major military campaign in Iraq that relied heavily upon the use of space-based capabilities for the purposes of force enhancement The SSWG noted that there was a widespread debate among space experts (especially within the US) regarding the effects of such growing dependence on space assets to support terrestrial military operations. While this trend clearly had positive dimensions, such as greater use of precision guided weapons, dependency on space assets also potentially increased the incentives on the part of other actors to develop capabilities to 'negate' these systems. A corresponding trend on the part of actors dependent upon space assets was to seek to protect these assets against such negation capabilities. These trends underscored the need for the careful management of the protection/negation dynamic in order to mitigate incentives to develop more destructive oriented negation capabilities such as anti-satellite weapons. Such a dynamic would have the potential to trigger an action-reaction cycle that could lead to the breaching of the normative barrier prohibiting the deployment of weapons in space, undermining the sustainability of space security over the longer term. **In view of these considerations, it was assessed that space security had been somewhat reduced during 2003 with respect to this indicator.**

10-Space Protection

A majority (15) of the SSWG members assessed that there had been little or no effect upon space security with respect to this indicator during 2003. A minority of the Group assessed that space security had been somewhat enhanced (4) or that space security had been somewhat reduced (3). A total of 27 Space Security Survey respondents assessed that there had been little or no effect upon space security during 2003. A total of 25 Survey respondents assessed that space security had been somewhat enhanced, with 17 responding that it had been somewhat reduced (17) or reduced (10). A total of 2 Survey respondents assessed that space security had been enhanced.

The SSWG assessed that key space security actors have clearly come to recognize the threats facing space systems and have started working to put protective measures in place. Balancing this move to protect government systems is the on-going inadequacy of protection measures for commercial space systems. Improved information assurance measures, electronic protection measures, increased encryption usage, and enhanced radiation hardening all add costs to space systems. Commercial providers in a competitive marketplace continue to remain reticent about paying for such additional measures. There appeared to have been no significant changes in the level of protection for commercial space systems in 2003. **In view of these developments, it was assessed that there had been little or no effect upon space security during 2003 with respect to this indicator.**

11-Space Negation

A majority (16) of the SSWG members assessed that space security had been somewhat reduced (15) or reduced (1) with respect to this indicator for 2003, with a minority (7) of the group assessing that there had been little or no effect (4) upon space security or space security had been somewhat enhanced (3). A majority (49) of Space Security Survey respondents also assessed that space security had been reduced (21) or somewhat reduced (28) with respect to this indicator, with a minority (21) of the respondents assessing that there had been little or no effect upon space security with respect to this indicator. A total of 14 respondents assessed that space security had been somewhat enhanced (11) or enhanced (3).

The SSWG expressed concerns that the jamming of navigation satellite signals during the Iraq war and the intentional interference with US satellite television signals during times other than war had helped to establish a state practice that could have a negative impact upon the sustainability of space security. Despite what appeared to be long range plans by some space actors to develop more robust space negation capabilities based on physical destruction of satellites, there was little evidence that such capabilities were being actively developed via funded programmes. A measured step was taken in 2003 by the U.S. to enhance its capabilities for space negation through the temporary and reversible effects of electronic warfare, which could be regarded more as a military force protection capability than a military force application capability. It remained to be seen, however, whether other space security actors would respond in kind, or escalate to develop capabilities for space negation predicated on the physical destruction or degradation of increasingly accessible satellites or their ground control stations. **No <u>space-based</u> negation activities occurred in 2003, but concern over possible future developments in this field led to an**

overall assessment that space security had been somewhat reduced during 2003 with respect to this indicator.

12-Space-Based Strike Weapons

A majority (13) of SSWG members assessed that space security had been somewhat reduced (12) or reduced (1) with respect to this indicator for 2003, with a significant minority (7) of the group assessing that there had been little or no effect upon space security. A majority (55) of Space Security Survey respondents also assessed that space security had been reduced (35) or somewhat reduced (20) with respect to this indicator, with a minority (15) of the respondents assessing that there had been little or no effect upon space security. A total of 8 Survey respondents assessed that space security had been somewhat enhanced (7) or enhanced (1).

The SSWG assessed that, according to available information, no Space-Based Strike Weapons (SBSW) were deployed in space during 2003, and only a few states possessed any of the key capabilities required for SBSW systems. The SSWG assessed that while space actors continued to enjoy access to and use of space for a wide variety of important functions, the sustainability of this access and the degree to which states believed they will continue to enjoy freedom from space-based threats remained an issue of significant concern for many space security actors. U.S. Missile Defence Agency plans to develop and deploy a space-based interceptor test bed by 2012, although representing a delay from previous estimates, were frequently cited in relationship to these concerns The reaction to these apparent trends by Chinese and Indian officials underscored the risk that other space security actors were beginning to assume that space would inevitably become weaponized and were beginning long term planning on this assumption. This highlighted the potential for a negative action-reaction cycle similar to those which animated arms competitions during the Cold War. **As a result, while no space-based strike weapons were deployed in place in 2003, concern over possible future developments led to an overall assessment that space security had been somewhat reduced during 2003 with respect to this indicator.**

The 2003 Space Security Assessment

Overall, the SSWG assessed that there was little or no effect upon space security related to developments with respect to 6 of the 12 indicators: Space Debris; Resource Allocation; Legal, Normative and Institutional Developments; Civil Space Programs and Global Utilities; Space Industry; and Space Protection. The SSWG assessed that there were two indicators where developments had somewhat enhanced space security: Space Access; and Space Surveillance. The SSWG assessed that there were four indicators where developments had somewhat reduced space security: National Space Security Policies and Doctrines; Space and Terrestrial Military Operations; Space Negation; and Space-Based Strike Weapons.

In view of developments related to these 12 indicators of space security and corresponding assessments of the impact of these developments upon space security, a significant majority (19) of the SSWG assessed that space security had been somewhat reduced during 2003. A total of 3 SSWG members assessed that there had been little or no effect upon space security with respect to these indicators during 2003.

Next Steps

The discussion paper seeks the views of others on the utility of this research approach to inform debate on space security issues. Your comments are welcome. This discussion paper and the completed research papers examining developments with respect to each of the 12 indicators of space security will be reviewed by a group of senior space experts in early May 2004. The final draft of this study will be published by July 2004.

I- THE SPACE ENVIRONMENT

1- SPACE DEBRIS: PRODUCTION AND MITIGATION

Introduction

The term "space debris" refers to both naturally-occurring orbital objects, and man-made ones such as non-functional spacecraft and related components and fragments that have increasingly populated near-Earth space since the dawn of the space age. All space missions inevitably involve the creation of space debris – booster stages are expended, exhaust products are created and paint is chipped. Factors that affect debris production include the number of satellites launched into orbit or actually on orbit every year, and the degree to which steps were taken to mitigate the debris caused by these launches and satellite activities. The possible future testing or use of kinetic energy anti-satellite weapons also raises significant debris concerns.

Even tiny fragments of space debris can harm operational spacecraft due to the high relative velocities of on-orbit collision. Thus space debris potentially threatens the secure access to and use of space. For example, Dr. Sally Ride has recounted how during her first mission, the Challenger Space Shuttle's windshield was pitted by what was later determined to be a fleck of paint smaller than 1 mm.[10] Indeed, NASA has to replace one or two Space Shuttle windows after each mission due to damage by small pieces of debris.[11] This indicator assesses two space debris trends related to space security consideration. First, developments which have increased or seem likely to increase the amount of debris in orbital space. Secondly, those developments which have tended to reduce either the amount of debris or the impact that it is having on the secure and sustainable access to and use of space.

Background

The U.S. Air Force has been tracking space objects since 1957, and since that time has registered more than 27,000 objects orbiting Earth.[12] There are only two monitoring systems today that are capable of reliably registering space objects: the U.S. Space Surveillance Network (SSN), operated by the U.S. Air Force, and the Russian Space Surveillance System (SSS). Almost all space agencies have debris units which focus on mitigation or tracking efforts. Experts note that it has been the debris mitigation efforts by the major space powers, particularly the militaries of the United States and Russia, that have helped prevent the emergence of a serious debris problem. Since 2001, the Inter-Agency Space Debris Coordination Committee (IADC), mandated by the U.N. Committee on the Peaceful Uses of Outer Space (COPUOS), has acted as the central body for the development of a set of voluntary international guidelines on debris mitigation. Members of IADC include the space agencies from Canada, China, France, Germany, India, Italy, Japan, Russia, Ukraine, the United Kingdom, the United States and the European Space Agency (ESA).

As early as the 1970s, space scientists began predicting (via observations and modeling) that the growth of orbital debris would increase the threat of damage to working satellites unless steps were taken to mitigate its creation. As concerns have grown about debris, space agencies and the space industry have increasingly focussed on mitigation efforts. Discussions among space agencies began in the 1980s, and since then many of the space-faring countries have developed debris mitigation guidelines. Although there has been a nearly steady annual growth of catalogued debris, that growth has been observed to be levelling off since the mid-1990s.[13] According to the web site of NASA's Orbital Debris Program, Low Earth Orbit is the area most heavily populated with debris.[14] However, debris at this orbit (especially below 800 km)

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[10] Dawn Levy, "Sally Ride Speaks On The Tactical Role Of Space And War," *Spacedaily.com*, 22 April 2002, http://www.spacedaily.com/news/milspace-02n.html

[11] Nicholas L. Johnson, "Space Debris, It's [sic] Causes and Management," presentation to Congress in Washington, D.C., sponsored by Rep. Adam Schiff, D-Calif., and organized by the Monterey Institute of International Studies, 24 July 2002.

[12] U.S. Strategic Command (STRATCOM) Fact Sheet, "Space Control: Reentry Assessment and Space Surveillance," U.S. Strategic Command Public Affairs, Offutt Air Force Base, STRATCOM website, http://www.stratcom.af.mil/factsheetshtml/reentryassessment.htm (last updated September 2002); latest data for July 2003 provided by a NASA official in August 2003.

[13] Johnson.

[14] http://sn-callisto.jsc.nasa.gov/photogallery/beehives.html#leo .

over time will fall back to Earth due to atmospheric drag and atmospheric heating caused by the 11-year solar cycle – although how quickly debris will leave LEO is hard to predict as it relies on numerous factors including mass, exact altitude, its cross section, atmospheric density and the strength of solar maximums.[15]

In recent years, the developed space powers have recognized the problem of space debris and taken technical and operational measures to mitigate its creation. However, the launch and commercial industries continue to present a challenge to reduction efforts despite the fact that the number of commercial orders has gone down,[16] and launch rates are at historically low levels.[17] At the same time, the number of space-faring nations has increased, while many other countries now own satellites purchased and launched from foreign providers. In 2001, COPUOS asked the IADC to develop and submit a set of voluntary international guidelines for debris mitigation. Those guidelines, submitted in November 2002 and expected to be endorsed by COPUOS in 2004, address debris production during normal space operations, the minimization of the potential for on-orbit break-ups, post-mission disposal and the prevention of collisions.

A combination of existing voluntary debris mitigation practices and the normal rates of debris re-entry at lower altitudes is helping to reduce the rate of annual growth in the debris population. However, some experts are concerned that the new IADC guidelines will be unable to prevent future growth in space debris populations. Given that most debris mitigation measures involve the use of valuable fuel for transfer to graveyard orbits, and/or an increase in launch costs associated with added weight, critics argue that commercial sectors will be unlikely to follow these profit-reducing guidelines if their competitors are not required to do the same. Further, it has become apparent in IADC-related discussions that the less affluent, emerging space powers may view the requirements as a barrier to competing in the global launch market.

Detecting, tracking and cataloging debris long has been, and today remains, a major challenge. Although capabilities and technology have improved over the past several decades, better measurements will be required to accurately predict collision potentials. Both the U.S. SSN and the Russian SSS have gaps, making accurate collision prediction in near-real time impossible. However, an enormous amount of ongoing research is aimed at improving space monitoring and tracking.

A future factor that could affect the population of space debris is the possibility that space may become weaponized. In particular, the testing or use of anti-satellite weapons (ASATs) using kinetic-kill vehicles could result in "a significant amount of debris."[18] Already, the U.S. Missile Defense Agency has implicitly recognized the possible debris problem by conducting tests of Ground-Based Missile defenses in a manner so as to limit debris creation.

While debris growth levels have tapered off in recent years, it is unclear that emerging space powers have yet learned the lessons of the past. Efforts to establish standard mitigation practices by the international community, under IADC and COPUOS, are to be welcomed – but many debris experts are convinced that such voluntary standards eventually will have to be replaced with legal or regulatory regimes. Indeed, as competition in the space launch business heats up – which is inevitable in the short term as new launching states enter the already overcapacity market – incentives to ignore practices that will require even modest extra expenditures may actually increase.

With regards to the growth in the number of satellites and the number of space-faring countries, the current trends are somewhat contradictory. The lull in the number of commercial launches over the past several years has also helped lower the growth rate of debris. Some nations also are considering development of kinetic energy weapons, the use of which would create large quantities of space debris that could seriously threaten satellites in nearby orbits. In addition, the ability to detect and track space debris to the precision necessary to predict possible collisions in a timely manner does not currently exist, though it appears that serious efforts to rectify this situation are being undertaken.

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[15] Orbital Debris: A Technical Assessment, National Research Council (National Academy Press, Washington, D.C., 1995), 27-28.
[16] Barnaby J. Feder, "Rebuilding Effort Could Help Space Industry in Long Run," *The New York Times*, 5 February 2003, A20.
[17] Data provided by a NASA official, August 2003.
[18] Daniel Gonzales, "The Changing Role of the U.S. Military in Space," Project Air Force, RAND, Santa Monica, Calif., 1999, 37.

2003 Developments

Developments in 2003 were consistent with the contradictory trends of the last several years. As mentioned above, these include a continued slump in the commercial marketplace, continued efforts to put in place voluntary mitigation guidelines and improve tracking, and continued movement by nations to explore new activities in space. One particularly interesting development was the entry of China into the exclusive club of countries with a manned space program, coupled with China's commitment to future space exploration; thus raising the question of how such a routine Chinese program might affect debris creation.

Space Security 2003: Key Assessments

Space Security Survey (October 20 to November 14, 2003)	Space Security Working Group (November 24-25, 2003)
Question: Taking into account your views on the effect of both production and mitigation of space debris in the past year, how have overall changes in this area affected space security?	*Question: In your view, space security with respect to this indicator has been?*
Enhanced : 0 Somewhat enhanced : 24 Little or no effect : 53 Somewhat reduced : 28 Reduced : 5	Enhanced : 0 Somewhat enhanced : 6 Little or no effect : 19 Somewhat reduced : 0 Reduced : 0

The SSWG assessed that developments with respect to this indicator were consistent with the contradictory trends of previous years. Space debris was a serious concern related to the secure and sustainable access to space -- particularly with respect to MEO and GEO. While amounts of debris continued to increase in absolute terms over 2003, the rate of this increase was declining. The UN-mandated Inter-Agency Space Debris Coordination Committee was successful in developing voluntary international guidelines for debris mitigation, which were expected to be endorsed by the COPUOS in 2004. Compliance with these voluntary guidelines remained a concern, as most mitigation measures require additional fuel to maneouver satellites into graveyard orbits and/or greater launch costs associated with added weight, which are significant considerations for commercial actors or newer space security actors. China's commitment to space exploration raised questions about how an enhanced Chinese space program might affect debris creation. **In view of these developments, it was assessed that there had been little or no effect upon space security during 2003 with respect to this indicator.**

2- SPACE RESOURCE ALLOCATION

Introduction

This indicator assesses trends in conflict and/or cooperation in the allocation and use of orbital slots and radio frequency spectrum by space actors, including compliance with existing norms and procedures developed by the International Telecommunications Union (ITU). The usefulness of satellites for both commercial activities and military operations is predicated on two major factors: the radio-frequency spectrum being used to transmit and broadcast signals (both for communications and for satellite operations themselves) and the orbital position being occupied. Both are what in the environmental arena would be termed "limited natural resources." Since space is considered, under the Outer Space Treaty, as open to everyone and belonging to no one, issues of how to allocate usage of these two "limited resources" have to be negotiated among space-faring powers.

While the RF spectrum runs from about 3 kilohertz to 300 gigahertz, most communications falls below 60 gigahertz because of the power requirements, costs and technology limitations for communications at higher frequencies. Therefore, users are competing for a relatively small portion of the spectrum – with demand greatest for spectrum under 3 gigahertz. However, much of this is already in use.

There are an estimated 620-plus operational satellites in orbit: about 270 in Low Earth Orbit (LEO), slightly more than 300 in Geosynchronous Orbits (GEO); and up to 50 in Medium Earth Orbit (MEO)[19] – although exact numbers are impossible to quantify due to the classified nature of many military satellites and the non-existence of any centralized tracking system for commercial and civil satellites.[20] Over the past two decades, demand for access to spectrum – and in particular for GEO orbits most used by communications and broadcasting satellites has skyrocketed – thus raising issues for their future secure use. Further, due to this scarcity, the greater the secure use and access of one actor to these resources, the less that use and access is available to others.

Background

The advent of space communications in 1963 began a major revolution in the telecommunications industry. And with the rapid technology development in the computer world over the past 20 years, satellites have become necessary for much of everyday life, especially in the developed world. TV, the Internet, ATM machines, phone service, credit card validation, weather prediction, mapping, natural disaster monitoring, and urban planning: all of these systems – and many more – rely on the use of satellites.

The ITU, under the auspices of the United Nations, has been coordinating space radio-communications and managing satellite spectrum and slot allocation since 1963. The ITU processes govern what portions of the spectrum (i.e. frequency ranges) may be used by different types of systems with signals that cross borders, no matter if those systems are on the ground, in the air, at sea or in any orbital plane – with the exception that nations may exempt military uses. The ITU "registration" process under which the body approves access to RF spectrum is especially important in GEO, where there are only so many positions, or "orbital slots" that satellites can usefully occupy to provide communications or broadcast services over particular spots on the Earth's surface. The ITU is open to governments, as well as private industry and groups who may participate in ITU activities but do not have voting rights.[21] There currently are 193 member states and about 400 sector members.[22] The ITU, however, has no enforcement powers – member states chose voluntarily to abide by ITU rules and regulations. Indeed, as noted above, members states may decline to abide by the rules for national defense reasons.[23] However, by signing the convention, members agree to resolve any conflicts about spectrum usage in good faith.

Concerns about spectrum interference and orbital crowding are most serious in GEO, since that is where most commercial communications satellites reside. Furthermore, GEO is rapidly becoming crowded; based on open-source estimates, there already are somewhere between 230 and 270 commercial communications satellites alone in GEO.[24] Requests to the ITU for satellites operating at the 7-8 GHz band commonly used by GEO satellites have been growing rapidly over the past two decades,[25] and are expected to continue to do so. In particular, U.S. military needs for bandwidth are growing rapidly.[26]

2003 Developments

Spectrum access has become a major issue in the United States in particular as military, government, commercial and consumer interests compete. Specific frequencies in the ultra-high frequency,

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[19] "Weaponization vs. Militarization of Space," Alvin M. Saperstein, *Forum on Physics and Society of the American Physical Society*, July 2002; http://www.aps.org/units/fps/newsletters/2002/july/saperstein.pdf.

[20] U.S. government officials, for example, unofficially estimate that, at the end of 2003, there were about 700 commercial, civil and classified military satellites world wide still in operation.

[21] "ITU Overview – History," International Telecommunications Union (ITU) website, http://www.itu.int/aboutitu/overview/history.html (last updated 13 February 2002).

[22] "NTIA Manual," Chapter 3, sections 3.1-3.2.4.

[23] Albert "Buzz" Merrill and Marsha Weiskopf, "Critical Issues in Spectrum Management for Defense Space Issues," *Crosslink: The Aerospace Corporation magazine of advances in aerospace technology*, Winter 2002, http://www.aero.org/publications/crosslink/winter2002/02.html.

[24] Saperstein; "Satellite Industry Overview," 2002, Satellite Industry Association, Washington, D.C., and the Satellite Broadcasting and Communications Association, Alexandria, Va., 14, http://www.sia.org/industry_overview/USTRSat101.pdf

[25] Merrill and Weiskopf.

[26] Warren Ferster, "Military Bandwidth Demand Energizes Market," *Space News*, 25 August 2003, Vol. 14, No. 33, 1.

X-band, and Ka-bands are reserved for U.S. military use,[27] but in recent years, commercial firms have been agitating for access to portions of this reserved spectrum.[28] They argue that failing to allow certain U.S. companies access to portions of the spectrum that are available to their competitors in Europe puts U.S. firms at a competitive disadvantage.[29] Solutions negotiated through the complex U.S. regulatory structure are often taken by Washington to the ITU, in hopes of persuading other nations to follow the same course; the U.S. military operates all over the world and can be affected by other nations' decisions on spectrum usage.

Perhaps one of the most serious disputes in recent years regarding spectrum usage has been the one between the U.S. and the E.U. over the planned EU *Galileo* satellite navigation system.[30] The U.S. military has been concerned that *Galileo* will interfere with future U.S. military operations relying on the planned upgrade of the U.S. Global Positioning System. The two sides reached a partial accord on July 4, 2003, on the outlines of a technical agreement on how to allow *Galileo* to use the same 1,164-1,215 MHz band as GPS.[31] There was also an agreement during 2003 on a new technical standard for managing interference between national assets and other services such as aeronautical radio navigation.[32] These developments suggest a positive trend in this aspect of the indicator.

A satellite's orbital slot determines what services it can best provide where on the globe. As more countries have entered, or plan to enter, the satellite market, competition for the best slots in GEO – especially for communications (both mobile and fixed) and broadcast – has heated up. As satellites can provide a variety of services that can aid in a country's development (such as remote sensing, weather forecasting and telecommunications), it is reasonable to assume that over time more countries will be interested in obtaining their own. And while most countries have continued to play by ITU rules, there are some signs of discontent – especially among developing countries and in the hot Asian market. There also have been active disputes over slot ownership, and experts expect more challenges in this area.

Part of the issue is the subject of "paper satellites"; i.e., satellite approval requests submitted to the ITU in order for the applicant to either hold open a slot and a frequency allocation for future use, or for leasing to others. This massive overfilling is due to a number of factors, including the realization of the growing economic value of the scarce spectrum and orbital resources.[33] This abuse of the process blocks legitimate users from access. Recognizing the problem, the ITU Radiocommunication Bureau in 2002 proposed an increase in the fee for application, more stringent requirements for information on a system's plan for operations, and penalties for not meeting ITU deadlines.[34] These rules were accepted and were implemented in August 2003.[35]

Despite the recent "dot.com bust," the information revolution of the past few decades has led inevitably to a crunch in the availability of bandwidth for both commercial and military communications. Similarly, the growing number of players in the satellite communications market has led to more competition and friction over orbital slot allocations, both in national processes and in the ITU. Perhaps most worryingly, both issues are highly political – as well as technically difficult – making any conflicts that arise quite difficult to resolve. While the ITU is working on improving its procedures, the lack of enforcement powers is a weakness in the RF and slot allocation system. At the same time, there are strong incentives for space users to cooperate in spectrum usage and slot allocation – if only to protect the functionality of their own assets. Further, there are positive signs that the international telecommunications

[27] Tim Bonds, Michael Mattock, Thomas Hamilton, Carl Rhodes, Michael Scheiern, Phillip Feldman, David Frelinger, Robert Uy, "Employing Commercial Satellite Communications: Wideband Investment Options for DoD," Project Air Force, RAND, Santa Monica, Calif., 2000, 14-15, http://www.rand.org/publications/MR/MR1192/.

[28] Mark Selinger, "Rumsfeld, Shelton seek comparable replacement for spectrum band," *Aerospace Daily*, (date unknown).

[29] Ibid.

[30] U.S. Mission to the European Union Press Release, "NATO's Bell Discusses GPS and Galileo Security Issues," 19 June 2002.

[31] "First Galileo-GPS Pact," *Intelligence Online*, 18 July 2003.

[32] "WRC Approves GPS-Related Rules," *GPS World*, 1 August 2003.

[33] Fred Donovan, "ITU Satellite Reforms Badly Needed, Experts Say," 3 July 2002.

[34] Donovan, "ITU Tries to Tame Paper Tigers."

[35] "Report on WRC-03 (Geneva, 9 June-4 July 2003)," 29 July 2003, 15, European Radiocommunications Office web site, http://www.ero.dk/wrc-03.

community is increasingly focused on potential long-term problems and working to develop technical, operational and process-oriented methods of avoiding them.

Space Security 2003: Key Assessments

Space Security Survey (October 20 to November 14, 2003)	Space Security Working Group (November 24-25, 2003)
Question: Taking into account your views on developments on both the allocation of orbital positions and radio frequencies in the past year, how have overall changes in this area affected space security?	*Question: In your view, space security with respect to this indicator has been?*
Enhanced : 2 Somewhat enhanced : 16 Little or no effect : 56 Somewhat reduced : 17 Reduced : 6	Enhanced : 0 Somewhat enhanced : 1 Little or no effect : 16 Somewhat reduced : 6 Reduced : 0

The SSWG assessed that demand for radio-frequency spectrum allocations and orbital slots in GEO continued to experience dramatic growth, largely related to competing demands for bandwidth. However, space security stakeholders have taken important steps to address these challenges by reforming procedures within the ITU for the allocation of GEO radio-frequency and orbital allocations. SSWG members and Survey respondents expressed concerns about the potential for future conflicts over space resource allocations. The US-EU dispute over *Galileo* spectrum allocation provided a current example of this type of conflict – although there was optimism that the parties to this dispute could find a satisfactory resolution. The Group noted that as societies became increasingly dependent upon space-based systems, thus increasing the demand for bandwidth for multiple applications, the potential for intense competition and over spectrum allocation could increase. **In view of these developments, it was assessed that there had been little or no effect upon space security during 2003 with respect to this indicator.**

II- THE INTENTIONS OF SPACE SECURITY ACTORS

3- NATIONAL SPACE SECURITY POLICIES AND DOCTRINES

Introduction

This indicator assesses trends in national space security relevant policies and doctrines. This includes authoritative policy statements regarding the intentions of space actors with respect to the access to and use of space by themselves and others. These policies set the operational context within which national civil, militaries and commercial space security relevant actors operate. Doctrines translate these policy objectives into space-security objectives, plans, programs, funding and capabilities with ability to affect space security. Broadly speaking, developments related to national policies and doctrines can be said to enhance space security when they facilitate secure and sustainable access to and uses of space and work to prevent space becoming the source of direct security threats. Developments related to national policies and doctrines can be said to reduce space security when they facilitate unsustainable forms of access to and uses of space or the development of space systems which are the source of security threats.

Background

The space policies and doctrines of space-faring states are remarkably consistent in terms of their underlying rationales and commitments. Almost all space-faring countries, for example, explicitly support the principles of peaceful and equitable use of space. Similarly, almost all make explicit reference to the goals of using space to promote national economic, social, scientific and technological development.[36] Beyond these general principles, a number of states make public their specific space objectives, for example, the objective of developing indigenous launch, remote sensing or telecommunications capabilities.[37] Some space-faring nations also have military space doctrines that establish objectives related to the development of specific space applications such as navigation, communications, intelligence, surveillance, reconnaissance, and meteorology. A strong majority of states supports the annual UN General Assembly resolution on the *Prevention of an arms race in outer space* that, inter alia, recognises that negotiations for the conclusion of an international agreement or agreements to prevent such an arms race remains a priority task for the Conference on Disarmament.[38]

The policies and doctrines of two key space-faring nations, however, go beyond this pattern in ways that are significant to space security. U.S. space policy and doctrine, while broadly consistent with those of other space-faring nations,[39] reflects a growing interest in 'space control,' the ability to ensure "freedom of action in space for friendly forces while, when directed, denying it to an adversary."[40] The roots of this interest can be traced to perceptions of the vulnerability of US space assets. For example, the 2001 Space Commission (established by the US Government although not charged with establishing official Government policy) argued that if the U.S. is "to avoid a 'Space Pearl Harbour' it needs to take seriously the possibility of an attack on U.S. space systems."[41] US space policy and doctrine is also informed by growing concerns that the US is vulnerable to ballistic missile attack.

This sense of vulnerability has fuelled an active debate regarding the best way to assure the security of U.S. space assets. Some advocate the development of robust space control capabilities – including enhanced protection, active defence systems, and space-based counter-space weapons.[42] Others advocate enhanced protection and similar measures, but oppose the deployment of weapons in space. There is also an ongoing debate regarding how best to defend the U.S. against ballistic missile attack, with some supporting a limited system of ground and sea-based interceptors, and others a more ambitious system

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[36] For a representative sample of policy statements see Brazil (http://www.inpe.br/english/about_inpe/mission.htm); the United Kingdom (www.bnsc.gov.uk); India (http://www.isro.org); and China (http://www.cnsa.gov.cn/fg_e.htm).
[37] See, for example, *White Paper: China's Space Activities*, available at http://www.cnsa.gov.cn/fg_e.htm.
[38] See discussion of the annual UNGA resolution on the Prevention of An Arms Race in Outer Space within the Legal, Normative and Institutional Developments indicator.
[39] See the 1996 *National Space Policy*, available at http://www.ostp.gov/NSTC/html/fs/fs-5.html.
[40] *Joint Publication 3-14: Joint Doctrine for Space Operations*, (9 August 2002), p. IV-5.
[41] *Report of the Commission to Assess United States National Security Space Management and Organization*, 2001, pp. viii-ix.
[42] For a discussion of the spectrum of views regarding space weapons see Peter L. Hays, "Current and Future Military Uses of Space". Available at http://www.unidir.org/bdd/fiche-article.php?ref_article=1989 .

including ground, sea, air and space-based interceptors. Despite concerns in some quarters regarding the dramatic picture of future space operations painted in documents like the USAF *Vision 2020* (1997) and the *Long Range Plan* (1998),[43] US military space doctrine has remained focused primarily on force enhancement as reflected the 1999 Department of Defense *Space Policy Update*.[44] The authoritative statement of joint doctrine, *Joint Publication 3-14*, also reflected a continuing emphasis on traditional force enhancement or combat support operations. With respect to space control, *Joint Publication 3-14* clearly emphasizes reversible and non-destructive approaches.[45]

A number of other states are also creating or elaborating space security policies and doctrines although, in most cases, open source material is nowhere near as easily obtained as for the parallel US developments. One example is China, whose space policy appears to be broadly consistent with those of other space-faring nations,[46] China appears to have grown increasingly concerned about America's space-based force-enhancement capabilities, its plans for space-based missile defences, as well as what they perceive to be an aggressive pursuit of space dominance and space control by the U.S.[47] The official Chinese position is that space security will be undermined rather than enhanced by the weaponization of space, and thus it has proposed a multilateral treaty banning all weapons in space.[48] Given China's preference for secrecy in matters of national security, it is difficult to determine precisely the nature of its military space doctrine in this regard. Some observers have argued that space is becoming a central focus of Chinese strategic thinking and that it is working to develop robust space-control capabilities, including anti-satellite systems.[49] Official U.S. documents have expressed concerns at what appear to be Chinese intentions to 'concentrate on intensifying research of the key technologies in anti-satellite weapons that attack ground and space bases (especially ground bases), and as quickly as possible develop one or two anti-satellite weapons that are useful as a deterrent against enemy space systems, in order to gain the initiative in future wars.'[50] Others have assessed that while basic research on anti-satellite technologies has been underway in China since the 1980s, evidence of China's commitment to developing an operational ASAT capability remains 'ambiguous' and "serious questions remain about their technical capability and political will to undertake such a costly program''.[51] What both camps seem to agree on is that China has the ability to develop basic space negation capabilities and that the Chinese military leadership understands the important role such a capability would play in any military confrontation with the U.S. or its allies.

2003 Developments

The U.S. Department of Defense budget for FY04 contained a number of space control items with potential implications for space security. The Pentagon's funding requests for space control efforts ($321m in 2004 and $2.8b in FY 2004-2009) were mostly being sought to support projects related to space situational awareness and to ground-based, non-destructive space negation capabilities. (See discussion within the space negation indicator). The US Missile Defense Agency requested US$14m for FY04 to support the development of missile interceptors for a space-based test-bed, although the projected date for this deployment was later delayed (see also discussion within the space-based strike weapons indicator).

In October, India's Air Chief announced that the Indian Air Force had started conceptual work on space weapons (see discussion within the space-based strike weapons indicator). Although the Air Chief retracted this statement, asserting that India's use of space for military purposes would be limited to force

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[43] *Vision 2020* and the *Long Range Plan* are available at http://www.fas.org/spp/military/docops/usspace.
[44] Available at http://www.fas.org/spp/military/docops/defense/dodspcpolicy99.pdf
[45] US DoD, *Joint Publication 3-14: Joint Doctrine for Space Operations*, 2002. Available at http://www.fas.org/spp/military/docops/defense/JP3-14Excerpt.htm
[46] See *White Paper: China's Space Activities*, op. cit.
[47] For a discussion, see William C. Martel and Toshi Yoshihara, "Averting a Sino-US Space Race", *Washington Quarterly* (Autumn 2003), pp. 19-35.
[48] See the Chinese working paper "Possible Elements of the Future International Legal instrument on the Prevention of the Weaponization of Outer Space", CD document CD/1645 of 6 June 2001; and "Russia-China CD Working Paper on New Space Treaty", CD document CD/1679 of 28 June 2002.
[49] For an extended statement of this case see Larry M. Wortzel, "China and the Battlefield in Space." Available at http://www.heritage.org/Research/AsiaandthePacific/wm346.cfm
[50] Report to Congress Pursuant to the FY2000 National Defense Authorization Act: 'Annual Report on the Military Power of the Peoples' Republic of China'. Available at http://www.fas.org/nuke/guide/china/dod-2003.pdf
[51] Phillip Saunders, et al., "China's Space Capabilities and the Strategic Logic of Anti-Satellite Weapons." P. 6. Available at http://cns.miis.edu/pubs/week/020722.htm

enhancement, this event raised concerns that other nations might be considering a policy of hedging against the growing space power of potential adversaries by developing space weapons.[52] Also of note in 2003 was the release of the European Union Green and White Papers on Space Policy which provided details on the European Union's intentions to use space to achieve economic and political objectives as well as to provide increased capacities to use space to support terrestrial military operations.[53]

Space Security 2003: Key Assessments

Space Security Survey (October 20 to November 14, 2003)	Space Security Working Group (November 24-25, 2003)
Question: Taking into account your views on developments in both policies/doctrine and budgets in the past year, how have overall changes in this area affected space security?	*Question: In your view, Space Security with respect to this indicator has been?*
Enhanced : 2 Somewhat enhanced : 13 Little or no effect : 14 Somewhat reduced : 42 Reduced : 31	Enhanced : 0 Somewhat enhanced : 1 Little or no effect : 4 Somewhat reduced : 20 Reduced : 1

The SSWG assessed that there were contradictory indicators of the intentions of key space security actors during 2003 which raised concerns about the sustainability of space security over the longer term. Although longer-range planning documents originating within services and agencies of the US military have recommended that the US seek offensive counter-space capabilities, current official US space doctrine emphasizes reversible and non-destructive means of pursuing space control. The announcement of the US Missile Defence Agency's intention to place on orbit a 'test bed' for space-based ballistic missile interceptors no earlier than 2012 represented a delay from previous estimates, it still raised concerns among some analysts, as did the announcement that the Indian Air Force has started conceptual work on anti-satellite weapons. Although the Indian announcement was later officially retracted, and the timelines later extended for the MDA space-based interceptor test bed, concerns remained about the intentions of these and other actors. For example, US defence officials have assessed that China is likely working on anti-satellite weapons. **Notwithstanding positive developments that occurred with respect to the policies and doctrines of certain states, therefore, it was assessed that space security had been somewhat reduced during 2003 with respect to this indicator.**

4- LEGAL, NORMATIVE, AND INSTITUTIONAL DEVELOPMENTS

Introduction

This indicator examines trends in legal, normative and institutional developments that are assessed to be relevant to space security considerations. The intentions of space security actors are very often shaped and/or framed by these legal and normative regimes. For example, the Outer Space Treaty establishes that the uses of outer space be confined to "peaceful purposes." A number of developments within international institutions such as the UN International Telecommunications Union (ITU) and the Conference on Disarmament (CD) are also relevant to space security considerations since they are the mechanism through which space security actors attempt to resolve perceived challenges to space security.

Background

Major legal instruments relevant to this indicator are numerous. First and most importantly, there is the Charter of the United Nations, which establishes the objective of peaceful relations between state actors including their interactions within space. Article 2(4) of the UN Charter prohibits the threat or use of force within international relations, while Article 51 codifies the right of self-defense in cases of aggression

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[52] PTI, 'IAF enter space age, starts work on laser weapons, killer satellites,' Oct. 6, 2003, http://newindiapress.com/news.asp?id=IEL20031006070831.

[53] EU, *Space: A New European Frontier for an Expanding Union* (Brussels, 2003).

involving the illegal use of force by another state(s). There are also a number of key space-specific treaties, including the 1967 Outer Space Treaty,[54] the Rescue Agreement,[55] the Liability Convention,[56] and the 1979 Moon Agreement.[57] These treaties establish the fundamental rights of access to space as well as state responsibility regarding space activities. They also remove space from national appropriation and prohibit certain space military activities, such as the placing in orbit of objects carrying nuclear weapons.

Another group of legal instruments are relevant to space security because they were created to provide predictability and transparency in the peacetime use and testing of weapons that either travel through space or can be used in space. These instruments include, for example, the 1973 Hotline Modernization Agreement[58] and the 2000 U.S.-Russian Joint Early Warning Center agreement. Other military peacetime treaties are concerned with the regulation of weapons with potential space applications, for example, the 1963 Partial Test Ban Treaty, the 1972 Biological and Toxins Convention, the 1970 Nuclear Non-Proliferation Treaty and the 1992 Chemical Weapons Convention. The demise of the 1972 Anti-Ballistic Missile Treaty in 2002 eliminated an explicit prohibition on the stationing of ballistic missile interceptors in outer space by the U.S., Russia and other U.S.S.R. successor states.

There are also instruments which regulate the international trade in launch services or related technology, including a range of bilateral agreements signed between the U.S. and either the Russian Federation, China, or Ukraine. This category also includes the Missile Technology Control Regime (MTCR), an association of states which share the goals of the non-proliferation of unmanned delivery systems for weapons of mass destruction, and coordinate national export licensing efforts aimed at preventing their proliferation.[59]

The treaties which have an impact on space security during times of armed conflict include the corpus of international humanitarian law composed primarily of The Hague and Geneva Conventions, also known as the law of armed conflict. These treaties regulate the means and methods of warfare. Through the concepts of *proportionality* and *distinction* they restrict the application of military force to legitimate military targets and establish that the harm to civilian populations and objects resulting from the use of specific weapons and means of warfare should not be greater that that required to achieve legitimate military objectives. The 1977 ENMOD Convention[60] explicitly prohibits the deliberate manipulation of the natural processes related to outer space environment as a method of warfare, a prohibition with potential applications to threats associated with high altitude nuclear detonations or the creation of space debris as forms of attacks on satellites.

The major international space security relevant institutions include the United Nations, through the UN General Assembly (UNGA), the UN Committee on the Peaceful Use of Outer Space (COPUOS), the Conference on Disarmament (CD), the International Telecommunication Union (ITU), the World Trade Organization (WTO) and the International Institute for the Unification of Private Law (UNIDROIT). The UNGA expresses its concern over space weaponry through an annual and almost unanimous resolution stating that the prevention of an arms race in outer space would avert a grave danger to international peace and security.[61] COPUOS is mandated to deal exclusively with international cooperation in the peaceful use of outer space and, through its Inter-Agency Space Debris Coordination Committee (IADC), has played an important role in developing space debris mitigation guidelines (see discussion within the space debris indicator). The CD is mandated to address the disarmament dimensions of space security and has

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[54] Treaty on the Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies.
[55] The Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space.
[56] The Convention on International Liability for the Damage Caused by Space Objects.
[57] Agreement on the Activities of States on the Moon and Other Celestial Bodies I.L.M. 1434 (1979).
[58] (1972) U.N.T.S. 402.
[59] MTCR countries exercise vigilance over the transfer of missile equipment, material, and related technologies through a system of national export controls. These controls are not intended to impede peaceful aerospace programmes. However, given the usefulness of some space technologies in the development of missiles, MTCR export controls can have this effect. Therefore, the MTCR is perceived by some countries, especially those outside the Regime, as a restrictive cartel impeding access to space. See for example, a paper presented by the Pakistan Mission to the UN on this issue (http://www.un.int/pakistan/13970723.html).
[60] The Convention on the Prohibition of Military or any other Hostile Use of Environmental Modification Techniques, 1977.
[61] These resolutions are available at http://www.un.org/documents/resga.htm.

completed extensive consultations over the years through its ad hoc committee on the Prevention of an Arms Race in Outer Space, although this committee has been unable to meet since 1998 due to the inability of the CD to agree on a Program of Work. The ITU manages the allocation of radio frequency spectrum and orbital slots (see discussion within the space resources indicator). The WTO has an annex concerning telecommunication services. UNIDROIT is playing a role in developing an international instrument which will facilitate the private financing of space assets, potentially improving access to space.

2003 Developments

International law and institutions evolve slowly. On the institutional level one of the most important developments of 2003 was the attempt to break a six year old stalemate within the CD through the "Five Ambassadors Initiative."[62] In August China announced that would accept the mandate for an ad hoc committee on the Prevention of an Arms Race in Outer Space (PAROS) as formulated by the Five Ambassadors proposal.[63] It was not clear how other key states would respond to this new display of flexibility on China's part. It is important to note that PAROS is neither the only issue on the agenda of the CD nor the only issue that must be resolved in order to arrive at a Program of Work. In December the UNGA resolution calling for progress within the CD to prevent an arms race in space was adopted (174 in favour, none against and 4 abstentions)[64] in a manner consistent with previous resolutions on the issue.

Space Security 2003: Key Assessments

Space Security Survey (October 20 to November 14, 2003)	Space Security Working Group (November 24-25, 2003)
Question: Taking into account your views on developments on both international legal and multilateral institutional developments in the past year, how have overall changes in this area affected space security?	*Question: In your view, space security with respect to this indicator has been?*
Enhanced : 2 Somewhat enhanced : 16 Little or no effect : 47 Somewhat reduced : 22 Reduced: 10	Enhanced : 0 Somewhat enhanced : 1 Little or no effect : 15 Somewhat reduced : 6 Reduced : 0

The SSWG assessed that the institutions charged with space security relevant issues such as debris, radio spectrum and orbit allocations were taking what appeared to be effective steps to deal with these challenges. The adoption of the annual UN General Assembly resolution on the CD in space provided a good indication of the continued strength of the norms supportive of the peaceful uses of outer space. However, the CD remained deadlocked throughout the year. The Chinese move within the CD to accept a compromise formulation of the mandate for an ad hoc committee on the prevention of arms race in outer space raised hopes that work on these issues might begin on this issue within the CD in 2004. **Overall, it was assessed that there had been little or no effect upon space security during 2003 with respect to this indicator.**

[62] By the Ambassadors of Algeria, Belgium, Chile, Columbia and Sweden.
[63] China, Statement by Mr. Hu Xiaodi, Ambassador for Disarmament Affairs of China at the Plenary of the 2003 Session of the Conference on Disarmament, August 7, 2003. For different reasons France and the USA remain as holdouts to this compromise. For an excellent report on these developments see http://www.ploughshares.ca/content/MONITOR/mons03b.html.
[64] UN resolution A/58/461. These four abstentions included Micronesia, Israel, Marshall Islands and the U.S.

III- THE CAPABILITIES OF SPACE ACTORS

5- SPACE ACCESS

Introduction

This indicator assesses trends in the number of actors with access to space through an indigenous launch capability or through access to the launch capabilities of others. This is a key indicator of trends in space security since developing or securing a means of placing assets in space is a pre-condition to using space for a wide range of civil, commercial and military applications. Thus, knowing who can reach space and maintain space-based assets is critical to any assessment of the status of space security. However, there are potential contradictions within this indicator. Since space security, as defined for this study, requires *secure and sustainable access to space,* an increase in the number of actors who can access space implies an increase in space security since the growth of such capabilities tends to increase the certainty and sustainability of space access. More space actors also means more actors with an interest in maintaining secure access to space. Yet more actors with space access also holds risks for space security, such as those associated with environmental factors (debris, scarcity of radio spectrum and orbital slots) as well as space control considerations (protection and negation concerns).

Background

The capability to access and use space requires the use of a launch and control infrastructure, a transport system, and a payload that accomplishes the mission. The three main orbital heights—Low Earth Orbit (LEO), Medium Earth Orbit (MEO) and Geostationary Orbit (GEO)—are useful for quite different applications. Hence, the space-based capabilities available to actors are highly dependent upon their ability to reach and exploit these different orbits. By virtue of its proximity to the Earth, LEO is the easiest orbit to reach and is particularly useful for the purpose of remote sensing. For actors creating a space-based communications or navigation infrastructure, MEO can be a very useful orbit. GEO is the most difficult orbit to reach, as it is the furthest from Earth, and is particularly useful for communications purposes since satellites in orbit follow the rotation of the Earth and remain fixed over one particular area.[65]

Date of selected countries' first space launches[66] *(unless otherwise indicated)*

Country	USSR/Russia	USA	France	Japan	China	ESA	India	Israel
Year	1957	1958	1965[67]	1970[68]	1970	1979[69]	1980	1988

The precursors to U.S. and Soviet space launch capabilities were their respective intercontinental ballistic missile programs. Over the past fifty years, the capability to access space through indigenous launch capabilities has spread, and now includes China, the member states of the European Space Agency, India, Israel, Japan and the United States. But space programs do not require indigenous launch capabilities. As of late 2003, the number of countries and organisations that had demonstrated the capability to place and maintain satellites on orbit either through an indigenous launch capability or through access to the launch capabilities of others had reached over 55.[70] This access has also become increasingly commercialized, meaning actors without their own launch capacity have access to space by means of commercial launches. The "X-Prize" is even encouraging private investors to develop reusable passenger spacecraft. Still, the military, civil and commercial space launch sectors retain a tremendous degree of interpenetration. This growth in space access capabilities has contributed to a steady decline in launch costs. The ability of Europe and Russia to undercut the U.S. in terms of launch costs has helped make ESA and the Russian space program the world's most active space launch providers. There has also been a

[65] http://www.apc.maxwell.af.mil/text/spio/orbit.htm .

[66] Jane's Space Directory. 2004.

[67] Space Today Online. 2003. "France's Historic Spaceports." *Spaceports around the world.* http://www.spacetoday.org/Rockets/Spaceports/France.html .

[68] Space Today Online. 2003. "Japan: One Of The First Spacefaring Nations." *Spacefaring Japan.* http://www.spacetoday.org/Japan/Japan/History.html .

[69] ESA. 2004. "Ariane 1, 2, 3." *About Launchers.* http://www.esa.int/export/esaLA/ASE6LU0TCNC_launchers_0.html .

[70] Goddard Space Flight Center. 2003. *Satellite Situation Report.* 45.12.

significant proliferation of ballistic missile capabilities. Many types of ballistic missiles have the ability to reach LEO, and thus are capable of interfering with space assets within that orbit. Detonating a nuclear device or introducing significant debris into LEO would certainly threaten the secure use of space by others.

Space launch vehicles currently have the capability to place payloads into space with single use rockets or reusable spacecraft. Today, while only the US, Russia and China have reusable spacecraft, there are over 50 expendable launch-vehicle variants built by 20 different manufacturers worldwide.

Commercially available launch vehicles, 2002[71]

Vehicle	Delta 2	Long March	Zenit 2	Soyuz	Zenit 3SL	Ariane 5	Atlas 3	Proton M	Atlas 5	Delta 4	GSLV	H 2A
Country	USA	China	Ukraine	Russia	USA/Sea Launch	Europe	USA	Russia	USA	USA	India	Japan

The commercial launch industry is able to provide these capabilities to a plurality of actors. Both Europe and Russia are able to provide cheaper access to space than the United States, and have thus come to dominate the commercial market. While India, Japan, China and Israel also have space launch capabilities, none of these countries are currently competing in the commercial launch market. Overall, competition has served to facilitate greater space access: between 1990 and 2000 the average price (in constant 2000 dollars) for delivering a payload into GEO dropped from $US 39,948/kg to $US 25,804/kg.[72]

Total Commercial Space Launches By Year[73] **(unless otherwise noted)**

Year	1998	1999	2000	2001	2002	2003[74]
Launch #	41	39	35	16	24	17

2003 Developments

On August 22, 2003 a Brazilian VLS-1 rocket exploded during a launch test, killing 21. On February 1, 2003 the U.S. Space Shuttle *Columbia* broke up upon re-entry, killing seven. The *Columbia* disaster demonstrated the importance of multiple means of access for space security, since Russia was able to assume responsibility for supplying the International Space Station. Arguably the most significant event in terms of space access to occur in 2003 was China's launching its first astronaut into LEO, on October 15. India's ability to access space also continued to expand throughout 2003 as it made significant progress towards being able to place payloads into GEO.[75] Expanded GEO launch availability could help to decrease commercial launch costs further. India also announced plans for a mission to the moon, to take place in 2007.[76] Somewhat removed from state-funded developments, an X-Prize team broke the sound barrier this year, and the organiser of the competition hopes to see a winner announced in 2004.

Perhaps the key lesson from the past year in terms of space security was that for a comfortable level of space security to exist, there must exist multiple pathways into space for all types of space activities. Overcapacity in access capabilities has been more the trend within the commercial sector, and financial hardships continue to threaten space industry. This could lead to a reduction in the ability to access space if actors leave the commercial launch market, thus reducing competition and raising prices. Higher costs could prevent new actors from establishing a presence in space. For example, Nigeria launched its first satellite in 2003,[77] and higher costs could make the uses of space more difficult for countries such as this.

[71] FAA Associate Administrator for Commercial Space Transportation. 2003. *Commercial Space Transportation Quarterly Launch Report: 4th Quarter 2003.* Washington: US Department of Transportation. Pg. 9.
[72] Futron. 2002. *Space Transportation Costs: Trends in Price Per Pound to Orbit 1990-2000.* Pg. 4.
[73] FAA. 2003. *Commercial Space Transportation: 2002 Year In Review.* Pg. 12.
[74] Space Security Network. 2003. Responses to the 2003 Space Security Survey "Space Industry."
[75] Indian GEO Launcher and Associated Comsat Do Okay In Second Test." *SpaceDaily.* http://www.spacedaily.com/news/rocketscience-03x.html .
[76] Nair, G. Madhavan. 2003. "Indian space program forges ahead!" *IndoLink,* http://www.indolink.com/Analysis/a011504-050423.php
[77] "Nigeria launches first satellite aboard Russian rocket." *SpaceDaily.* http://www.spacedaily.com/2003/030927071108.d5actbne.html

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Space Security Survey (October 20 to November 14, 2003)	Space Security Working Group (November 24-25, 2003)
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Enhanced : 3 Somewhat enhanced : 35 Little or no effect : 18 Somewhat reduced : 31 Reduced : 4	Enhanced : 1 Somewhat enhanced : 15 Little or no effect : 6 Somewhat reduced : 4 Reduced : 1

The SSWG assessed that China's first manned space mission and India's successful test of its GEO-launch capability suggested that space access developments during 2003 should be judged in a fairly positive light. A greater number of actors having access to space had the potential to enhance space security by providing competition, access to space for actors without a dedicated launch program and redundancy in the case of system failures. The Brazilian and U.S. civil space tragedies in 2003 underscored the risks associated with space access as well as the corresponding value of a growing diversity of space access capabilities. However, as indicated in both the quantitative and qualitative results from the Space Security Survey, there is also a level of concern that more actors with access to space could increase the threat to space assets, undermining space security over the longer term. **Overall, however, it was assessed that space security had been somewhat enhanced during 2003 with respect to this indicator.**

6- CIVIL SPACE PROGRAMS AND GLOBAL UTILITIES

Introduction

This indicator assesses trends in civil space programs as well as the development and management of space-based utilities such as the Global Positioning Systems (GPS). The civil space sector is composed of all those organizations involved in the exploration of space, as well as those engaged in pure research in or related to outer space. For example, this sector includes national space agencies, pure scientific research efforts as well as a broad range of remote sensing applications such as weather services. Global utilities are space-based applications that can be used by any actor equipped to receive the data they provide. These universally available resources include a range of telecommunications, remote sensing and satellite navigation systems.

Civil space programs and global utilities are relevant to space security since they underscore the vast social, scientific and commercial benefits of secure and sustainable access to space. Global utilities also broaden the community of actors supportive of the security of space access and uses well beyond space faring nations to include thousands of civil, commercial and military actors who rely upon space-based services for navigation, weather forecasting and communications functions. Finally, international cooperation between civil space programs facilitates enhanced transparency among space security actors.

Background

Through most of the Cold War, the U.S. and the U.S.S.R. engaged in significant space competition driven by political considerations as well as the practical benefits of space research for a wide variety of civil, commercial and military applications. The precursor to the China National Space Administration (CNSA) was founded in the late 1950s. The involvement of other actors was however quite minimal. Since the end of the Cold War, American and Russian civil space funding has declined significantly and today there is a relatively wide variety of states making significant investments in civil space programs. The approximate annual civil space budgets of selected states at the beginning of this decade included: the U.S. at US$15 billion;[78] China at US$2 billion; Japan at US$1 billion; France at US$1 billion; India at US$500 million;[79] Canada at US$270 million and the UK at US$260 million.[80] An actor growing in importance within the civil space sector has been the European Space Agency. While not formally the "national" space agency for the European Union (EU), the two organizations do share "a joint space strategy."[81] Other countries have also been increasing their civil space programs, including Brazil, India and Nigeria.

Global utilities continue to offer space-based applications that even nations without space programs can access. The archetypal global utility is the GPS system. Operated by the US Air Force, it provides free navigation information to anyone who owns an inexpensive GPS receiver. By 2008, GPS should be complemented by the European *Galileo* navigation system. It will be owned and operated by the civilian authorities from the 25 EU member states that are financing the project.[82] Another key global utility is the *COSPAS/SARSAT* satellite network, a joint Canadian-American-French-Russian system used to support search and rescue missions.

2003 Developments

The *Columbia* disaster, the first shuttle loss since the *Challenger* explosion in 1986, put an immediate halt to all planned shuttle missions for the year, although unmanned American launches continued. Similarly, the Brazilian rocket explosion provided a significant challenge to Brazil's efforts to establish an independent launch capability. In January, the EU and the ESA published a joint Green Paper on *European Space Policy* that indicated the EU's desire to play a greater role in the use of space by working even more closely with ESA.[83] This report was followed in November by a White Paper, subtitled *An action plan for implementing the European Space Policy* (see discussion of these documents within the National Space Security Policies and Doctrines indicator).

In July, ESA awarded the first contracts for experimental *Galileo* satellites. *Galileo* received a further boost later in the year when it was announced that China would participate in the project. China is believed to be planning to invest approximately $US 259 million in *Galileo*, a sum equal to what is expected to be a fifth of the cost needed to build the system.[84] This all bodes well for the establishment of a new global utility, although if China decides to adopt *Galileo* widely, it is expect to include military as well as civilian applications.[85]

The investment that went into China's launch of an astronaut indicated China's commitment to the civil space sector and suggests that China will want to play a greater role in influencing issues relevant to space use and exploration in the future. China is working to expand its manned space program further as well as the launch of a new series of communications and Earth-imaging satellites.[86]

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[78] NASA. 2003. *National Aeronautics and Space Administration FY 2004 Budget Overview*. S&AP 3-2.
[79] SpaceDaily. 2003. "Government Space Budgets to Continue Growth." *SpaceDaily.com*. http://www.spacedaily.com/news/satellite-biz-03zzzl.html
[80] *Jane's Space Directory*. 2003 unless otherwise indicated.
[81] Membership of the ESA is composed of Austria, Canada, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom. European Space Agency. *ESA Facts and Figures*. http://www.esa.int/export/esaCP/GGG4SXG3AEC_index_0.html .
[82] de Selding, Peter B. 2003. "U.S., European Negotiators Hopeful About Galileo Deal." *SpaceNews*. http://www.space.com/spacenews/spacenews_businessmonday_030602.html .
[83] Commission of the European Communities. 2003. *Green Paper: European Space Policy*. Pg. 26.
[84] BBC News. 2003. "China joins EU's satellite network." *BBC News*. http://news.bbc.co.uk/1/hi/business/3121682.stm .
[85] BBC News. 2003. "China joins EU's satellite network." *BBC News*. http://news.bbc.co.uk/1/hi/business/3121682.stm .
[86] Caceres, Marco Antonio. 2003. "Launch Services: Too Many Rockets, Too Few Payloads." *Aviation Week and Space Technology*. January 13th: 135-137. Pg. 136.

Space Security 2003: Key Assessments

Space Security Survey (October 20 to November 14, 2003)	Space Security Working Group (November 24-25, 2003)
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Enhanced : 4 Somewhat enhanced : 7 Little or no effect : 48 Somewhat reduced : 30 Reduced : 10	Enhanced : 0 Somewhat enhanced : 8 Little or no effect : 11 Somewhat reduced : 4 Reduced : 0

SSWG assessments were mixed regarding developments within this indicator and their implications for space security during 2003. The importance of international cooperation within civil space programs was underscored by developments during the year - in particular Russia's agreement to continue servicing the International Space Station following the *Columbia* tragedy. China's entry into manned space flight was also an important civil space development which appeared to stimulate the civil space activities of others. The continued dispute between Europe and the US over *Galileo* spectrum allocation was highlighted by many SSWG members and Survey respondents as a source of concern regarding global utilities. **Overall, it was assessed that there had been little or no effect upon space security during 2003 with respect to this indicator.**

7- SPACE INDUSTRY

Introduction

This indicator assesses trends in the space industry sector – those firms engaged as builders and users of space hardware (e.g. rockets, satellites, etc.), information technologies (e.g. software applications), and space products (e.g. remote sensing data). The space insurance sector is also part of space industry, since the owners of satellites use insurance to protect themselves from liability for damage caused by a malfunction of their launch vehicles or satellites. Much like the civil space indicator, space industry is relevant to space security considerations because it tends to underscore the growing benefits of secure and sustainable access to space. For example, every branch of the U.S. Postal Service and every Wal-Mart store use commercial satellite communications.

All space actors depend on space industry to a certain extent. Actors with independent access capabilities employ space industry to build system components, while actors who simply want to deliver payloads into orbit or take advantage of space-based resources can purchase these services from space industry actors. The space industry is, therefore, linked to an assessment of space security since it provides the hardware to access space and represents a rapidly growing community of actors who depend upon space for commercial utilities.[87] For example, in 1980, the commercial space sector accounted for just $US 2.1 billion in revenues, yet by 2000, the sector collected $US 94.5 billion in revenue.[88]

Background

The companies involved in the space industry are becoming increasingly important for the world's national economies and a vital part of economic growth. As the technology industry went through a

[87] Satellite Industry Association. *Satellites as Critical Infrastructure*. Pgs. 16-17.

[88] Higginbotham, John. 2002. "Private Possibilities in Space." *Space: The Free Market Frontier.* Edward L. Hudgins ed. New York: Cato Institute. Pg. 146.

substantial boom through the 1990s, many expected that the commercial space sector would also continue to expand. Yet in 2000, the technological sector saw the start of a massive downturn, which has significantly curbed the growth of the space sector in recent years. Still, companies, governments and individuals worldwide use commercial space services on a daily basis and their loss would have significant economic implications.

There are many important sub-divisions within the space industry. Commercial activities in space include: building satellites and ground control stations; providing satellite communication services; launching satellites; providing remote sensing services; providing satellite navigation services; and helping design scientific research projects.[89] One major component of the commercial space market is the commercial satellite sector. Satellites are currently able to provide communication services, including telephone services; remote sensing services; GPS and navigation services; broadband services, including internet delivery and videoconference delivery; television and radio services.[90] Hence, even when the commercial space industry is in a period of stagnation, as it has been for a while, most space actors are interested in preserving a functional commercial space sector.

In the past, the space race and military competition between the United States and the former Soviet Union was the principle driver for the commercial space industry. During much of this period, the US commercial space industry largely benefited from military and civil space pursuits. At the height of the Apollo mission in 1966 for example, NASA's budget as a percentage of the US federal budget peaked at 4.4%. By 2001, NASA's budget was a more modest 0.7 % of federal US spending[91]. Communication satellites became the first commercial endeavours to exploit space with the launch of the Canadian and American domestic satellites in the early 1970's. Today, it is the dominant sector of the space services industry. In 1986, Spot Image Corporation, a French company became the first commercial remote sensing satellite system. The Global Positioning System - a military navigation satellite system - has increasingly characterised an important trend in commercial space industry, wherein a greater portion of space manufacturing revenue is associated with the production of ground terminals than the satellites themselves.

Since the end of the Cold War in 1991, the space industry has undergone several deep rounds of consolidation, first in the United States and then in Russia, as overcapacity in the aerospace industry became increasingly acute in these two countries. Today, there are but three giant aersopace companies in the US - Boeing, Lockheed Martin and Loral. Europe has also experienced several consolidations to produce Astrium and more consolidations are expected for the state-sponsored industries of France and Italy. Meanwhile, new entrants are poised in Israel, China, Japan and India to increase global commercial competition for both hardware and services. As the space industry is dominated by communication satellites, the meltdown in the global telecommunications sector of the past few years has cut deep into the confidence of commercial space industrialists. Government support, whether military or civil, may be increasingly welcomed in order to slavage national industries many consider to be of vital strategic national interest.

Insurance is available to cover damage to systems before launch, during launch, and to payloads in orbit.[92] Between 1987 and 2002, in-orbit premiums stayed under 5% of the total value of the systems.[93] However, in 2002, the space insurance industry paid out $830 million in claims while it collected just $490 million in premiums.[94] In light of this depressed industry, insurers have begun offering shorter terms, with higher rates and deductibles.[95] There does appear to be some room to raise these premiums, considering that space insurers tend to set "higher deductibles to ensure that clients do everything possible to reduce risk."[96] Moreover, there are already insurance exclusions for events such as terrorism.[97] However, if

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[89] McLucas, John L. 1991. *Space Commerce.* Cambridge: Harvard University Press. Pgs. 5-6.
[90] Satellite Industry Association. 2003. *2001-2002 Satellite Industry Indicators Survey.* Pg. 4.
[91] Randy Seftas, "The Civil Space Sector," Staff Background Paper prepared for the Commission to Assess United States National Security Space Management and Organization, (2001).
[92] FAA. 2002. *Commercial Space Transportation Quarterly Launch Report 4th Quarter 2002.* Pg. 8.
[93] FAA. 2002. *Commercial Space Transportation Quarterly Launch Report 4th Quarter 2002.* Pg. 10.
[94] Taverna, Michael A. 2002. "Worsening Insurance Crunch Worries Space Industry." *Aviation Week & Space Technology.* Pgs. 156.20: 47.
[95] Taverna, Michael A. 2002. "Worsening Insurance Crunch Worries Space Industry." *Aviation Week & Space Technology.* Pgs.156. 20: 47.
[96] FAA. 2002. *Commercial Space Transportation Quarterly Launch Report 4th Quarter 2002.* Pg. 10.

insurers perceive that intentional damage to space assets is likely, they may well make it more difficult for some actors to get insurance, raising the cost of space access.

Military space actors are increasingly seeking the cost savings and effectiveness that commercial services can provide. When the US began its military campaign in Afghanistan in late 2001 it purchased all of the imagery available for the country from the private satellite imaging firm Space Imaging Corp. This deal was not a form of shutter control, but rather a strictly commercial arrangement to meet a demand for current imagery. Such military-commercial interdependence underscores the importance of cooperation among space actors. Moreover, it could lead to improvements in satellite protection, such as hardening satellites against electro-magnetic pulses, as commercial actors providing services to the military become more aware of the need for protective measures.[98]

2003 Developments

Overall, 2003 was not a good year for the space industry. Loral Space & Communications Corporation, for example, filed for bankruptcy protection and sold "present and future satellite assets" worth $US 1 billion.[99] Loral's problems are significant since it is considered one of the "big five" manufacturers of satellites.[100] Commercial launches meanwhile dropped to a reported 17 in 2003.[101] This decline in launches signalled overcapacity in the space industry sector. In the short term, this may pressure service providers to reduce costs to attract customers and lower the costs of accessing and using space over the long term; however, continued weakness in demand for space industry products could significantly weaken the sector by eliminating a number of actors from the market, reducing competition and the corresponding range of options to access and use space.

The other important trend identifiable in 2003 was an increase in military demand for space industry products. Besides providing a manufacturing boost, this trend deepened the degree of interdependence between the military and commercial space sectors. For example, 2003 saw the U.S using commercial remote sensing services for military and government purposes to a greater degree than ever. In early 2003 Space Imaging and DigitalGlobe received government imaging contracts that could be worth as much as $500 million each over five years.[102] This decision appeared to be based, in part at least, on a desire to sustain the American remote sensing industry and keep at the technological forefront for reasons associated with national security concerns.[103]

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Enhanced : 2 Somewhat enhanced : 21 Little or no effect : 24 Somewhat reduced : 29 Reduced : 8	Enhanced : 0 Somewhat enhanced : 0 Little or no effect : 15 Somewhat reduced : 8 Reduced : 0

There were somewhat mixed views within the SSWG on developments within this indicator and their implications for space security. The over-riding feature of the space industrial sector in 2003 was a

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97 FAA. 2002. *Commercial Space Transportation Quarterly Launch Report 4th Quarter 2002*. Pg. 10.
98 Space Security Network. 2003. Responses to the 2003 Space Security Survey "Space Industry."
99 Mecham, Michael. 2003. "Loral Enters Chapter 11." *Aviation Week and Space Technology*. July 21st: 32.
100 Space Industry Association. *Satellites as Critical Infrastructure*. Pg. 9.
101 FAA. 2004. *Commercial Space Transportation Quarterly Launch Report 1st Quarter 2004*. Pg. 6.
102 Morring, Frank Jr. 2003. "Industry Could Gain $1 Billion From NIMA," *Aviation Week & Space Technology*. 158.4: 32.
103 Rooselvelt, Ann. 2003. "Feds Want More Reliance On Commercial Satellites." *Defense Week*.
http://www.globalsecurity.org/org/news/2003/030519-feds-satellites01.htm

ongoing economic downturn. While governments and militaries turned increasingly to commercial space services to meet their needs for space services, the space industry sector remained burdened by overcapacity. This overcapacity was viewed by some as having a negative impact on space access, and thus on space security itself. However, this overcapacity also tended to increase competitive pressures and contributed to pressures for lower space access costs. **In view of these developments, it was assessed that there was little or no effect upon space security during 2003 with respect to this indicator.**

8- SPACE SURVEILLANCE

Introduction

This indicator assesses trends in capabilities to track, identify, and catalogue significant objects in earth orbit including functional satellites and space debris. These space surveillance capabilities allow actors to predict the orbital paths of space objects to prepare for potential re-entry into the atmosphere.[104] It facilitates secure access to space through collision avoidance, and can be used for ballistic missile tracking to provide early warning of missile launches aimed at terrestrial or space-based locations/targets.[105]

Advanced space surveillance capabilities have the potential to enhance security by support collision avoidance efforts and promoting transparency in space activities. However, these possible benefits to space security are mitigated by the dual-purpose nature of space surveillance technologies. The same technology used for monitoring debris and operational satellites can also be used for targeting in support of space negation activities. There is growing interest in establishing space surveillance capacity to acquire heightened 'space situational awareness' for defensive and potentially offensive uses, and surveillance is seen as an essential element of a 'space control' mission.[106]

Background

The earth's orbit is cluttered with thousands of objects, including both natural debris and operational satellites and detritus from fifty years of human activity in space. Since even fragments of debris threaten the structural integrity of spacecraft, there is a continual effort to 'see' smaller particles at greater distances. Detecting and tracking these objects requires a variety of technologies, including ground-based radars, optical and electro-optical telescopes, and a new space-based sensor, while algorithmic models are used to predict orbital behaviour. The US is the world leader in space surveillance, but Russia makes a significant contribution and Canada, China, France, Germany and Japan are becoming increasingly engaged in this field.

The US Space Surveillance Network (SSN) is the world's most extensive space surveillance system and the largest of data on objects in orbit. Today, the SSN consists of 30 radar and optical sensors at 16 locations worldwide, a single experimental space-based sensor, and operations facilities to track 9,000 space objects, as small as 5-7 cm in diameter in Low-Earth Orbit (LEO) and as small as 1 m in Geosynchronous Orbit (GEO).[107] The 1st Space Control Squadron of the U.S. Air Force Space Command maintains a Space Catalogue, including status reports and orbit tracking information on each monitored object – only 7 % of which are operational satellites.[108] Although it remains the most comprehensive space surveillance system in the world, the SSN has some limitations, including aging sensors, and limited

[104] US Strategic Command fact file, "Space Control" Online at: http://www.stratcom.af.mil/factsheetshtml/reentryassessment.htm
[105] Ballistic Missile Early Warning radars at Thule, Fylingdales and Clear, AK; the Perimeter Acquisition Radar Characterization System in North Dakota and the PAVE Phased Array Warning System radars at Cape Cod, MA and Beale, CA are primarily used for ballistic missile early warning and attack assessment, but serve as collateral sensors feeding data into the Space Surveillance Network.
[106] The *Quadrennial Defense Review Report* noted: "As the foundation for space control, space surveillance will receive increased emphasis. DoD will pursue modernization of the aging space surveillance infrastructure, enhance the command and control structure, and evolve the system from a cataloging and tracking capability to a system providing space situational awareness." 30 September 2001, 44. Online at: http://www.defenselink.mil/pubs/qdr2001.pdf
[107] About 2,000 objects with diameters greater than 10 cm, and a further 2,000 as small as 5-7 cm, are routinely tracked by the SSN, although these objects are not yet formally catalogued. Personal correspondence with Nicholas Johnson, Chief Scientist and Program Manager, Orbital Debris Program Office, NASA Johnson Space Center.
[108] The number of operational spacecraft is imprecise, but ranges from 500-600. Johnson.

capacity to view objects smaller than 10 cm in LEO and 1 m in GEO. Furthermore, without dedicated sensors in the southern hemisphere, it lacks global coverage.[109]

Russia developed its space surveillance system during the Cold War to track satellites and space objects, and provide ballistic missile early warning. Now called the Space Surveillance System, this network of sensors consists of ground-based radars and electro-optical telescopes although the fall of the Soviet Union left the system fragmented, with several sensors in newly independent states. Through bilateral agreements with Azerbaijan, Belarus and Ukraine, Russia has managed to retain access to some of the radar stations for limited terms and in 2002, the upgraded Qabala radar station in Azerbaijan and the Okno electro-optical facility in Tajikistan became operational.[110] Although many of the remaining sensors have long outlived their intended service lives, and funding is limited, the Russian system is still a useful source of information on catalogued space objects.

While the U.S. and U.S.S.R./Russia have made the largest contributions to the space surveillance capabilities, other actors are increasing their capabilities. China has a tracking, telemetry and communications system, including large phased array radars, to monitor its national satellites and spacecraft, although it is not yet able to track uncooperative space objects.[111] Japan has built two new facilities – an optical site and large phased array radar – for space surveillance, primarily for asteroid detection as well as monitoring of debris and satellites.[112] Canada has experimented with a satellite tracking system, and is currently engaged in research and development of space-based surveillance technology, including a microsatellite-based option.[113] Debris monitoring is a mission of the European Space Agency, which operates an optical facility in the Canary Islands and accesses the powerful FGAN Tracking and Imaging Radar in Darmstadt, Germany.[114] France is pursuing debris monitoring in GEO through two new projects, incorporating advanced optical telescope technology.[115] The US ballistic missile defence system has also supported new space surveillance initiatives, including upgrades to aging early warning facilities and space-based surveillance projects.

2003 Developments

The past year has shown positive technological developments, including the US upgrade of the L-band Cobra Dane radar on Shemya Island, Alaska, which increased the SSN's sensitivity to objects in the 5-7 cm range.[116] Russia now has access to the upgraded Volga radar at Baranovichi, Belarus and the Okno electro-optical site in Tajikistan is operational.[117] France, Japan and Canada all made progress on their nascent space surveillance programs. A growing number of nations were working trans-nationally; for instance the European Space Agency coordinated European debris monitoring through the Network of

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[109] The SSN's limitations include: "instantaneous coverage gaps and not all space objects can be detected directly at any instant in time. Consequently, accurate orbit-prediction algorithms are a necessary element in producing an accurate real-time space surveillance picture." Daniel Gonzales, *The Changing Role of the US Military in Space,* RAND Report 1999, p 47.
[110] "Russian Space Forces Inaugurate New Space-Tracking Facility" Associated Press, 18 July 2002.
[111] Mark Stokes, *China's Strategic Modernization: Implications for the United States* (Carlisle, PA: Strategic Studies Institute, September 1999) 40-42.
[112] The Japan Spaceguard Association, a non-profit organization concerned with near earth asteroid detection, has funded the surveillance projects. The Bisei Spaceguard Center began operations in 2000 and the Kamisaibara radar is not yet fully operational. "Space Debris Optical Observation and Orbit Determination Experiment Initiated," NASDA Report 99, September 2000. Online at: http://www.nasda.go.jp/lib/nasda-news/2000/09/head_e.html
[113] The High Earth Orbit Space Surveillance program proposes to mount a space-based telescope on a microsatellite to search for near-earth asteroids, specifically Aten class NEAs; and to track satellites. HEOSS will demonstrate optical sensor technology for a proposed satellite-based surveillance system, project Sapphire. Personal correspondence with Dr. Brad Wallace, Principal Investigator, Satellite Tracking Science Team High Earth Orbit Space Surveillance TDP, Defence R&D Canada.
[114] The Darmstadt facility includes an L-band radar, a Ku-band radar and a 34-metre computer controlled parabolic antenna. Targeting debris in LEO, the L-band is used primarily for detection and tracking of space objects, while the Ku-band radar simultaneously images the same targets. Mehrholz et al., "Detecting, Tracking and Imaging Space Debris," *ESA Bulletin* 109, February 2002, 128-134, 130.
[115] The TAROT and ROSACE telescope programs are surveyed in Fernand Alby et al. "Status of CNES Optical Observations of Space Debris in Geostationary Orbit" COSPAR (2002).
[116] Hardware and software upgrades to the L-band Cobra Dane radar have increased its sensitivity, enabling it to track objects in LEO in the range of 5-7 cm. *The Orbital Debris Quarterly News,* Vol 8, Issue 1, January 2004, 7-8.
[117] "Russian radar put into operation in Belarus" 1 October 2003, *Russian Information Agency Novosti.* "Radar system to guard northwest", 2 October 2003, *The Russian Journal Daily.*

Centres Working Group on Space Debris.[118] Canada proposed that its space-based surveillance sensor could contribute to the SSN's Space Catalogue,[119] while other nations are cooperating in satellite tracking. There are indications that international cooperation in space surveillance will increase.

In 2003, the U.S. supported several space surveillance projects, particularly those linked to the ballistic missile defence program. The recently upgraded Cobra Dane Radar was designated for future use as a BMD sensor, and development of the Space Tracking and Surveillance System (formerly SBIRS Low), an essential element of BMD necessary for ballistic missile early warning and tracking, continued at high funding levels.[120] Conversely, funding for upgrades to the radar Fence, which is a major source of data about objects in LEO, was in called into question.[121] The U.S. has committed to projects such as the DARPA micro-satellite space-based surveillance system, which could be used for targeting of satellites.[122]

As the dominant source of space surveillance data, the U.S. controls its distribution. Until 2001, open access to unclassified data from the Space Catalogue was provided through a website managed by the Orbital Information Group. This access was restricted to registered users in the wake of the September 11 terrorist attacks, and in 2003, Congress approved funding for a pilot project to re-structure the manner in which the data is distributed. This project would ensure data support is provided to commercial and non-U.S. government entities, with no guarantee of public access and with the condition that access must be "in the national security interests of the United States."[123]

Space Security 2003: Key Assessments

Space Security Survey (October 20 to November, 14 2003)	Space Security Working Group (November 24-25, 2003)
Question: Taking into account your views on developments in both space monitoring and transparency in the past year, how have overall changes in this area affected space security?	*Question: In your view, space security with respect to this indicator has been?*
Enhanced : 3 Somewhat enhanced : 34 Little or no effect : 28 Somewhat reduced : 15 Reduced : 4	Enhanced : 0 Somewhat enhanced : 17 Little or no effect : 4 Somewhat reduced : 0 Reduced : 0

The SSWG assessed that space security actors have shown increased interest in and some increased capacities to support cooperative space surveillance capabilities. An experimental space-based optical sensor, in particular, suggests the potential for improvements in the capability of the U.S. Space Surveillance Network to detect smaller objects. Space surveillance capabilities were also critical to collision avoidance and protection against orbital debris. Space surveillance capabilities are generally based on dual-use technologies, and there were indications of U.S. interest in developing these technologies in support of space control and ballistic missile defence missions. The SSWG assessed that it is the positive contributions of these capabilities that, on balance, supported an increase in the transparency of space

[118] The November 2003 European Commission White Paper identified space surveillance as an area for future work and the Network of Centres Working Group on Space Debris is coordinating work in this field. http://www.estec.esa.nl/wmwww/wma/Collaborations/NoCDebris/General%20Information.html

[119] Major Frank Pinkney, CAF quoted by David Pugliese, in *Space News*, 9 September 2003.

[120] The Space Tracking and Surveillance System has experienced significant cost overruns and the technology is still not mature. Any future role it might play in general space surveillance has not yet been defined. *Missile Defense: Alternate Approaches to Space Tracking and Surveillance System Need to be Considered.* United States General Accounting Office, GAO-03-597 May 2003.

[121] In 2003 the Pentagon transferred authority for the Fence from the Naval Space Command to the Air Force and the future of the system is in question as cost-cutting measures are considered and priority is placed in space-based sensors. Jeremy Singer, "Shutdown of Fence System Could Impair Tracking of Debris," *Space News*, 25 April 2003.

[122] *Fact File: A Compendium of DARPA Programs*, Defense Advanced Research Projects Agency, August 2003, 14. Online at: http://www.darpa.mil/body/pdf/final2003factfilerev1.pdf

[123] FY2004 Defense Authorization Bill Conference Report, Title IX – Department of Defense Organization and Management, Section 913: Pilot Program for Provision of Space Surveillance Network Services to Non-United States Government Entities, Item 2274: Space surveillance network: pilot program for provision of satellite tracking support to entities outside United States Government. 7 November 2003.

activities and efforts aimed at the management of space for peaceful purposes. **In view of these developments, it was assessed that space security had been somewhat enhanced during 2003 with respect to this indicator.**

9- SPACE AND TERRESTRIAL MILITARY OPERATIONS

Introduction

This indicator assesses trends in the development of space-based assets providing support to terrestrial military operations, including their vulnerability to attack. This includes developments related to the relative *dependence* of space security actors on 'force enhancement' systems.[124] Simply put, force enhancement refers to all space activities that help increase the effectiveness of terrestrial military forces. *Dependence* on space-based force enhancement systems refers to the degree to which military operations in all three terrestrial combat environments (land, sea and air) require – or are significantly enhanced by – functions performed by military and civilian satellites. Broadly speaking, *dependence* can be said to affect space security in two ways. First, the more heavily dependent a state becomes on space-based force enhancement systems, the greater the incentives its potential adversaries have to develop offensive space negation capabilities in an effort to neutralize any military advantage that those systems provide. Second, as a state becomes more heavily dependent on space assets, the incentives for that state to develop its own space protection and negation capabilities tend to increase.

Background

There is little doubt that the US is the global leader when it comes to the military use of space for force enhancement purposes. While other countries have military space programs that involve one or more primary force enhancement mission areas,[125] none can rival the US in terms of either the range of missions performed or the number of satellites – both military and civilian – that perform these missions. As of the end of 2002, and as a result of an acceleration of migration of force enhancement tasks to space since Operation Desert Storm, the US was operating an extensive system of military satellites for missile launch detection; strategic and tactical communications; navigation and timing; intelligence, surveillance and reconnaissance; and meteorology.[126] The US military was also using a number of civilian satellites in support of terrestrial military operations – especially in the areas of communications; meteorology; and remote sensing.[127]

This extensive space-based force enhancement infrastructure supports a US military that has become increasingly dependent on space. As noted by the US Space Commission in 2001: "Today, information gathered from and transmitted through space is an integral component of American military strategy and operations. Space-based capabilities enable military forces to be warned of missile attacks, to communicate instantaneously, to obtain near real-time information that can be transmitted rapidly for satellite to attack platform, to navigate to conflict areas while avoiding hostile defenses along the way, and

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[124] Closely related to *dependence* is *vulnerability* – that is, the degree to which space-based force enhancement systems assets are susceptible to disruption, denial and destruction. Developments related to vulnerability will be discussed in the chapters dealing with 'negation' and 'protection'.

[125] According to the US Air Force *Space Almanac* there are several force enhancement missions performed by military and civilian satellites: Communications; Environmental/Remote Sensing; Navigation and Timing; Reconnaissance and Surveillance; Space Environment/Meteorological Support; Strategic Early Warning; and Tactical Warning/Attack Assessment. See US Air Force *Space Almanac 2003*, p. 35. Available at http://www.afa.org/magazine/May2003/default.asp

[126] Major systems include Defense Meteorological Satellite Program (metereology); Global Broadcast System (communications); Defense Satellite Communications System III (communications); Milstar Satellite Communications System (communications); Polar Military Satellite Communications (communications); Global Positioning System (timing and navigation); UHF Follow-On Satellite (communications), White Cloud (ocean reconnaissance), Trumpet (signals intelligence), Improved Crystal (electro-optical imaging), and Onyx/Lacrosse (radar imaging). See *Space Almanac, op. cit.*

[127] Including Advanced Communications Technology Satellite (communications), the Geostationary Operational Environmental Satellite (storm monitoring and tracking, meteorological research), Globalstar (communications), Ikonos (remote sensing), Inmarsat (communications), Intelsat (communications), Iridium (communications), Landsat (mapping), Telstar (communications), NOAA/ TIROS (weather forecasting), Orbcomm (communications), Pan Am Sat (communications), Quickbird 2 (remote sensing), SPOT (remote sensing), and TDRSS (communications). See *Space Almanac 2003, op. cit*

to identify and strike targets from air, land or sea with precise and devastating effect."[128] Indeed, there are concerns among senior U.S. officials that the U.S. may be becoming *overly* dependent on such systems.[129]

An important indicator of this growing U.S. dependence on space systems is the increasing demand for satellite bandwidth. According to one U.S. government report, 'satellite bandwidth used in Operation Allied Force in Kosovo was 2.5 times greater than that used in Desert Storm, while forces used were only one-tenth the size.'[130] By some projections, military satellite bandwidth demand may grow by as much as 90% by 2005.[131] This growing demand for bandwidth is related to an important shift in the U.S. use of space-based systems from 'strategic' missions to 'operational' and even 'tactical' mission support. Whereas in the past, force enhancement systems tended to focus on missions such as strategic warning and intelligence collection, they are now being integrated with attack platforms and even individual combatants in order to make them 'force enablers' rather than merely 'force enhancers.'[132] This trend has raised concerns (as noted by the Space Commission) about the vulnerability of the U.S. to a 'space Pearl Harbour' scenario.[133] These concerns have fuelled a growing interest in developing space control capabilities as a means of reducing this vulnerability. Beyond the U.S., the demonstrated effects of the highly successful integration of space assets into American terrestrial military operations had prompted other states to begin developing or enhancing their own space-based force enhancement capabilities. It may also have provided incentives to certain states to develop anti-satellite systems capable of attacking U.S. space-based assets in an effort to neutralize the effectiveness of these systems.

While no other country rivals the military space-dependency of the U.S., several other space powers nevertheless possess space-based force enhancement capabilities. Russia, the country with the most extensive capabilities, operates the Glonass and Parus navigation systems; the Strela, Raduga and Geizer military communications satellite systems; Oko early warning satellites; Tselina signals intelligence series; Kobalt photo-reconnaissance satellites; and the Arkon imagery intelligence satellite system.[134] China maintains the Feng Huo military communications satellite (which appears to be a dual-use military and civilian system) as well as a pair of Beidou navigational satellites. Other countries with space-based force enhancement assets in operation at the end of 2002 included France (Helios image intelligence satellite and the Telecomm-2 communications satellite),[135] Italy (Sicral communications satellite), Spain (Hispasat communications satellite), Britain (Skynet-4 communications satellites), Israel (Eros and Ofeq-5 imagery intelligence satellites), India (TES photo-reconnaissance satellite); Japan (commercial Superbird communications satellite system); and South Korea (Kompsat-1 remote sensing satellite).[136]

2003 Developments

According to the US Air Force Deputy Undersecretary for Military Space, Operation Iraqi Freedom marked a crucial turning point with respect to space and American military power. Whereas even as recently as Operation Desert Storm, US space assets had largely been limited primarily to strategic- and operational-level tasks, by the time the US commenced operations against Iraq in 2003 space systems were providing extensive support at the tactical level as well. Indeed, Operation Iraqi Freedom marked the first time that satellites were widely integrated into weapon systems, sensors, command posts, and forces in the field. As the Undersecretary noted, Iraqi Freedom demonstrates that satellites have transcended the traditional force enhancement role and now 'enable just about everything we do' in war.[137]

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[128] United States, 2001, *Report of the Commission to Assess United States National Security Space Management and Organization* (known as the Space Commission). Available at http://www.defenselink.mil/pubs/space/20010111.html, p. 13.
[129] 'Rumsfeld Asks if Pentagon is Over-Reliant on Space Systems', *Space News*, 13 May 2002, p. 4.
[130] Theresa Hitchens, 'Monsters and Shadows: Left Unchecked, American Fears Regarding Threats to Space will Drive Weaponization', *Disarmament Forum*, no. 1 (2003), p. 17. Available at http://www.unidir.ch/bdd/fiche-article.php?ref_article=1884
[131] John Donnelly, 'Panel Probes Military's Fight for Radio Waves', *Defense Week*, 22 April *2002*.
[132] Robert S. Dickman, US Air Force Undersecretary for Military Space, as quoted in James W. Canan, 'Iraq and the Space Factor', *Aerospace America*, August 2003.
[133] See Space Commission Report, *op. cit.* See also 'National Space Policies and Doctrines' section of this paper.
[134] International Institute for Strategic Studies, 'Russia's Military Satellites', *Strategic Comments*, Volume 7, Issue 6 (July 2001). Available at http://bbb.darktech.org/~phriik/text/Military/sc0706ru.pdf
[135] International Institute for Strategic Studies, 'Russia's Military Satellites', *Strategic Comments*, Volume 7, Issue 6 (July 2001). Available at http://bbb.darktech.org/~phriik/text/Military/sc0706ru.pdf
[136] For a detailed discussion see John Pike, 'The Military Uses of Outer Space', *SIPRI Yearbook: Armaments, Disarmament and International Security* (2002), pp. 1-43.
[137] 'Iraq and the Space Factor', *op. cit.*

US satellite bandwidth requirements continued to grow in the period between Operation Desert Storm and Operation Iraqi Freedom. According to one senior official, while 99 Mbs of bandwidth were used by the US military to support Desert Storm, fully 380 Mbs were required to support Iraqi Freedom. Closely related to this was an increase in the use of commercial bandwidth by the military. One estimate suggested that the commercial space sector supplied 80% of the bandwidth used in Iraqi Freedom.[138] In 2003 Japan launched a pair of 'Information Gathering Satellites.' One of the satellites utilizes an optical camera to provide black-and-white with a resolution of about 1 metre. The other makes use of synthetic aperture radar technology capable of seeing at night or through cloud cover.[139]

Space Security 2003: Key Assessments

Space Security Survey (October 20 to November 14, 2003)	Space Security Working Group (November 24-25, 2003)
Question: Taking into account your views on developments in both military dependence on space assets, and on the vulnerability of those assets in the past year, how have overall changes in this area affected space security?	*Question: In your view, space security with respect to this indicator has been?*
Enhanced : 4 Somewhat enhanced : 13 Little or no effect : 13 Somewhat reduced : 37 Reduced : 21	Enhanced : 0 Somewhat enhanced : 5 Little or no effect : 4 Somewhat reduced : 13 Reduced : 1

During 2003, the US launched a major military campaign in Iraq that relied heavily upon the use of space-based capabilities for the purposes of force enhancement The SSWG noted that there was a widespread debate among space experts (especially within the US) regarding the effects of such growing dependence on space assets to support terrestrial military operations. While this trend clearly had positive dimensions, such as greater use of precision guided weapons, dependency on space assets also potentially increased the incentives on the part of other actors to develop capabilities to 'negate' these systems. A corresponding trend on the part of actors dependent upon space assets was to seek to protect these assets against such negation capabilities. These trends underscored the need for the careful management of the protection/negation dynamic in order to mitigate incentives to develop more destructive oriented negation capabilities such as anti-satellite weapons. Such a dynamic would have the potential to trigger an action-reaction cycle that could lead to the breaching of the normative barrier prohibiting the deployment of weapons in space, undermining the sustainability of space security over the longer term. **In view of these considerations, it was assessed that space security had been somewhat reduced during 2003 with respect to this indicator.**

10- SPACE PROTECTION

Introduction

This indicator assesses trends related to the development of capabilities related to the protection of space assets including trends related to the research, development, testing and deployment of systems designed to protect military and non-military space assets from potential interference by others. The objectives of passive defence are to mitigate the vulnerabilities and to strengthen the survivability features of space systems, the information they provide, and the infrastructure that supports such space operations. A variety of passive defence means are available to protect the ground, space and link segments of space systems. These measures include: camouflage, concealment and deception; dispersal, mobility, and manoeuvrability; hardening and shielding; electronic attack and protection; information assurance; and, redundancy and reconstitution. The objectives of active defence are to detect, track, identify, intercept and

[138] Theresa Hitchens, 'Developments in Military Space: Movement Toward Space Weapons?'. Available at http://www.cdi.org/pdfs/space-weapons.pdf

[139] Stephen Clark, 'Japan Enters Spy Satellite Arena with Rocket Launch', *Space Flight Now* (28 March 2003).

deny or destroy an enemy's means to negate coalition space systems. Active defence can include military operations against an enemy's ground-based infrastructure needed to target space systems or the command and control of its space negation assets; direct attack of the space negation means themselves, or the application of military force on the launch infrastructure supporting an adversary's access to space. Because active defensive space protection means can possess capabilities tantamount to space negation means, the following analysis considered active defensive means predicated on the physical destruction of negation assets and supporting infrastructure as a space negation means. Active defensive measures predicated on non-lethal means, such as deceiving, disrupting or denying the homing radar of an approaching interceptor with deployable jammers, however, are considered as active protection measures. This approach is slightly different from another expressed doctrine of defensive counterspace operations, which considers the application of lethal means that results in physically degrading or destroying an approaching interceptor, as an active space protection means.[140]

Space protection capabilities are directly related to space security considerations since they support the security of an actor's access to and uses of space. The sophistication of these space protection capabilities also potentially influences an actor's perception of space security issues more generally by reducing its sense of vulnerability. Moreover, in addition to increasing the ability of a space system to avoid, withstand, or reconstitute after an attack, protection capabilities may also assist in deterring an actor from undertaking space negation operations. For example, if an actor assesses that it is either futile or too costly to undertake an attack against a well-defended system, that actor may refrain from launching an attack against that space system. Unlike space negation as a means of protecting space assets therefore, a reliance on non-offensive defences may be less likely to lead to a space arms race spiral among competitors.

Background

During the late 1970s and the 1980s, each of the two Superpowers pursued defence policies aimed at prevailing in a nuclear conflict. Thus, space protection measures were aimed at hardening these assets against the effects of nuclear weapons, as well as developing anti-jam technologies to ensure robust command and control capabilities. U.S. space systems, such as the Defense Support Program (DSP) early warning missions, Keyhole reconnaissance missions, Navstar global navigation satellite systems and the third generation Defense Strategic Communication System (DSCS III) satellites, were all hardened against the radiation and electromagnetic pulse effects of nuclear detonations. The DSCS III system also employed technology designed to increase its jamming resistance. Mobile, dispersed, redundant and deeply buried terrestrial command and control operations centres were also pursued to increase the survivability of strategic space systems.[141] Robust production lines, the proliferation of redundant satellites in constellations, and a responsive launch readiness contributed to the survivability of Soviet space capabilities during the Cold War. There were also attempts to restrain the development and use of electronic warfare techniques capable of interfering with early warning satellites assisting in the verification of strategic arms control treaties.

In the aftermath of the Cold War, space protection measures continued to be implemented on military space systems as policies and doctrines mandated such measures. However, as the revolution in military affairs increased the reliance of military powers on space for force enhancement missions, the limited capacity of robust military systems was being increasingly supplemented with commercial service providers.[142] As of 2002, these commercial systems were not being hardened to the same degree as military systems, given the cost, mass, power and throughput penalties to be paid in meeting the survivability demands necessary to support tactical military operations. Given the continued proliferation of dual-use high energy lasers, computer technology and communications equipment capable of interfering with unhardened satellite operations, the absence of passive space protection measures is increasingly becoming a shared vulnerability by space-faring and space-dependent nations alike. This is especially true in a

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[140] US Air Force Space Operations, *Doctrine Document 2-2*, August 23, 1998.

[141] Maj. Michael J. Muolo, Space Handbook A War Fighter's Guide to Space, Vol. 1, Air University Press, Maxwell Air Force Base, Alabama, December 1993.

[142] National Air Intelligence Center, *Threats to U.S. Military Access to Space*, Document 1422-0989-98 (Wright Patterson Air Force Base, Ohio). The reliance of the DOD is most evident during times of conflict as commercial communications satellites were used in 45 percent of all communications between the United States and the Persian Gulf region during Desert Shield/Desert Storm.

computer networked world. Protection is not only important to those states that possess the largest number of space assets. While the U.S. and Russia rely on hundreds of satellites, a smaller state with only one satellite may be equally dependent if that satellite is performing a critical security function. The operators of space systems, as a result, have a common interest in ensuring the integrity of their systems and in fostering a widely accepted standard of protection. Where states and other operators diverge is in their ability and willingness, technologically and financially, to protect their space systems.

2003 Developments

ASEAN nations, the E.U. and the U.S. were the sources of noteworthy developments in 2003 with respect to the development of protection means and methods for space related computer systems. The southeast Asian information and communications ministers announced plans to establish an early warning system against computer viruses and form specialist emergency response teams to deal with cyber attacks.[143] ASEAN members hoped to put into place by 2004 a cooperation framework for sharing real-time information on computer threats as well as assessments of vulnerabilities. By 2005, all ASEAN members[144] were expected to have formed Computer Emergency Response Teams (CERTs) to deal with attacks from hackers or viruses. During three virus attacks in 2003 that cost an estimated US$800 million globally, the CERTs of several ASEAN countries swung into action but there had been no co-operation among ASEAN nations themselves.

The E.U.'s *Galileo* satellite navigation system was a prominent issue in bilateral space relations with the U.S. throughout 2003 as another attempt was made to resolve differences on de-conflicting proposed frequencies for *Galileo* and for the next generation of GPS. Specifically, the frequency adopted by the Europeans for *Galileo* would directly overlay the American GPS signal. Extending international co-operation to both China and India also introduced a third party stake in the E.U. system. In a colourful expression of European independence, Gilles Gantlet, spokesman for EU Transport Commissioner Loyola de Palacio expressed it this way: "if you always use your parent's car, there will come a day when it's not available."[145] The Green Paper on the E.U.'s space policy also stressed the importance that "the services offered by space systems in normal times and crises are adequately protected."[146]

For FY 2004, the US Congress approved $14.7 million US dollars for space control technologies. In accordance with a FY2004 budget request, the U.S. Department of Defense sought to spend at least $1.7 billion dollars from fiscal year 2004 to fiscal year 2009 on three space control program elements, one of which was Defensive Counterspace (DCS) or space protection.[147] The requested funding for DCS includes near-term protection measures to enhance spacecraft survivability by improving tactics, techniques, and procedures and ensuring that future spacecraft incorporate survivability measures.[148] In particular, DCS includes developing a system to detect attacks on US space systems and an improved processing system for attack characterization. This funding request is consistent with the Air Force Space Command's latest Strategic Master Plan to field transformational space-based capabilities in the mid-to long-term including: space-based space surveillance systems for close-proximity inspectors that are capable of providing details of space objects unattainable by ground-based systems; an attack detection and reporting architecture based on the Rapid Attack Identification, Detection, and Reporting System (RAIDRS) concept capable of detecting, characterizing (identify and geo-locate) and reporting attacks on space systems; and, active on-board and/or on-orbit capabilities to protect space systems from manmade or environmental threats.[149]

Conclusions from a 2002 US General Accounting Office report calling for commercial satellite security to be more fully addressed went unheeded in 2003.[150] The report specifically recommended that

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[143] "ASEAN ministers agree to boost defences against cyber attacks", *AFX News*, September 19, 2003.
[144] Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam.
[145] Daniel Michaels, "Satellite Skirmish Looms Between Europe, the US – EUs Planned Galileo System Raises Ire of Washington, Which sees a Rival to its GPS", *The Asian Wall Street Journal*, April 2, 2003.
[146] *Green Paper European Space Policy*, The European Commission, Luxemburg, 2003, pg. 25.
[147] "USAF Pursues Technology to Block Enemy Access to SATCOM, Imagery", *Inside the Air Force*, Vol. 14, No. 26, June 27, 2003.
[148] Air Force Space Command Strategic Master Plan FY2004 and Beyond, US Air Force Space Command, Peterson Air Force Base, Colorado, November 5, 2003.
[149] "Satellite Self-Protection Equipment Attracts USAF Interest, Investment", *Aviation Week &Science Technology*, August 16, 1999.
[150] Critical Infrastructure Protection Commercial Satellite Security Should Be More Fully Addressed, United States General Accounting Office, GAO-02-781, Washington, August 2002.

commercial satellites be identified as a critical infrastructure in the U.S. national critical infrastructure protection strategy, given the importance of this sector to U.S. economic and security interests.

Space Security 2003: Key Assessments

Space Security Survey (October 20 to November 14, 2003)	Space Security Working Group (November 24-25, 2003)
Question: Taking into account your views on developments in both space protection doctrine and the various kinds of systems development in the past year, how have overall changes in this area affected space security?	*Question: In your view, space security with respect to this indicator has been?*
Enhanced : 2 Somewhat enhanced : 25 Little or no effect : 27 Somewhat reduced : 17 Reduced : 10	Enhanced : 0 Somewhat enhanced : 4 Little or no effect : 15 Somewhat reduced : 3 Reduced : 0

The SSWG assessed that key space security actors have clearly come to recognize the threats facing space systems and have started working to put protective measures in place. Balancing this move to protect government systems is the on-going inadequacy of protection measures for commercial space systems. Improved information assurance measures, electronic protection measures, increased encryption usage, and enhanced radiation hardening all adds costs to space systems. Commercial providers, in a competitive marketplace continue to remain reticent about paying for such additional measures. There appeared to have been no significant changes in the level of protection for commercial space systems in 2003. **Overall, it was assessed that there had been little or no effect upon space security during 2003 with respect to this indicator.**

11- SPACE NEGATION

Introduction

This indicator assesses trends in the development of capabilities related to space negation, including trends related to the doctrine, research, development, testing and deployment of systems designed to negate the use of space by others. Space negation is the use of lethal or non-lethal means to neutralize an adversary's space systems, the information they provide, or the infrastructure that supports such systems. Negation can inflict permanent damage in order to degrade or destroy the satellites or ground facilities supporting the space system, or seek to temporarily disrupt or deny the use of such assets or the communication links connecting them. Deception represents another means to negate a space system by causing an opponent to question the veracity of the information the space system provides.

Space negation can involve taking action against any element of a space system, such as a satellite dish, a receiver terminal or an associated computer network of the ground segment, the links to and from a satellite, or against the satellite itself. Action taken to negate space systems can be undertaken through both space-based and terrestrially-based means, although only terrestrially-based space negation systems have been demonstrated thus far. Space negation doctrine has also been developed from both the offensive and defensive perspectives. Offensive negation seeks to deceive, disrupt, deny, damage or destroy an adversary's space systems. Defensive negation consists of the same goals carried out in self-defence in order to protect one's own space systems. Space negation doctrine and systems development is directly related to space security in that the use of negation measures can adversely affect the capacity of those targeted to gain access to and use space in a secure manner. Conversely, restraint in the development of space negation doctrine and systems has the potential to enhance space security by reducing threats to the secure access to and use of space.

Background

Space negation concepts and capabilities have been under active consideration since the launch of the world's first artificial satellite in 1957. In the early 1960s, the U.S. and U.S.S.R. experimented with nuclear weapon-tipped missile interceptors designed primarily to defend against ballistic missiles. After nuclear test explosions in LEO proved harmful to unhardened satellites, further nuclear weapon tests in space were prohibited. Between the late 1960s and early 1980s, the U.S.S.R. developed and tested a series of ground-launched, limited duration, co-orbital anti-satellite interceptors. These tests produced mixed results and generated a substantial amount of dangerous space debris. In 1985, the U.S. responded with a single successful test of an air-launched, direct-ascent miniature homing vehicle aimed at one of its own satellites. Since then, there have been no recorded tests of dedicated anti-satellite weapons systems and no actor has developed anti-satellite weapons capable of reaching beyond LEO. Strategic stability considerations during the Cold War also helped to restrain bilateral competition in the use of readily available electronic warfare means to interfere with 'national technical means' of verification, early warning satellites and certain communication satellites carrying 'hotline' channels. In 1997, the U.S. illuminated one of its own imaging satellites with a ground-based high energy laser developed for testing advanced ballistic missile defence technologies.[151] The test, at much lower power levels than that required to destroy the satellite, was performed to determine the satellite's degree of vulnerability to such attacks. Russia still maintains access to its Soviet-era high energy laser facilities in Kazakstan and China, according to one assessment,[152] may have acquired high-energy laser equipment and technical assistance, which probably could be used in the development of ground-based ASAT weapons.

Space negation, however, is not necessarily the preserve of space-faring powers. Given that most elements of a space system are earth bound, it is likely that the initial targets of space negation efforts will be on the earth, or will be readily accessible from Earth, such as the electromagnetic links connecting ground stations to satellites. Target options and effectiveness of a state's space negation capabilities are proportional to its level of technological development, but access to space is not a prerequisite for a state to negate space systems. For example, a nation can carry out conventional air strikes against the ground command or reception facilities of an adversary's space systems, whether fixed or mobile. More subtle, but no less effective, unprotected satellite communication links are vulnerable to intentional interference generated by terrestrial sources such as radiofrequency jammers. Unhardened reconnaissance or remote sensing satellites are also vulnerable to ground-based low energy laser "dazzlers". Information or cybernetic attacks can also strike at data tasking or data dissemination means upstream or downstream of the facilities used to command or distribute data generated by a space system, especially when space systems are networked to other communication or computer systems.

In the more recent past, doctrinal developments have moved the concept of space negation from theory towards a posture of readiness. The 1996 US National Space Policy declares that "consistent with treaty obligations, the United States will develop, operate and maintain space control capabilities to ensure freedom of action in space and, if directed, deny such freedom of action to adversaries." At the end of 2002, no state possessed a dedicated, operationally deployed system to negate space systems, although some civil communication or military electronic warfare means were available to interfere with satellite signals on an *ad hoc* basis. For example, in a much publicised dispute over geostationary orbital slot assignments, Indonesia interfered with and denied the services of a commercial satellite belonging to the South Pacific island kingdom of Tonga in 1997.[153]

2003 Developments

Several seminal events occurred in 2003 with respect to the operationalization of space negation means and methods. Iran, Iraq and the United States were sources of newsworthy events. Persian language TV signals beamed into Iran via satellite originating from the United States were jammed during July of 2003[154] when someone operating out of Latin America or the Caribbean interfered with the transmissions

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[151] Komarow, S., "Army scores a hit on satellite in test of laser", *USA Today*, pp. A6, October 21, 1997.

[152] US Department of Defence, *Annual Report on the Military Power of the People's Republic of China*, Washington, DC, (July 28, 2003).

[153] US General Accounting Office, *Critical Infrastructure Protection Commercial Satellite Security Should be More Fully Addressed*, GAO-02-781, Washington, DC (August 2002).

[154] Peter Goodspeed, "US broadcasts spark tech war with Iran", *The Ottawa Citizen*, July 12, 2003, pg. A10.

of the Voice of America broadcasts. Iranian officials branded the US broadcasts as a "cultural invasion." US officials characterized the 30 minute nightly news broadcasts as part of their public diplomacy efforts to get the US Government's message through Iranian government censors.

During the U.S. military operation "Iraqi Freedom," the Iraqi military used jammers against the U.S. Global Positioning System (GPS) in the first action were the US Department of Defense acknowledged that an adversary tried to disrupt the GPS signal with an operational use of CounterNAV space negation systems. Iraq is reported to have placed electronic jamming equipment on towers around Baghdad prior to the launch of the war.[155] While the Iraqi attempt failed to disrupt or deny the use of GPS to U.S. and coalition forces, their presence gave cause for concern as 80% of the US Tomahawk Land Attack Cruise missiles used in the conflict were reliant solely upon GPS for their method of guidance.

Fairly specific information pertaining to U.S. offensive counterspace accompanied the fiscal year 2004 budget requests by the US Department of Defense. Space control includes space situational awareness (SSA), defensive counterspace (DCS) and offensive counterspace (OCS) missions. Offensive counterspace operations are "operations conducted to attain and maintain a desired degree of space superiority by allowing friendly forces to exploit space capabilities while negating an adversary's ability to do the same."[156]

According to the FY2004 budget request, the U.S. planned to spend at least $1.7 billion dollars from fiscal years 2004 to 2009 on the three space control program elements. For FY2004, $215.5 million was requested for space control modernization in three areas: space control technology ($14.7 million); counterspace systems ($82.6 million); and spacetrack ($118.2 million).[157] Within the counterspace budget item, $9.6 million was request for "CounterComm," "transportable system that can disrupt adversary satellite-based communications that are deemed to be hostile to the US or friendly forces using temporary and reversible, nondestructive means."[158] An operational CounterComm system was projected to be fielded during FY2005. The Pentagon also requested $66.4 million dollars in FY2004 for Counter Surveillance Reconnaissance System (CSRS, pronounced "scissors"). CSRS would also employ reversible means against military, civil or commercial imaging systems and it is geared to the threat posed by enemy access to satellite imagery. The plan is to deploy operational units by fiscal year 2008. While not all funding requests are approved by the U.S. Congress, the following table illustrates past US DOD funding requests and Congressional appropriations for space control technologies and systems.[159]. Here space control technologies funds are largely allocated to space protection measures, while space control systems are dedicated to the procurement of space negation systems.

US Space Control Spending	**FY 2000**		**FY 2001**		**FY 2002**		**FY 2003**		**FY 2004**	
	Req.	**App.**	**Req.**	**App.**	**Req.**	**App.**	**Req.**	**App.**	**Req.**	**App.**
Space Control Technologies	9.8	12.8	9.7	9.7	33	32.3	13.8	13.8	14.7	14.7
Space Control Systems	0	0	0	0	0	0	40	40	82.6	82.6

The ground-based kinetic energy anti-satellite weapon program was, in practical terms, zero-funded in the FY2004 budget. In its Strategic Master Plan FY04 and Beyond,[160] the US Air Force Space

155 Michael Sirak, "Holding the higher ground", *Janes Defence Weekly*, October 8, 2003.
156 "Air Force Doctrine Document 2-2", Space Operations, USAF, November 27, 2001.
157 "USAF Pursues Technology to Block Enemy Access to SATCOM, Imagery," *Inside the Air Force*, Vol. 14, No. 26, June 27, 2003.
158 "USAF Pursues Technology to Block Enemy Access to SATCOM, Imagery," *Inside the Air Force*, Vol. 14, No. 26, June 27, 2003.
159 Marcia S. Smith, "U.S. Space Programs: Civilian, Military, and Commercial", Congressional Research Service Report IB92011, The Library of Congress, Washington D.C., Updated October 6, 2003.
160 "Strategic Master Plan FY04 and Beyond", US Air Force Space Command, November 5, 2002.

Command postulates full spectrum, space-based counterspace systems capable of preventing unauthorized use of friendly space services and negating adversarial space capabilities from LEO to GEO altitudes, although this is not official government policy.

Space Security 2003: Key Assessments

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Enhanced : 3 Somewhat enhanced : 11 Little or no effect : 21 Somewhat reduced : 28 Reduced : 21	Enhanced : 0 Somewhat enhanced : 3 Little or no effect : 4 Somewhat reduced : 15 Reduced : 1

The SSWG expressed concerns that the jamming of navigation satellite signals during the Iraq war and the intentional interference with US satellite television signals during times other than war had helped to establish a state practice that could have a negative impact upon the sustainability of space security. Despite what appeared to be long range plans by some space actors to develop more robust space negation capabilities based on physical destruction of satellites, there was little evidence that such capabilities were being actively developed via funded programmes. A measured step was taken in 2003 by the U.S. to enhance its capabilities for space negation through the temporary and reversible effects of electronic warfare, which could be regarded more as a military force protection capability than a military force application capability. It remained to be seen, however, whether other space security actors would respond in kind, or escalate to develop capabilities for space negation predicated on the physical destruction or degradation of increasingly accessible satellites or their ground control stations. **No space-based negation activities occurred in 2003, but concern over possible future developments in this field led to an overall assessment that space security had been somewhat reduced during 2003 with respect to this indicator.**

12- SPACE-BASED STRIKE WEAPONS

Introduction

Space-based strike weapons (SBSW) are systems operating from orbit with the capability to inflict damage to terrestrial targets (land, sea or air), or to terrestrially-launched objects passing through space, via the projection of mass or energy.[161] (This does not include strikes against space-based targets, which are covered under the Space Negation indicator). Mass-to-target weapons cause damage by colliding with targets with the combined mass and velocity of the space-based weapon itself or by shooting targets with inert or explosive devices. According to available evidence no such systems are currently deployed in space. Examples of such systems would include space-based ballistic missile interceptors such as the Brilliant Pebbles concept or inert hardened rods designed to be de-orbited to strike terrestrial objects with substantial energy. Energy-to-target weapons cause damage by transferring destructive energy through an energy beam focussed on a target for example, via lasers, microwaves or neutral particle beams. This includes concepts such as space-based lasers which would attempt to destroy ballistic missiles by heating the body of the missile and exploding the fuel within the missile. SBSW systems have the potential to affect space security in very direct ways. An actor with such capabilities would be able to prevent other

[161] Adapted from Bob Preston et al., *Space Weapons, Earth Wars*. p. xvi. (RAND: 2002). See also Michael Krepon and Christopher Clary, *Space Assurance or Space Dominance? The Case Against Weaponizing Space*, The Henry L. Stimson Center, 2003, p. 30. and Barry Watts, *The Military Use of Space: A Diagnostic Assessment, Center for Strategic and Budgetary Assessments*, February 2002, p. 86.

actors from accessing and thus using space. Such capabilities would also provide an actor with the capability to threaten others from space.

This indicator assesses trends in the development of operational military doctrine related to SBSW, as well as trends related to the research, development, testing and deployment of SBSW. This includes key enabling technologies for such systems such as: space access and precision re-entry; precision attitude control and maneuverability; micro-satellites; high-energy laser and particle beam projection; and large deployable optics.

Background

A number of SBSW related development programs were funded by the US and USSR during the Cold War.[162] In the 1960s, the USSR developed a fractional orbital bombardment system (FOBS) the capability of which was designed to deliver from orbit a nuclear weapon onto an enemy target on Earth, while circumventing warning systems. Following 24 launches, of which 17 were successful, the system was declared operational in 1968. The US also conducted research and development on FOBS system during the 1960s but this work was significantly reduced during the 1970s.

In the 1980s, the United States conducted research and testing of several SBSW systems under the Strategic Defense Initiative (SDI). This was to be a ballistic missile defense program, including active components that were space based, most notably (1) the space based interceptor (SBI) capable of disabling enemy missiles either by hit-to-kill or by delivery of conventional arms and (2) the space based laser (SBL) for use to destroy missiles in the launch and mid-course phases. The SBI program, from 1983 to the early 1990s, focused on the 'Brilliant Pebbles' concept[163] which envisioned an orbiting constellation of mini-SBI satellites each capable of autonomous interception of enemy missiles that travelled within its range. Ground testing of a Brilliant Pebble interceptor was conducted,[164] and the manufacturing and integration of a kinetic kill vehicle for flight-testing was completed.[165] This vehicle was not ultimately flight tested due to cancellation of the program by the Clinton administration. The U.S.S.R. reportedly orbited, but did not successfully test, a directed energy experiment included on a 100-ton satellite launched by an Energiya rocket in 1985, and flight tested particle beam technology during the planetary probe programs.[166]

The US conducted an underground test of the nuclear-pumped X-ray laser in 1985[167] but this was not a fully integrated system. There was also laboratory research into nuclear pumped particle beams and free electron lasers.[168] The Relay Mirror Experiment was flight tested in 1990 successfully demonstrating ground-based laser re-directing and pointing.[169] While SDI encountered congressional concerns due to high costs and technology immaturity, these programs did establish a considerable technological base for these types of capabilities.

In the post-Cold War period, a number of key US military doctrine and policy related documents made reference to the potential use of SBSW, including the 2001 Space Commission Report and the Air Force Space Command Strategic Master Plan, which emphasized the need for "space control" and called for the ability for force application "in, from, or through" space.[170] The US maintained an active SBSW

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[162] Bob Preston, et al., *Space Weapons Earth War*, Ch.2 (RAND: 2002) and references therein; Michael Krepon and Christopher Cleary, *Space Assurance or Space Dominance?* Ch.1 (Stimson: 2002).

[163] *Ibid*, and Ball Aerospace fact sheet on Brilliant Pebbles: http://www.ball.com/aerospace/bpebbles.html

[164] Philip Coyle, personal communication, Feb 3, 2004 & http://www.globalsecurity.org/wmd/facility/nts.htm

[165] *Ballistic Missile Defense (U) Budget Activity: 03, Program Element: 0603217C Project Number: 1214*, 1994 http://www.fas.org/spp/starwars/budget/peds_95/603217ca.htm; *Lawrence Livermore Timeline*, http://www.llnl.gov/timeline/80s.html , *Adapting to a Changing Weapons Program*, Lawrence Livermore, http://www.llnl.gov/str/January01/Batzel4.html

[166] "Space Based Laser." Globalsecurity.org. http://www.globalsecurity.org/space/systems/sbl.html .

[167] Robert Scheer, *Pssst. Want to Know a Secret? Just Ask Teller*, May 25, 1999 Los Angeles Times http://www.robertscheer.com/1_natcolumn/99_columns/052599.htm; Joseph Nilsen, *Legacy of the X-ray Laser Program* Lawrence Livermore National Laboratory, 2004 http://www.llnl.gov/etr/pdfs/11_94.2.pdf .

[168] "Space Based Laser." Globalsecurity.org. http://www.globalsecurity.org/space/systems/sbl.htm

[169] *Relay Mirror Experiment* Ball Aerospace http://www.ball.com/aerospace/rme.html .

[170] *Air Force Space Command Strategic Master Plan FY06 and Beyond*, http://www.peterson.af.mil/hqafspc/library/AFSPCPAOffice/Final%2006%20SMP--Signed!v1.pdf; *Report of the Commission to Assess United States National Security Space Management and Organization* http://www.defenselink.mil/pubs/spaceabout.html; *Joint Vision 2020*, http://www.dtic.mil/jointvision/jvpub2.htm .

research program within the framework of Ballistic Missile Defense, including ongoing work on the Space-Based Interceptor and Space-Based Laser. The Clementine mission flight-tested several components of the sensor hardware developed for Brilliant Pebbles.[171] Because executive and legislative opposition meant that SDI hardware would not be tested in LEO, Clementine was sent on a mission to test its sensors by exploring the Moon and an Earth-crossing asteroid. The SBL program was re-configured in the mid-1990s and was placed on a schedule for a flight test post 2010.[172] In the mid-1990s the US Air Force briefly studied the concept of uranium tipped tungsten rods approximately a few meters in length, which could be de-orbited for the purposes of a terrestrial strike[173].

Although having not significantly increased capabilities since the end of the Cold War, Russia retained a number of key prerequisite SBSW technologies. There was little unclassified evidence of Russian SBSW doctrine or R&D programs, and Russian officials repeatedly stated their concerns with U.S. SBSW related doctrine and R&D programs.[174] China developed some key prerequisite technologies for SBSW such as launchers and controlled re-entry, high-powered lasers, and precision guidance through its microsatellite program.[175] There was little unclassified evidence of Chinese SBSW doctrine or R&D programs. Chinese officials repeated expressed concern about U.S. space doctrine[176] and, with Russia, have continued to urge for a prohibition on space weapons in the Conference on Disarmament. There was little evidence of significant SBSW capabilities being developed by other actors.

2003 Developments

The U.S. Missile Defense Agency announced in December 2002 its intention to place on orbit a 'test-bed' for space-based ballistic missile boost-phase interceptors by the 2007/2008 timeframe,[177] but by July 2003 had delayed this projected date.[178] A total of US$14M was authorized by the US Congress in 2003 for FY2004 for R&D for this project.[179] In November 2003, the U.S. Air Force and the Defense Advanced Research Projects Agency (DARPA) announced the FALCON program[180] which included the development of a "Common Aero Vehicle" (CAV) a hypersonic, maneuverable glide vehicle for carrying a variety of payloads, including conventional weapons from space to earth-based targets. The Space Based Laser program office was closed due to immaturity of technology.[181]

Citing the programs of other actors, the Chief of the Indian Air Force announced that India had begun work on the "conceptualization" of weapon platforms in space,[182] though he later retracted this statement.[183] Both China and the US expressed concerns about each other's space programs. China expressed new flexibility within the Conference on Disarmament with respect to the possible mandate to address the issue of Preventing and Arms Race in Outer Space. U.S. officials stated that China's manned space program was directly linked to efforts to enhance their security interests and would "contribute to improved military space systems in the 2010-2020 timeframe."[184] Justification for this assessment appeared

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[171] William Burrows in Air&Space Aug 1996 http://www.airspacemag.com/asm/Mag/Index/1996/AS/nmlm.html; Henry F. Cooper *Why Not Space-Based Missile Defense?,* Wall Street Journal/May 7, 2001 http://www.highfrontier.org/wsj_may7_01.htm .
[172] Worden, personal communication.
[173] Kelly, Jack. Possible space weapons of the Future. July 28 2003 Pittsburgh Post-Gazette.
[174] *Russia Statement to CD*, 28th June 2003 http://disarmament.un.org:8080/cd/cd-docs2002.html .
[175] Leonard David, "China's Space Ambitions Keep Western Experts Guessing." Space.com. July 8, 2002. http://www.space.com/missionlaunches/storming_heaven_020708-1.html .
[176] *China Statement to the CD*, February 7 2002, http://www.acronym.org.uk/docs/0202/doc05.htm .
[177] Missile Defense Agency, Fiscal Year (FY) 2004/FY 2005 Biennial Budget Estimates Submission, Press Release, January 2003, p. 16.
[178] Kerry Gildea, *Missile Defense Agency's Space-Based Boost Phase Program Put On Hold* Defense Daily, Aug. 1, 2003.
[179] *Missile Defense Test Fails, But Congress Approves FY04 Budget,* UCS Update, 27 June 2003 http://www.ucsusa.org/global_security/armsnet/page.cfm?pageID=1220 .
[180] *Falcon Technology Demonstration Factsheet,* DARPA, http://www.darpa.mil/body/NewsItems/pdf/falcon_fs.pdf
[181] Hitchens, Theresa, *Developments in Military Space: Movement Towards Space Weapons?* presented to the workshop on "Outer Space and International Security: Options for the Future," October 29, 2003.
[182] *India Working on Space Weapons: IAF Chief,* Rediff.com, October 03, 2003. http://ushome.rediff.com/news/2003/oct/06iaf1.htm?zcc=ar .
[183] *Space will not be used for arms delivery,* The Hindu, Nov. 1, 2003 http://www.hindu.com/2003/11/01/stories/2003110102181200.htm .
[184] *Annual Report on the Military Power of the People's Republic of China,* United States Department of Defense, July 28, 2003. p.37 http://www.defenselink.mil/pubs/20030730chinaex.pdf.

to be provided by a Chinese report which stated "for countries that can never win a war with the United States by using the method of tanks and planes, attacking the U.S. space system may be an irresistible and most tempting choice."[185] With the reaction of India, these developments highlighted the potential for negative action-reaction cycles that have, in the past, played a role in arms races.

Space Security 2003: Key Assessments

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Question: Taking into account your views on developments within doctrine, orbital bombardment and space-based missile defences) in the in past, how have overall changes in this area affected space security?	*Question: In your view, space security with respect to this indicator has been?*
Enhanced : 1 Somewhat enhanced : 7 Little or no effect : 15 Somewhat reduced : 20 Reduced : 35	Enhanced : 0 Somewhat enhanced : 0 Little or no effect : 7 Somewhat reduced : 12 Reduced : 1

The SSWG assessed that, according to available information, no Space-Based Strike Weapons (SBSW) were deployed in space during 2003, and only a few states possessed any of the key capabilities required for SBSW systems. The SSWG assessed that while space actors continued to enjoy access to and use of space for a wide variety of important functions, the sustainability of this access and the degree to which states believed they will continue to enjoy freedom from space-based threats remained an issue of significant concern for many space security actors. US Missile Defence Agency plans to develop and deploy a space-based interceptor test bed early in the next decade were frequently cited in relationship to these concerns as was what appeared to be a growing tendency among US officials to regard the weaponization of space as inevitable, and, for some, desirable. The reaction to these apparent trends by Chinese and Indian officials underscored the risk that other space security actors were beginning to assume that space would inevitably become weaponized and were beginning long term planning on this assumption. This highlighted the potential for a negative action-reaction cycle similar to those which animated arms competitions during the Cold War. **As a result, while no space-based strike weapons were deployed in place in 2003, concern over possible future developments led to an overall assessment that space security had been somewhat reduced during 2003 with respect to this indicator.**

[185] Wang Hucheng, *The US Military's 'Soft Ribs' and Strategic Weaknesses* Beijing Xinhua Hong Kong Service, July 5, 2000.

ANNEX A: Participants, Space Security Working Group (SSWG) Washington Meeting, March 6-7, 2003

Ms. Susan Eisenhower, President of The Eisenhower Institute, member of the International Space Station Management and Cost Evaluation Task Force (the Young Commission), former member of the NASA Advisory Council.

Dr. Charles D. Ferguson, Scientist-in-Residence, Center for Nonproliferation Studies, Monterey Institute of International Studies.

Professor Joanne Gabrynowicz, Director, National Remote Sensing and Space Law Center, University of Mississippi School of Law.

Ms. Rose Gottemoeller, Carnegie Endowment for International Peace.

The Honorable Thomas Graham, Jr., Morgan, Lewis & Bockius LLP.

Lt. Colonel Peter L. Hays, USAF, Executive Editor, Joint Force Quarterly, Fort Lesley J. McNair.

Ms. Theresa Hitchens, Vice President, Center for Defense Information.

Ms. Rebecca Johnson, Director, Acronym Institute for Disarmament and Diplomacy.

Mr. David A. Koplow, Director, Center for Applied Legal Studies, Georgetown University.

Dr. Andrew Latham, Assistant Professor, Department of Political Science, Associate Director, Center for Scholarship & Teaching, Macalester College.

Dr. Robert Lawson, Senior Policy Advisor, Non-Proliferation, Arms Control and Disarmament, Department of Foreign Affairs and International Trade, Canada..

Mr. Robert McDougall, Director, Non-Proliferation, Arms Control and Disarmament, Department of Foreign Affairs and International Trade, Canada.

Mr. Michael Moore, Senior Editor, Bulletin of the Atomic Scientists.

Dr. Dennis Papadopoulos, Professor in the Departments of Physics and Astronomy at the University of Maryland.

Dr. Ernie Regehr, Executive Director, Project Ploughshares.

Dr. Roald Sagdeev, Distinguished University Professor and Director of the East-West Space Science Center at the University of Maryland, former Director of the Space Research Institute in Moscow, former Director of the International Mission to Halley's Comet and former advisor to Soviet President Mikhail Gorbachev on the Strategic Defense Initiative.

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Dr. Michael I. Yarymovych, ANSER Analytic Services, Inc., President of the International Academy of Astronautics and former Vice President of International Technology and Advanced Systems of the Boeing Company.

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Mr. Tyler Nottberg, Program Officer, The Eisenhower Institute.

Mr. Andrew Park, Project Officer, The Eisenhower Institute.

ANNEX B: Participants, 2nd Annual Meeting of the Eisenhower Institute Expert Advisory Panel, Paris, April 1-2, 2003.

Dr. V.S. Arunachalam, Former Defense Science Advisor for the Government of India, former advisor to Prime Minister Rajeev Gandhi.

Dr. Roger Bonnet, former Scientific Director of the European Space Agency, Director of the International Institute of Space Research, Bern, Switzerland.

Dr. Jacques Blamont, Scientific Advisor to the Chairman, Centre National d'Études Spatiales, France.

Dr. Hubert Curien, President of the French Academy of Sciences, former President of CNES and former French Minister of Science and Technology.

Ms. Susan Eisenhower, President of The Eisenhower Institute, member of the International Space Station Management and Cost Evaluation Task Force (the Young Commission), former member of the NASA Advisory Council.

Dr. Kerstin Fredga, Chair, Alfvén Laboratory, The Swedish Royal Institute of Technology (KTH); former director of the Swedish Space Agency; Executive Secretary of the Swedish Space Board; Chairman, Space Science Council of the European Space Agency; and President of the Royal Swedish Academy of Sciences.

Dr. Robert Lawson, Senior Policy Advisor, Non-Proliferation, Arms Control and Disarmament, Department of Foreign Affairs and International Trade, Canada.

Dr. André Lebeau, President of the French Meteorological Society.

Dr. Reimar Lüst, former President of Max Plank Gesellschaft, and former Director General of the European Space Agency.

Dr. Vittorio Manno, Program Manager of the International Space Science Institute in Bern, Switzerland; former Senior Scientist at the European Space Agency's Science Directorate.

Dr. David Mutimer, Deputy Director, Centre for International and Security Studies, York University, Canada.

Dr. Dennis Papadopoulos, Professor in the Departments of Physics and Astronomy at the University of Maryland.

Dr. Roald Sagdeev, Distinguished University Professor and Director of the East-West Space Science Center at the University of Maryland, former Director of the Space Research Institute in Moscow, former Director of the International Mission to Halley's Comet and former advisor to Soviet President Mikhail Gorbachev on the Strategic Defense Initiative.

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ANNEX C: Participants, Space Security Working Group Meeting, Washington, November 24-25, 2003

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Ms. Susan Eisenhower, President of The Eisenhower Institute, member of the International Space Station Management and Cost Evaluation Task Force (the Young Commission), former member of the NASA Advisory Council.

Ms. Sarah Estabrooks, Project Ploughshares, Institute of Peace and Conflict Studies.

Professor Joanne Gabrynowicz, Director, National Remote Sensing and Space Law Center, University of Mississippi School of Law.

Mr. Graham Gibbs, Canadian Embassy, Space Affairs/CSA.

The Honorable Thomas Graham, Jr., Morgan, Lewis & Bockius LLP.

Lt. Colonel Peter L. Hays, USAF, Executive Editor, Joint Force Quarterly, Fort Lesley J. McNair.

Ms. Theresa Hitchens, Vice President, Center for Defense Information.

Mr. David A. Koplow, Director, Center for Applied Legal Studies, Georgetown University.

Dr. Andrew Latham, Assistant Professor, Department of Political Science, Associate Director, Center for Scholarship & Teaching, Macalester College.

Dr. Robert Lawson, Senior Policy Advisor, Non-Proliferation, Arms Control and Disarmament, Department of Foreign Affairs and International Trade, Canada.

Dr. John Logsdon, Director, Space Policy Institute, George Washington University.

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Mr. Michael Moore, Senior Editor, Bulletin of the Atomic Scientists.

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Dr. Dennis Papadopoulos, Professor in the Departments of Physics and Astronomy at the University of Maryland.

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Mr. Kevin Power, European Competitive Telecommunications Association.

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Government Consultations with Civil Society on Issues Related to International Security, Nuclear Weapons and Other Weapons of Mass Destruction and their Delivery Systems

IDD Scenario for the Opening Session 0900-1015 hrs, Robertson Room, DFAIT

You will chair the opening session where MJW will make a presentation to be followed by a question and answer period.

There are four distinct groups represented at these consultations. Academics, NGOs, government officials, and youth (the recipients of the Simon's Centre/DFAIT graduate research awards.) This is the second set of consultations in this current cycle of semi-annual consultations.

The steering committee has chosen fewer agenda items and fewer participants for these consultations with the expectation that this will facilitate more detailed and substantive exchanges of views.

Following your chosen words of welcome you may wish to invite participants to introduce themselves.

You may wish to remind participants of the following:

- Participants will have been provided with the latest version of the agenda for the meeting in their consultation packages. We have also included in their packages any papers that have been provided to us for distribution to participants.

- Simultaneous translation is being provided in both official languages, and participants should feel free to express themselves in the language of their choice.

- The consultations and the public report of the consultations that will be prepared will follow the "Chatham House Rule". This means participants are free to use the information and views received during the event, but that no individual contributor or participant can be quoted, or their identity or affiliation revealed, without their express permission.

- We will maintain a speakers list to provide some order to our discussions. If you wish to make a point in 'hot pursuit' of a point please raise two fingers. If you simply wish to placed on the speaker list for a related but not urgent point please raise you hand.

- Any administrative or substantive concerns regarding the consultations can be directed to Bob Lawson or William Henry Mcken.