

CONFERENCE PROCEEDINGS

RAND

Toward Fusion of Air and Space

*Surveying Developments and
Assessing Choices for
Small and Middle Powers*

Dana J. Johnson and Ariel E. Levite, editors

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*Prepared for the
Fisher Institute for Air and Space Strategic Studies*

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The contemporary international security environment is increasingly volatile. It is also characterized by the rapid acceleration of technological change and the growing availability and proliferation of advanced commercial technologies and systems. These developments have led to the rethinking of military doctrine, the wider application of these technologies and systems to operational exercises, and complications for interoperability among coalition partners with differing technological capabilities.

These developments assume special significance in the domain of space, as this domain has come to acquire a broad and unique appeal as offering tangible and public advantages. Many nations, including a growing number of small and medium powers, are thus presently confronting important choices in deciding how to proceed in their space activity. Specifically, they commonly debate whether and how far to go in acquiring independent aerospace capabilities, whether to depend on other nations for aerospace support, whether potential costs and vulnerabilities are incurred for those relationships, and whether they are willing politically to accept both the benefits and the risks of dependence. Prudent decisions in this area clearly require a deep understanding of what commercial and technological developments are occurring in the utilization of space, as well as what is involved in integrating commercial and civil aerospace systems and technologies into military operations and organizations in order to determine which national courses of action to pursue and which to avoid.

The choices made by this fast-growing number of small and medium powers are not only affected, but also increasingly affect the space pursuits of the bigger and more established space powers. It is this background that has inspired RAND and the Fisher Institute for Air and Space Strategic Studies to hold an international conference focusing on the space activities and choices faced by small and medium powers.

This document presents the proceedings of this conference held March 19–21, 2001, in Tel Aviv, Israel, and cosponsored by RAND and the Fisher Institute for Air and Space Strategic Studies, in collaboration with the Israeli Air Force and the Israel Space Agency. The conference addressed developments in both national and international security and the commercial space community, with specific emphasis on the strategic choices facing small and medium powers. Conference speakers included a broad cross section of international government, academic, and industry

experts. The conference was attended by representatives from approximately 25 countries.

RAND supported this conference through the use of internal funds and within the National Security Research Division (NSRD). NSRD conducts research and analysis for the Office of the Secretary of Defense, the Joint Staff, the Unified Commands, the defense agencies, the Department of the Navy, the U.S. intelligence community, allied foreign governments, and foundations. The papers presented in this document should be of broad interest to government, military, and industry readers who follow international air and space issues and trends affecting global and national security.

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RAND and the Fisher Institute for Air and Space Strategic Studies, in collaboration with the Israeli Air Force and the Israel Space Agency, organized and hosted a conference in Tel Aviv, Israel, in March 2001 that brought together a wide range of perspectives and insights on air and space issues pertaining to national security. The title of the conference was "Toward Fusion of Air and Space: Surveying Developments and Assessing Choices for Small and Middle Powers." This document collects the presentations delivered at that conference.

The conference addressed developments in both national and international security and the commercial space community, particularly in the growing connection among governmental, international, and commercial interests. The keynote speech and tone for the conference were set by retired United States Air Force Chief of Staff, General Ronald R. Fogleman. Noting that multinational operations are becoming the norm for a full range of activities—from humanitarian relief, response to natural disasters, and peacekeeping to coalition warfare—General Fogleman observed that the growth and demonstrated effectiveness of air and space capabilities worldwide are forcing nations to make critical decisions about where and how to invest national resources to protect their national interests. Of particular interest to this conference are the strategic choices available to small- and medium-sized powers in view of their national interests; the availability of technologies, systems, and resources; and the opportunities to cooperate or collaborate in such pursuits. The fusion of air and space expands the range and complexity of those opportunities, as was illustrated in the presentations given during the conference.

Background, Purpose, and Organization of the Conference

The conference was organized along the following topics:

- *Military and Commercial Space Realities: a tour d'horizon* of the technological, economic, and security environments, including current international security requirements, national interests, and potential vulnerabilities; the growth in the commercial space sector (international and indigenous); regulatory and legal issues and trends; and the implications for the defense industrial base, particularly from an American viewpoint. Speakers for this panel included Major General William R. Looney III, U.S. Air Force Space Command, 14th Air Force Commander, and component commander, USAF Space Operations, United States Space

Command; Colonel James D. Rendleman, USAF, Headquarters, United States Air Force; Kevin O'Connell, RAND; John P. Barker, U.S. Deputy Assistant Secretary of State for Nonproliferation Controls, U.S. Department of State; and Scott Pace, RAND.

- *Additional Perspectives:* a presentation of additional perspectives on space strategy and developments by other significant powers involved either in space programs and/or in exploiting space militarily and commercially as well as in setting the norms for doing so, such as Russia, China, and Europe. Speakers on this panel included Grigori Chernyavsky, director and chief designer at the Center for Program Studies, Rosaviakosmos, and corresponding member of the Russian Academy of Sciences; Xavier Pasco, Foundation for Strategic Research, Paris, France; and Joan Johnson-Freese, Department of Transnational Studies, Asia-Pacific Center for Security Studies, Honolulu, Hawaii.
- *Additional Dilemmas and Opportunities:* discussions on understanding the implications and challenges of trends in space-related international law and arms control for the conduct of military operations, either unilaterally or in coalition operations; addressing the risks and opportunities of space activities for the Middle East; and the use of commercial satellite imagery for conflict resolution. Contributors to this topic were Lieutenant General Johan Kihl, Swedish Armed Forces; Paul Meyer, Director-General, International Security Bureau, Department of Foreign Affairs and International Trade, Ottawa, Canada; Gerald Steinberg, Bar-Ilan University, Israel; and John C. Baker, RAND. Further illumination on additional dilemmas and opportunities for air and space power were offered by Serge Plattard, director of International Relations at CNES (the French space agency) at lunch the first day of the conference.
- *Strategic Choices for Small and Medium Powers:* insights from experiences and ongoing programs and activities of a set of diverse small and medium powers. The panel focused on the strategic dilemmas in aerospace capabilities facing nations of similar size and capabilities, and identifying national, regional, and commercial implications for coalition military operations. Specific effort was made to identify the trade-offs of various choices in space strategy available to those small and middle powers, such as relying on traditional sources or capabilities provided by major space powers, undertaking collaborative approaches to developing and procuring aerospace capabilities, or encouraging growth in indigenous commercial, military, and/or dual-use space capabilities. Speakers included U. R. Rao, member, Space Commission, Department of Space, India; Hong-Yul Paik, director of the Satellite Operation Center, Korea Aerospace Research Institute, South Korea; Demetrio Bastos-Netto, chief of the Combustion and Propulsion Laboratory, INPE-CES, Brazil; Roy Sach, director, Defence Space Engagement, Department of Defence, Australia; Tetsuo Tamama, senior researcher, Defense Research Center, Japan; and Dana J. Johnson, RAND.
- *Space Vision and Policy Options—Israeli Perspectives:* a case study of small and medium powers, this discussion focused on the challenges and opportunities facing Israel's space community, including research and development (R&D) issues, operational issues, and economic and commercial interests. Speakers in-

cluded Major General (Res.) Meir Amit, Israel; and Major General Dani Haloutz, commander of the Israeli Air Force.

In addition to the 11 nations represented on the panels, officials from more than 25 countries were in attendance, offering overall a good cross section of both established and developing air and space powers and emerging issues affecting all. After the presentations, an Israeli industry day was held at which representatives from many of Israel's prominent air and space industries provided overviews of their programs and trends. Representatives from the Israel Aircraft Industries (IAI) discussed new trends in mini-satellites, such as IAI's Ofeq (Horizon) program of small satellites; the EROS satellite program; and the involvement of IAI in manufacturing, testing, and integrating various Israeli government and commercial satellite systems. Officials from Electro-Optics Industries, Ltd. (Elop) also gave overviews of their programs and described their electro-optics research in lasers, thermal imaging, space systems, airborne reconnaissance, E/O payloads, and displays. Elop's work has included standoff, long-range, airborne reconnaissance systems that rely on oblique views for collecting data in both day and night environments. A tour of both IAI and Elop facilities was given to conference participants.

Emerging Insights and Observations

Some of the insights and developments that emerged from the presentations and discussions included the following points:

- A clear "race" for presence in and utilization of space is under way worldwide, with diverse technological and economic levels of emphasis and sophistication as well as strategic and political orientation. This "race" is not the same as what was commonly termed the "U.S.-Soviet space race," but one that is much more complex and far-reaching among all nations, not just a few.
- This "race" is driven by a myriad of pressures, from national prestige to strategic and economic advantage, to commercial and financial opportunities, operational requirements, and technological realities. It is encouraged by lower barriers to entry and more widespread utilization by non-space-faring nations for more than purely space applications. For example, applications of positioning/navigation/timing activities enabled by the Global Positioning System (GPS) in many respects far outstrip the immediate military benefits of the system—indeed, GPS is considered critical to the U.S. national infrastructure and a global utility.
- Nevertheless, access to space remains a very costly proposition, and a fundamental problem barring greater utilization of space is lowering the cost of access, i.e., space launch. The possibility exists for small and medium powers to gain direct access to space through the development of launch vehicles, but it may be in their strategic and economic interests to pursue collaborative activities, whether of a national security, civil, or commercial nature.

These trends can also be viewed in concert with continuing developments in the aviation sector both historically and more currently in the use of air capabilities to support national security and military operations. Many of the challenges facing the expanded utilization of space are similar to those faced by the aviation community in the early days of the airplane nearly 100 years ago. Today, the operational, organizational, and economic implications of integrating air and space assets are beginning to be addressed for their potential advantages in enhancing national security and collaborative activities among nations. In short, we are witnessing a broad and rapidly evolving international trend of fusing air and space.

Military and Commercial Space Realities

The points above were amply illustrated and defined within individual national contexts by the range of speakers. From an American perspective enunciated by several speakers on the first panel, the policies, legal ramifications, assumptions, and guiding principles behind U.S. efforts in space, particularly from a national security sense, contribute to developing constructive security relationships in space cooperation. The U.S. military has defined "space power" as "the capability to exploit space forces to support national security strategy and achieve national security objectives. It involves the exploitation of civil, commercial, intelligence, and national security space systems and associated infrastructure to support national security strategy and national objectives from peacetime through combat operations." U.S. utilization of space for a number of critical national security purposes will grow due to *access* (to denied areas), *precision* (location, rapid delivery, and strike), and "*full-spectrum operations*" ("spectrum" in this sense meaning a range of operations across the spectrum of conflict) enabled by space systems. Situation awareness is also enabled through the combined utilization of information derived from air- and space-based platforms and enables military forces to carry out effective, measured, and both peacekeeping and lethal operations.

However, with an evolving and dynamic international security environment in which U.S. forces are likely to operate worldwide, the U.S. must leverage technological and operational resources of allies and coalition partners in geographically, economically, and technologically diverse theaters. This includes space systems. Yet interoperability among coalition partners, especially in space, is likely to be difficult to achieve, largely because of existing restrictions from technology transfer and export control laws and regulations; technological differences; cultural factors; language barriers; and differing levels of readiness, training, and personnel among the coalition partners. As was discussed in the first panel, the United States adheres to certain legal mechanisms, including export control laws and regulations, that guide and shape cooperation and planning for the use of air and space capabilities in bilateral and multilateral relationships. A number of considerations need to be kept in mind when considering the transfer of key technology to support the formation of a coalition, including the effect of technology transfer upon regional stability and whether the coalition partner can operationally employ the capabilities offered by the United States in pursuit of coalition objectives.

The market context and contribution of commercial applications of payloads and services—particularly commercial space-based remote sensing, to coalition operations and, more broadly, to meeting the needs of the larger information market—were addressed by several panel members. Many speakers observed that space-based remote sensing, or imagery, has evolved from being primarily a government-only or government-dominated activity to one having wide commercial applications, although no “killer application” for commercial remote sensing (CRS) has been identified and the uncertainty of future information-economy supply and demand makes raising capital problematic. Furthermore, competition with non-space information sources (such as aerial photography) and other challenges (including the high-profile launch failures of several CRS firms) have slowed the growth of the industry. Governments also have affected the market, depending on both policies put in place that either encourage or inhibit government purchase, use, and reliance on CRS, and actions such as licensing and shutter control that may ultimately restrict commercial opportunity and competition while protecting national security interests. Bottom line: The commercialization of remote sensing from space has been both dynamic and volatile—dynamic in the numbers of commercial firms seeking to enter the information technology (IT) market, and volatile in the uncertainty among governments about how best to regulate an evolving industry. To be successful in the future, CRS must find its proper niche as a part of the broader IT market, and enjoy both greater technological success and greater support by government regulation—or at least less uncertainty as to the limits imposed on it.

Beyond CRS, space-related activities like telecommunications and GPS-related applications have seen varying success. Revenues from commercial space activities such as satellite manufacture, space launch, ground equipment, and services have been estimated to exceed \$100 billion per year.¹ While some sectors are growing faster than others, the overall average compound growth rate has been about 9 percent per year. This is in contrast to U.S. government spending, which has been relatively flat in real-dollar terms. Thus, over time, the importance of the commercial activities to the economy has become more important relative to the size of public space activities. One speaker observed a resulting cultural shift in the U.S. space industrial base, which is becoming more responsive to global market forces than to government contracts alone. Accurate prognostications about future market growth have been notably unsuccessful, and developments in applications such as those generated by GPS, direct broadcast audio, and mobile satellite services (MSS) were unforeseen. Areas of future international commercial competition and conflicting national interests lie in space launch, in European pressures to fund and develop Galileo as a viable alternative to GPS, and in spectrum, used by all satellites regardless of function. Global transparency—when people and organizations are able to acquire information and communicate across political and geographical borders easily and more effectively—poses not only new opportunities for fusion of information derived from space, air, and other terrestrial platforms, but also creates security risks through exposure of military operations and sensitive facilities. This perhaps

¹International Space Business Council, *1999 State of the Space Industry* (Arlington, Va.: ISBC with KPMG Peat Marwick, Space Publications, 1999).

represents the ultimate tension between public- and private-sector interests, and ultimately has a bearing on the strategic choices available to all nations for air and space capabilities, products, and services.

For the United States, maintaining military advantages through the use of space systems is necessary to the execution of national security strategy. However, the execution of that strategy is shaped not only by limited resources but also by access to commercial space technologies and the market. High technology itself creates vulnerabilities off the battlefield as well as advantages on it—requiring that the U.S. defense community must consider incentives to reduce the gap between military and commercial requirements in space. Deterring conflict or prevailing should deterrence fail requires attention to the underlying commercial and technical forces that increasingly determine advanced military capabilities. For regional powers, security requirements may not be global, but budgetary limits are likely to be more severe than for the United States, thus necessitating harder strategic choices about where to place those scarce resources. Multilateral cooperation in practical civil applications of space technologies can serve to strengthen alliance relationships as well as build ties among potential adversaries, thus enhancing regional stability.

For both regional and global powers, space “utilities” such as GPS and satellite communications can be exploited by adversaries in asymmetric threats across the spectrum of conflict. Increasing technical gaps between conventional forces of allied countries pose a particular problem for the use of space systems for coalition or allied command, control, communications, and intelligence (C3I). Oftentimes, international responses to crises become “coalitions of the willing” rather than formal allies, with the result being interoperability problems that can only be alleviated through attention to doctrine, organization, exercises, and training in using space capabilities. Greater use of commercial space capabilities can enhance standardization and interoperability at affordable cost, if potential vulnerabilities from commercial dependency can be understood and managed. Efforts by national security communities to address common international and domestic dependencies on dual-use systems and technologies can help to “shape the future battle space” to enhance both international space cooperation and to more effectively and efficiently utilize space capabilities in pursuit of international security issues and problems.

Additional Perspectives, Dilemmas, and Opportunities

Other perspectives on the role and contribution of space power in an international context were offered by the second conference panel. For example, French space policy is shaped by a number of “balancing factors.” These balancing factors include the Franco-European relationship in the programmatic domain (i.e., in a unified European policy); and the evolving military-civilian space relationship in France as illustrated in programs such as the Pléiades program, which was designed by CNES (the French space agency) but has national security users. The key notion is for France to be able to build a coherent approach at the European level that provides sufficient autonomy to any European military endeavor both without building unnecessary new military tools that may duplicate those existing in other alliances

such as NATO, but also without giving up completely the military type of capability that remains at the center of what the French view as national sovereignty. Finally, a third balancing factor is the national-global relationship where systems developed for national purposes may contribute as regional resources or play complementary roles in larger military architectures such as NATO's.

Developing indigenous space programs is a complex process, as shown by the case of China. China's primary requirements for development of an indigenous space capability have been similar to those of the United States and Russia, yet the distinguishing feature has been money (due to poor Chinese economic performance in the 1960s compounded by the Cultural Revolution and the national priority on developing nuclear capabilities). Political incentives generated by perceived national threats such as the U.S. Strategic Defense Initiative (SDI) and the competition with the Soviets provided the impetus behind a Cold War focus of Chinese defense policy. More recently, the Chinese, like others, have emphasized the link between the space and information fields, and have stressed the importance of economic development as the guiding principle for current Chinese space activities. Nevertheless, the dual-use nature of many space technologies provides the Chinese with potentially sophisticated capabilities for national security use. Hence, consideration of determining probable intentions should be maintained toward making meaningful assessments of potential use.

In addition to commercial market trends and factors identified above, a number of other issues—what the conference organizers termed “dilemmas”—also play important roles in the decisionmaking realm for not only the major space-faring nations but also the small and medium powers. One such dilemma is the transformation of existing military organizations and capabilities along the lines of the opportunities posed by the “revolution in military affairs” (RMA). Incorporating the advantages of transitioning to information-enabled military forces offers the benefits of advanced ITs to speed decisionmaking and improve force effectiveness and responsiveness. Space systems provide key elements to enable the RMA and allow a military organization to adopt network-centric warfare as its concept of operations. Conversely, this has important implications for interoperability of forces within international or allied coalitions. Another dilemma highlighted by one speaker is concerned with the role and contribution of arms control measures as tools to shape the policy and operational realms of space, and to inhibit the use of space for the deployment of conventional or other weapons. Existing arms control and international space law could in theory be extended as part of a cooperative international regime safeguarding the peaceful exploitation of space.

Finally, another dilemma concerns the potential for dual-use space systems, such as imaging satellites, to either enhance or exacerbate regional tensions in areas such as the Middle East. In the view of one speaker, “[I]nstead of contributing to confidence building, high-resolution commercial imaging also has the potential for aggravating conflicts and international instability, changing the balance of power, sharpening existing asymmetries in military capabilities, and making regional and international conflicts harder to manage.” Another speaker countered by suggesting that the utility of information derived from commercial imagery can contribute to resolving

border and other disputes between nations, such as in the negotiation of the Dayton Accords in 1995 and the Ecuador-Peru border resolution in 1998. Nevertheless, full exploitation of commercial imagery is largely dependent upon the ability of nations to decipher that information accurately and in the timeliness required for intelligence-gathering or military missions; this, in turn, requires a certain level of technical sophistication and appreciation for the skills and operational experience required for imagery analysis.

Strategic Choices for Small and Middle Powers

As previously discussed, this conference's theme was to examine the strategic choices available to small and middle powers concerning exploitation of space. The choices available to these nations include indigenous development of aerospace capabilities, continued reliance on the major space-faring nations for those capabilities, reliance on commercially available space systems and technologies, or some combination of these choices. Each choice carries both advantage and risk: advantages in enabling national security activities either unachievable or inconceivable before, and risks in creating potential vulnerabilities and dependencies that previously did not exist so prominently. Individual national choices will be made on the basis of national security concerns and priorities, available resources, and other factors such as enhancing national prestige.

The speakers on this panel examined these issues from their individual national perspectives, and in toto represented a good cross section of the range of potential courses of action to be considered.

Korean choices in air and space development are driven by the view of national needs and a technology development strategy. These are shaped by the geopolitical and strategic situation that Korea occupies in the Far East. While Korean technologies are fairly sophisticated, Korean industries face extensive commercial competition, both in the airplane market and in space satellite development. Korea's goal is to become one of the top ten space-faring nations by 2015, and to do this Korea is developing an indigenous rocket launch and satellite capability, including space-based science, communications, and imagery, facilitated by a mid-entry strategy characterized by "smart selection" based on strategic interest and cost-effectiveness.

Brazil's experience is a combination of indigenous development in space applications and launch vehicle technology, and a strategy of enhanced cooperation with other countries. It is relatively mature in remote sensing and meteorology, has a reasonable foundation in space technology and engineering, and enjoys growing participation by Brazilian industry in space projects. Like other countries, Brazil has shifted emphasis from military programs to civilian applications of dual-use technologies. Brazil also sees its regional position as important; the country follows basic principles of finding and filling niches based on its unique geolocation and internal needs, and enhancing integration within international programs through scientific and technological cooperation.

Australia chooses to focus its space activities on its traditional long-term and highly successful alliance relationship with the United States, both to enrich the relationship and to support interoperability between U.S. and Australian military forces. For the most part Australia relies, militarily, on collaborative and coalition space arrangements. Where it does have exclusive space resources, they tend to be acquired by leasing or perhaps buying components of more extensive systems. Australia does not yet have a space launch capability, despite several past attempts at space launch business ventures involving favorable Australian access to the equator. Much of its space-relevant military expertise is concentrated on acquiring, analyzing, and distributing space-sourced data. In view of the developing Australian and worldwide commercial space market, the complexities of coalition arrangements and space engagement concerns pose critical implications for such matters as the vulnerability of critical aspects of the infrastructure and formulating appropriate and practical approaches to those vulnerabilities.

Finally, Japan's perspective is a unique one, fitting both the small power view in terms of size, population, and geography, and the view of an economic superpower in terms of gross national product. Japanese sensitivity on defense and national security influences its perspectives on aerospace as well and places a distinctive barrier between the civil and national security communities (the latter being a very small minority). This is especially visible in space activities, with the basic tone of Japanese space activities following the principle laid down in the "Peaceful Use of Space" Diet Resolution of 9 May 1969. The resulting effect is that Japan is small among the developed nations in aerospace ratio to GDP, and while the Japanese aircraft industry is heavily dependent on the domestic defense market, the space industry and defense are almost unrelated.

Final Observations and Conclusions

As a result of the conference, a number of observations and preliminary conclusions that have broader implications for the international security community can be made. Briefly, offensive and defensive military capabilities are increasingly available to small and medium powers and, in some cases, to nonstate entities as well. This availability dilutes the strategic advantage and exclusivity to space that major powers possessed, and enables smaller powers to engage in international affairs once considered the purview of the superpowers. As small and medium powers become increasingly reliant on space capabilities, however, their vulnerability to disruption of access to space also increases. Furthermore, as more nations and corporations become increasingly engaged in activities providing space-related goods and services to global markets, economic incentives may drive them toward initiatives that further regulate those activities. At the same time, however, efforts to increase global harmonization of space policy and activities may be increasingly complicated by competing individual national interests and commercial incentives.

This conference was important for generating a dialogue among the participants and for examining contemporary worldwide space activities, illuminating areas of common interest as well as areas of potential concern. If, as emerging trends indicate,

nations will collaborate more in the future against common threats yet continue to compete commercially, having a greater understanding of individual national interests and expectations is important to the success of that collaboration as well as to understanding motivations behind politically and economically driven decisions. Many small and medium powers have the technological potential, the political willingness, and/or the military and economic capability to be able to play important major roles in space, and to affect the course of events in space and on Earth. Determining what roles to play and the implications for international security will be the dominant theme for the next few years in international space activities.

CONFERENCE AGENDA

MONDAY EVENING, 19 MARCH 2001

Welcome Remarks

Major General (Res.), Hertzle Bodinger, Chairman of the Board, The Fisher Institute for Air and Space Strategic Studies

Jeffrey A. Isaacson, Vice President and Director, National Security Research Division, RAND

Aby Har-Even, Director, Israel Space Agency

Major General (Res.) Avihu Ben-Nun, President, Israeli Air Force Association

Major General Dani Haloutz, Commander of the Israeli Air Force

Opening Keynote Address: "VISIONS OF SPACE"

General Ronald R. Fogleman, former Chief of Staff, United States Air Force (Ret.)

Reception

TUESDAY, 20 MARCH 2001

08:00-08:30 *Informal breakfast*

08:30-08:40 **Welcome**

Brigadier General (Res.) Rafi Harlev, CEO of the Fisher Institute

Major General Dani Haloutz, Commander of the Israeli Air Force

08:40-10:25 **Session One: "MILITARY AND COMMERCIAL SPACE REALITIES"**

Moderator: Major General (Res.) Mordechai Hod, former Commander of the Israeli Air Force

The Role of Space in Military Operations: Imperatives and Vulnerabilities

Major General William R. Looney III, U.S. Air Force Space Command, 14th Air Force Commander, and component commander, USAF Space Operations, United States Space Command

International Military Space Operations and Cooperation

Colonel James D. Rendleman, Assistant Director for Space Operations and Integration, Deputy Chief of Staff/Air and Space Operations, USAF

Commercial Space Industrial Base: Status and Trends

William F. Ballhaus, Jr., President, The Aerospace Corporation, El Segundo, California²

Commercial Applications of Payloads and Services: Remote Sensing

Kevin O'Connell, RAND, Arlington, Virginia

U.S. Legal, Regulatory, and Policy Factors in Military and Commercial Space

John P. Barker, Deputy Assistant Secretary of State for Nonproliferation Controls, U.S. Department of State, Washington, D.C.

Emerging Challenges: National Security Requirements and Economic/Commercial Interests

Scott Pace, RAND, Arlington, Virginia

10:25–10:45

Coffee break

10:45–11:45

Session Two: "ADDITIONAL PERSPECTIVES"

Moderator: Uzi Arad, Director, Institute of Policy and Strategy, IDC Herzliya, Israel

The Role of Space in Global Security

Grigori Chernyavsky, Director and Chief Designer, Center for Program Studies, Rosaviakosmos, and Corresponding Member of Russian Academy of Sciences

²NOTE: As Dr. Ballhaus was unable to attend the conference, his briefing was presented by Dr. Scott Pace, RAND. The briefing is included in the Appendix to these proceedings, and appreciation is extended to The Aerospace Corporation for their support.

A Question of Balance: French Space Policy in the Global Age

Xavier Pasco, Foundation for Strategic Research, Paris, France

Requirements for Indigenous Military Capabilities: The Case of China

Joan Johnson-Freese, Department of Transnational Studies,
Asia-Pacific Center for Security Studies, Honolulu, Hawaii

11:45-12:00

Break

12:00-13:10

Session Three: "ADDITIONAL DILEMMAS AND OPPORTUNITIES"

Moderator: Ariel E. Levite, Head of the Scientific Advisory
Committee, The Fisher Institute

Revolution in Military Affairs: Choices for a Small Nation

Lieutenant General Johan Kihl, Director, Strategy, Plans, and
Policy, Swedish Armed Forces, Sweden

Arms Control Options in and from Space

Paul Meyer, Director-General, International Security Bureau,
Department of Foreign Affairs and International Trade, Ottawa,
Canada

*Dual-Use Aspects of Space Technology and the Implications for the
Middle East*

Gerald Steinberg, Bar-Ilan University, Israel

*Case Studies in Using Commercial Satellite Imagery for Regional
Conflict Resolution*

John C. Baker, RAND, Arlington, Virginia

13:15-14:30

Luncheon

**Luncheon Address: *Becoming a Space Power: A European
Perspective*, Serge Plattard, Director of International Relations,
CNES, Paris, France**

Moderator: Aby Har-Evan, Director, Israel Space Agency

14:30-16:15

**Session Four: "STRATEGIC CHOICES FOR SMALL AND
MEDIUM POWERS"**

Moderator: Major General (Res.) Eitan Ben-Eliyahu, former
Commander of the Israeli Air Force

Dilemmas in Space Strategy for Regional Powers

Professor U.R. Rao, Member, Space Commission, Department of Space, India

Hong-Yul Paik, Director, Satellite Operation Center, Korea Aerospace Research Institute, South Korea

Demetrio Bastos-Netto, Chief, Combustion and Propulsion Laboratory, INPE – CES, Brazil

Meeting Australia's Space Requirements Through Collaborative and Coalition Arrangements

Roy Sach, Director, Defence Space Engagement, Department of Defence, Australia

Japanese Aerospace and National Security

Tetsuo Tamama, Senior Researcher, Defense Research Center, Japan

Implications and Challenges for the Effective Use of Space

Dana J. Johnson, RAND, Washington, D.C.

16:15–16:30 *Coffee break*

16:30–17:45 **Session Five: "SPACE VISION AND POLICY OPTIONS: AN ISRAELI PERSPECTIVE"**

Moderator: Jeffrey A. Isaacson, Vice President and Director, National Security Research Division, RAND

Commercial Uses of Space: AMOS and Beyond

Major General (Res.) Meir Amit, Chairman of the Board, SPACECOM, Israel

Air and Space Strategy for Small Powers: Needs and Opportunities

Major General Dani Haloutz, Commander of the Israeli Air Force

WEDNESDAY, 21 MARCH 2001

09:00–13:45 **Session Six: "INDUSTRIAL PERSPECTIVES"**

Israeli and international industry presentations

14:45–18:30 **Session Six: "INDUSTRIAL PERSPECTIVES" (continued)**

Industrial site tours

ACKNOWLEDGMENTS

This conference would not have been possible without the generous support of the Fisher Institute for Air and Space Strategic Studies and RAND's National Security Research Division (NSRD). Grateful recognition and thanks go to Brigadier General (Res.) Rafi Harlev, president of the Fisher Institute; Jeffrey Isaacson, vice president of NSRD and director of the National Defense Research Institute (NDRI) at RAND; Major General Dani Haloutz, commander of the Israeli Air Force (IAF); and Aby Har-Even, director of the Israel Space Agency, for their generous support and contributions to making the conference a success. Major General (Res.) Hertzle Bodinger, chairman of the Fisher Institute, and Major General (Res.) Avihu Ben-Nun, president of the Israeli Air Force Association, also deserve thanks for their encouragement and support of the conference. The Boeing Company and a number of Israeli aerospace industries, including the Israel Aircraft Industries (IAI) and the Electro-Optics Industries, Ltd. (Elop), also provided generous financial support for the conference. The Herling-Weinberg Group, led by Avital Herling, provided excellent conference administrative support and handled with the highest degree of professionalism and courtesy the myriad of complex details that only a conference attended by representatives of more than 25 nations can bring.

RAND and the Fisher Institute are also particularly grateful for the participation of the speakers and their perspectives and insights, which made for a very enriching and thought-provoking conference. The speakers included many senior officials, policy analysts, and active-duty and retired military officers from the United States, Russia, France, Sweden, Canada, Israel, Brazil, South Korea, Japan, Australia, and India. In addition, the conference was attended by representatives from more than 25 countries, including those officials from foreign embassies in Tel Aviv, so it was truly an international conference in scope and approach.

The editors are also most grateful for the financial support and moral encouragement received by their RAND colleagues Jerrold Green, Rachel Swanger, and Nurith Berstein. Green provided critical funding and support in the preparation of the conference agenda, materials, and papers by the RAND participants, for which all of us are very grateful. Shivaulie Feliciano was indispensable in making the U.S. conference attendees' travel and other arrangements, and Amy Pett provided follow-up support after the conference. RAND Publications' staff, particularly Steve Baeck and Christopher Kelly, were also instrumental in seeing the document through to publication.

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—Dana J. Johnson and Ariel E. Levite

September 2002

ACRONYMS

AECA	Arms Export Control Act
ASAT	Antisatellite
BMD	Ballistic missile defense
CMC	Central Military Commission (China)
CNES	Centre National d'Etudes Spatiales
COSTIND	Commission on Science, Technology, and Industry for National Defense (China)
CRS	Commercial remote sensing
C2	Command and control
C3I	Command, control, communications, and intelligence
DBA	Dominant Battlespace Awareness
DBS-A	Direct Broadcast Service–Audio
DE	Dynamic engagement
DS	Decision superiority
EAA	Export Administration Act
ELOP	Electro-Optics Industries, Ltd.
EO	Executive Order
EOC	Earth observation camera?
EROS	Earth Remote Observation System
ESA	European Space Agency
ESDP	European Security and Defense Policy
FAS	Federation of American Scientists

FSU	Former Soviet Union
GEO	Geosynchronous Earth orbit
GIS	Geographic information systems
GLONASS	Russian Global Navigation Satellite System
GMES	Global Meteorological Environmental System
GOES	Geostationary Operational Environmental Satellites
GPS	Global Positioning System
GSD	Ground separation distance
GTGA	Government-to-government agreement
IAF	Israeli Air Force
IAI	Israel Aircraft Industries
IC	Integrated circuits
ICBM	Intercontinental ballistic missile
ISS	International Space Station
IT	Information technology
ITAR	International Traffic in Arms Regulation
ITU	International Telecommunications Union
KARI	Korea Aerospace Research Institute
LEO	Low Earth orbit
MEA	Multilateral environmental agreement
MEI	Ministry of Electronics Industry (China)
MII	Ministry for Information Industry (China)
MIRV	Multiple Independent Reentry Vehicles
MPS	Materials Processing in Space
MPT	Ministry of Post and Telecommunication (China)
MSC	Multispectral camera
MSS	Mobile Satellite Services
MST	Ministry of Science and Technology (China)
NASA	National Aeronautics and Space Administration

NIMA	National Imagery and Mapping Agency
NMD	National Missile Defense
NSDM	National Security Decision Memorandum
OSMI	Ocean-scanning multispectral imager
PDD	Presidential Decision Directive
PLA	People's Liberation Army
PNAE	Brazilian National Space Program
PNDAAE	National Policy for the Development of Space Activities (Brazil)
R&D	Research and development
RMA	Revolution in military affairs
SAIC	Science Applications International Corporation
SAR	Synthetic aperture radar
SDI	U.S. Strategic Defense Initiative
SDRS	Saudi Center for Remote Sensing
SOE	State-Owned Enterprises (China)
SPS	Science physics sensor
SSTC	State Science and Technology Commission (China)
SwAF	Swedish Armed Forces
UAE	United Arab Emirates
UAV	Unmanned aerial vehicle
UHR	Ultrahigh resolution
USAF	United States Air Force
USML	U.S. Munitions List
WMD	Weapons of mass destruction

CONFERENCE OVERVIEW AND OPENING KEYNOTE ADDRESS

CONFERENCE OVERVIEW

Ariel E. Levite and Dana J. Johnson

Background and Purpose

Since the end of the Cold War, the world has seen the emergence of a dynamic and evolving international security environment. This environment is characterized by increasing globalization as well as growing instability in the Middle East, South Asia, and other regions. Nations are faced with domestic political, budgetary, and economic pressures that have influenced not only alliance relationships but also their ability to conduct and support multinational operations such as humanitarian relief actions and peacekeeping.

In parallel with these environmental changes, a tremendous growth in air and space commercialization has occurred, with the potential not only to enhance but also to dramatically change national and regional economies. The rapid acceleration of technological change and the growing availability of advanced commercial technologies and systems have led to the rethinking of military doctrine, of the wider application of these technologies and systems to operational exercises, and of the complications for interoperability among coalition partners with differing technological capabilities. Nations are facing important choices in deciding whether to acquire independent aerospace capabilities, whether to depend on other nations for aerospace support, whether potential costs and vulnerabilities are incurred for those relationships, and whether they are willing politically to accept both the benefits and the risks of dependence. Understanding what is involved in integrating commercial and civil aerospace systems and technologies into military operations and organizations is also a necessary element of determining which national courses of action to pursue and which to avoid. Small and medium powers must take these considerations into account when faced with opportunities for exploiting air and space.

This document is the proceedings for a major international conference on air and space issues, cosponsored by the Fisher Institute for Air and Space Strategic Studies and RAND, in collaboration with the Israeli Air Force and the Israel Space Agency, held March 19–21, 2001, in Tel Aviv, Israel. The conference addressed developments in both national and international security and the commercial space community,

particularly in the growing connection among governmental, international, and commercial interests. The conference was organized along the following topics:

- *Military and Commercial Space Realities: a tour d'horizon* of the technological, economic, and security environments, including current international security requirements, national interests, and potential vulnerabilities; the growth in the commercial space sector (international and indigenous); regulatory and legal issues and trends; and the implications for the defense industrial base, particularly from an American viewpoint
- *Additional Perspectives: a presentation* of additional perspectives on space strategy and developments by other significant powers involved either in space programs and/or in exploiting space militarily and commercially as well as in setting the norms for doing so, such as Russia, China, and Europe
- *Additional Dilemmas and Opportunities: discussions* on understanding the implications and challenges of trends in space-related international law and arms control for the conduct of military operations, either unilaterally or in coalition operations; addressing the risks and opportunities of space activities for the Middle East; and the use of commercial satellite imagery for conflict resolution
- *Strategic Choices for Small and Medium Powers: insights* from diverse small and medium powers on the strategic dilemmas in aerospace capabilities facing nations of similar size and capabilities, and identifying national, regional, and commercial implications for coalition military operations. Specific effort was made to identify the trade-offs of various choices in space strategy available to those small and middle powers, ranging from relying on traditional sources or capabilities provided by major space powers, undertaking collaborative approaches to developing and procuring aerospace capabilities, or encouraging growth in indigenous commercial, military, and/or dual-use space capabilities.
- *Space Vision and Policy Options—Israeli Perspectives: a case study* of small and medium powers, presenting the challenges and opportunities facing Israel's space community, including research and development (R&D) issues, operational issues, and economic and commercial interests

Conference speakers included a broad cross section of international government, academic, and industry experts from 11 different countries. Attendees included representatives from more than 25 nations worldwide. Conference organizers hoped that the dialogue among the speakers and conference participants will contribute to enhancing the community's understanding of the opportunities and challenges facing small and medium powers as they seek to develop a balance among protecting their security interests, encouraging indigenous air and space capabilities, and exploiting commercial aerospace capabilities.

Emerging Insights and Developments

The following are some of the more notable space-related developments that emerged from the various presentations:

- A clear “race” for presence in and utilization of space is under way, involving many nations around the world—with diverse technological and economic prowess, as well as strategic and political orientation. Going beyond traditional space-faring nations, this “race” bears only partial resemblance to the “race to the moon” or “the U.S.–Soviet space race,” as it is only partly influenced by rivalry and competition between specific rivals or adversaries. More importantly, the force and motivation underlying it is driven by a widely and strongly felt imperative to conduct activities in space, whether for economic competition, national prestige, technological or strategic advantage, or to stay ahead of one’s adversaries or competitors or at least not to concede grounds to them.
- The “race” for space is driven by a myriad of political and strategic (military and other security) incentives, commercial and financial opportunities, operational requirements, and technological realities.
- This “race” is facilitated first and foremost by dramatically lower barriers to entry and/or utilization of space in terms of either the technological requirements or the economic barriers.
- Still, while utilization of space is, relatively speaking, much less costly now, access to space and sustained utilization of space remain a very costly proposition in absolute terms, and is one of the fundamental problems facing everyone. For small and medium powers this means that it is possible to play and benefit from activity in this heretofore-exclusive big power game. But this can be done in a serious and sustained way only through a combination of multilateral (or multinational) collaboration of some form, as well a synergy and growing overlap among civilian, commercial, and military (including launch) space activity.
- The “race” is evident across the board of space activities, ranging from space launchers and payloads to services providers and consumers and the scope and intensity of consumption.
- Most small and medium powers are still lagging far behind in utilizing the ever-growing opportunities inherent in space. Nevertheless, they are becoming increasingly aware of this deficiency and ever more determined and competent (but also dependent) on harnessing space for many of their activities, mostly but not exclusively in the security domain. These activities range from communication, navigation, and weather forecasting to intelligence collection and early warning.

These trends can also be viewed in concert with continuing developments in the aviation sector both historically and, particularly not in the least, in the use of air capabilities to support national security and military operations. Viewed in a historical perspective, current efforts and challenges to utilize space are reminiscent of the efforts to take advantage of the opening of the air for both civilian and military applications shortly after the turn of the previous century. And looked upon in a current perspective, the operational, organizational, and economic implications of integrating air and space assets, also termed “aerospace integration,” are beginning to be addressed for their potential advantages in enhancing national security and

collaborative activities among nations. In short, we are witnessing a broad and rapidly evolving international trend of fusing air and space.

Many implications flow from these developments that are worthy of careful consideration. These vary significantly between and across nations, and the ability to discuss them at length transcends the scope of the current volume. Below we highlight only a few of the broader and more generic implications:

- Offensive and defensive military space capabilities, previously almost exclusively the domain of the major powers, are now increasingly available to small and medium powers as well. These capabilities dilute at least some of the monopolistic advantages the big powers were able to derive from their exclusive access to space, and empower the smaller and medium powers to engage in activities well beyond their original reach.
- With few exceptions, the ability to derive benefits from access to space is thus increasingly dependent less on the technical access to unique space capabilities and much more on development of sophisticated and elaborate organizational arrangements and relationships, procedures, infrastructure, and skilled personnel for efficiently harnessing the benefits offered by various space assets. These arrangements and relationships cut across the national security, civil, and commercial "sectors" of space activities. (Dividing space into these "sectors" may, in fact, be solely a U.S. phenomenon, as distinctions between government-sponsored activities and so-called "commercial" space activities are much less demarcated in other nations.)
- The growing dependence of small and medium powers on utilization of space based on nonindigenous space assets is also creating an increasingly salient potential source of vulnerability to disruption of access.
- At the same time, the profound international implications of potential disruption to access may drive up dramatically the costs and risk associated with such a course of action.
- The expanding number of players involved in the development and marketing of space assets and services makes it increasingly difficult for any one nation to regulate the market and affect its future course to that nation's advantage. In fact, the freedom of action for any nation to do so is significantly diminished by such development, and attempts to do so involve significant security, financial, and industrial perils.
- For many nations and corporations involved in space activities or providing space-derived services and products, ever stronger economic incentives accompanied by increasing security pressures may lead them to pursue initiatives toward updating and expanding the realm of international norms governing the utilization of space or at least regulating some space activities.
- At the same time, the number and diversity of national, multinational, international, and commercial players in space appear to be creating growing complications and hurdles to harmonizing individual national policies on space activity as well as global harmonization of policy, namely, reaching new international

agreements on the utilization of space. Whether global harmonization of space policy and activities is desired or achievable in light of individual national interests is beyond the scope of this conference, but may be of interest to some governments.

In conclusion, the conference proceedings that follow provide a rare and valuable perspective. This conference was important for generating a dialogue among the participants and for examining contemporary space activities across the world, illuminating both areas of common interest as well as areas of potential concern. If, as emerging trends indicate, nations will collaborate more in the future against common threats yet continue to compete commercially, having a greater understanding of individual national interests and expectations is important to the success of such collaborations as well as to understanding motivations behind politically and economically driven decisions. Many small and medium nations have the technological potential, the political willingness, or the military and economic capability to play important major roles in space, and to affect the course of events in space. Determining what roles to play and the implications for international security will be the dominant theme for the next few years in international space activities.

Organization of This Document

This document is organized along the following lines. This chapter provides the contextual background and purpose to the conference, and includes the opening keynote presentation by General Ronald R. Fogleman, former Chief of Staff of the United States Air Force (USAF), which set the tone for the conference. General Fogleman offers a unique, historically based perspective on a number of critical issues facing not only the United States but also many other countries considering the acquisition and exploitation of air and space capabilities to support national objectives. Chapter 2, titled "Military and Commercial Space Realities," consists of primarily an American perspective of current issues facing military space operations, including international cooperation, regulatory and legal issues and trends, commercial applications of payloads and services with an emphasis on remote sensing, the space industrial base, and emerging challenges for balancing national security requirements and economic/commercial interests.

Chapter 3 offers additional perspectives on the contribution of space systems to the global security environment. The panel included representatives from Russia and France, and an American researcher examining requirements for indigenous military space capabilities, as exemplified by the case of China. Chapter 4, titled "Additional Dilemmas and Opportunities," includes a review of the Swedish implementation of the so-called "revolution in military affairs" (RMA); arms control options in and from space; a Middle East perspective on the costs and benefits of scientific, commercial, and dual-use space activities; and, finally, case studies using commercial satellite imagery for conflict resolution. Chapter 5 examines the strategic choices available to small and medium powers for space capabilities, and includes presentations from India, South Korea, Brazil, Australia, and Japan. Chapter 6 includes a perspective on

air and space strategy for small powers from the commander of the Israeli Air Force, Major General Dani Haloutz.

**OPENING KEYNOTE ADDRESS:
A VISION FOR AIR AND SPACE POTENTIAL
General Ronald R. Fogleman, United States Air Force (Ret.)**

Introduction/Agenda

Nearly three years ago, in this very hotel, I stood before another audience and confessed to be less qualified to speak on the appointed subject than many, if not most, of those in the audience. Some things just don't change! When I saw the list of participants for this conference I was struck by the depth and breadth of knowledge and the international flavor of the intellect that would be present. I congratulate the sponsors, The Fisher Institute for Air and Space Strategic Studies and RAND, along with the Israeli Air Force and Israel Space Agency.

I am clearly not the expert on the fusion of air and space power, but I have had the opportunity to broaden my knowledge of the subject by virtue of recently serving on two very interesting studies. The first was as a team member on the National Aeronautics and Space Administration (NASA)-sponsored review called "The Mars Program Independent Assessment Team." The most recent was service as a commissioner on the congressionally directed Commission to Assess United States National Security Space Management and Organization.

These two panels addressed disparate and apparently unconnected segments of the space community. In the first case, interplanetary exploration was the focus; in the second, the organization and management of U.S. national security space assets. In the United States, the first is defined by our civil agency, NASA, and the second shaped by our intelligence and defense agencies: the Central Intelligence Agency and the Department of Defense. Seemingly missing was the third major participant in the space arena: the commercial segment. I say "seemingly" because the commercial is in fact deeply involved and growing in importance to both space exploration and national security.

All segments of a national space program share certain attributes, challenges, and—by virtue of cost and availability—resources. The last time I spoke in Israel I focused my remarks primarily on the military advantages of having the capability to operate in, from, and through space. Clearly the objective of this conference is to go beyond that discussion. The conference agenda notes pointed out the fact that the end of the Cold War and subsequent globalization movement within the commercial space and information technology (IT) industries has led to a dynamic and still somewhat unfamiliar international security environment. Multinational operations are becoming the norm for everything from humanitarian relief, response to natural disasters, and peacekeeping to coalition warfare. At the same time, nations must maintain the capability to unilaterally respond to threats to their national interests—locally and globally. The growth and demonstrated effectiveness of air and space capabilities in the national security as well as the commercial arenas are forcing nations to make critical decisions about where and how to invest national resources in terms of

money, infrastructure, and people. These issues—which touch on the advantages, potential costs, and vulnerabilities associated with independent or interlinked air and space capabilities and will be addressed by our distinguished participants—are of great importance to small- and medium-sized nations. Indeed, they are important to all nations.¹

Air Power and Space Power: A Little History

The airplane arrived on the scene relatively early in the 20th century and almost from the beginning people began to refer to the product of air forces as “air power.” While the contributions of air power to the outcome of World War I were relatively small, the basic mission areas of reconnaissance, close air support, bombardment, and offensive and defensive counter air and transport were demonstrated and practiced. From these wartime experiences came theoretical writings and the beginnings of air power doctrine during the 1920s and '30s. Many of the documents spoke of future capabilities that would come from the inherent characteristics of aircraft—range, speed, and flexibility—unfettered by traditional geographic constraints. While technology was lagging the imagination of the airmen, the idea of air power as a major force in future conflicts became a part of military thought and organizations.

For the United States, World War II began with an attack from the air at Pearl Harbor in December 1941 and ended with attacks from the air at Hiroshima and Nagasaki in August 1945. In the intervening years, air power came of age. In Europe, the Allies opened a second front with the Combined Bomber Offensive several years before a land invasion of the continent could be assured of success. This campaign proved to be very costly in terms of casualties and aircraft lost. But no other viable option to strike at the German homeland was available and the impact on the Axis war effort was considerable. The Combined Bomber Offensive set the stage for the Allied invasion in 1944 by dissipating German resources, isolating the battlefield, and providing air superiority for the allied ground forces. In the Pacific, the Allies used a combination of carrier and land-based air to roll back the Japanese aggression and move ever closer to Japan’s heartland. Faced with the prospects of an invasion of Japan and the projected casualties of such an operation (approximately 100,000), the decision was made to employ the atomic bomb. With the peace that followed, the world soon found it engaged in another conflict, the Cold War, which would last for the next 45 years.

The Cold War was primarily framed by air power and its deterrent value. Initially, the two chief adversaries relied on air-breathing platforms capable of delivering nuclear weapons over great distances. As missile technology matured, a combination of bomber and missile forces came to dominate the great power standoff. Throughout this period and the 1990s that followed, the conventional conflicts fought by the principals and their allies or surrogates were shaped by air power: Berlin Airlift, Korea, Arab–Israeli conflicts, Cuban Missile Crisis, Vietnam, Pakistani–Indian con-

¹Conference Agenda Notes for an International Conference on the Fusion of Air and Space (Tel Aviv, 2001).

flicts, Afghanistan, Desert Storm, Serbia, and Kosovo. It was during the early years of the Cold War that space was first used for military purposes and a well-publicized technological space race between the United States and the Soviet Union became an interesting sidelight to the struggle. From the launching of Sputnik by the Soviets through the landing on the moon by U.S. astronauts, the accomplishments of each side were the source of great pride by the citizens of both countries. It was during this period that people began to talk about "space power" in much the same way they had become accustomed to speaking about "air power."

After the end of the Cold War, one of the first detailed studies of the utility of space in the pursuit of future U.S. national security objectives was conducted in 1994. This study, SPACECAST 2020, made clear the two primary military advantages of space: First, it is the ultimate high ground and, second, it gives continuous and rapid access to the entire surface of the planet.² A nation that is positioned to exploit these advantages will be able to dominate many critical aspects of military operations to include intelligence, communications, command and control, navigation, presence, and force employment, and—by virtue of the continuous and rapid access to the entire surface of the planet—has a tremendous commercial and economic advantage. To fully exploit these advantages in the 21st century, nations large and small, powerful and weak must understand some of the challenges to fusing air and space power. It is not an easy task even for the more rich, powerful, and more experienced nations as evidenced by the mandate from the U.S. Congress to form a commission to study the subject.

As demonstrated by the session titles of your program, the fusion of air and space power is complicated by several factors, such as the ability of a nation to generate and/or assimilate the required technology, resource availability and distribution, commercial viability, legal constraints, and, as is the case in most cutting-edge endeavors, strategic vision.

Technology

If a nation hopes to be a major player in the air and space arena, it must have access to the latest technology. There are four fundamental ways to get technology: heavily invest in basic and focused research, buy it, pirate it, or do a combination of all of the above. To ensure access and availability, the first is the safest but most expensive approach. The U.S. experience might be instructive.

During the Cold War, the United States developed an offset strategy wherein we relied on qualitative advantages from innovative technologies to offset the quantitative advantages enjoyed by the Soviet Union. Former Secretary of Defense William Perry described it this way:

What we had done in the offset strategy—the application of the reconnaissance strike force, the application of proceed and strike—had a secondary policy objective, an alternative policy objective when used in a major regional conflict like Desert Storm.

²"Executive Summary," *Report of SPACECAST 2020* (Air University Press, 1994).

When used against an opponent with equal numbers, (it) did not simply offset the other side; it gave us the ability to win quickly, decisively, and with remarkably few casualties. And when we ... studied the result, we looked at the kind of policy problems and military operational issues we're going to be facing in the years ahead, we said the very same technology that was developed to deal with superior numbers of Soviets would become the key to our new systems."³

Our perceptions of the threat had led the United States to take three different approaches to technological innovation during the Cold War. The first was to make incremental improvements to the systems as new technology could be applied to existing employment concepts. Here we are talking about new models of aircraft or weapons that go higher, faster, further and demonstrate ever increasing advances in roll, pitch, and turn rates. The second was to apply innovative technology applications in ways that produced revolutionary impacts and led to new operational concepts to deny an enemy the sanctuaries of night and weather. Synthetic aperture radar, LANTIRN, and LONGBOW targeting systems are examples of this kind of technology "applique."

Finally, we pushed for fundamental breakthroughs in science and technology programs that allowed us to leapfrog enemy systems and their associated operational and doctrinal thinking. Examples include stealth treatment for air-breathing vehicles; geostationary sensors in space to provide an enduring presence intelligence, surveillance, and, for missile launch warning, a global positioning satellite constellation to enable precision engagement at night and in and through the weather; and a global command and control infrastructure. This final category of technology application can be most useful when it negates conventional operational and doctrinal thinking and offers the national leadership new security options.

Resource Availability and Distribution

Innovation that involves new and exotic technologies is rarely inexpensive. This is particularly true of a robust effort in space. Not many nations can afford to engage in the full range of space activities starting with science and technology and going through R&D, test, launch, exploration, command and control, and employment of space-based systems for commercial as well as military applications. On the other hand, if nations are truly looking at a revolution in military and commercial affairs, which will be primarily paced by space, they must find a way to unilaterally, or through partnerships, make the investment.

One of the findings of the SPACECAST 2020 study group was that if a nation wants to maintain or increase its presence in space it must pay the price to do so. Recent studies identified the fact that there are more than 500 satellites in space valued at more than \$100 billion. More than 40 percent of these belong to the United States and about half of those have missions that are purely military. At the same time, this is not just a superpower game. There are more than 30 nations operating their own geosynchronous communications satellites; more than 50 percent of all space cen-

³William Perry, speech before an industry group in Alexandria, Virginia (January 1997).

ters are neither U.S. nor Russian controlled; and more than 25 percent of all space launches are neither U.S. nor Russian. More and more nations are coming to depend on space capabilities for political, economic, and military purposes in peace and war.⁴

As the Commission to Assess United States National Security Space Management and Organization concluded, the challenge for national command authorities is to properly organize and balance the allocation of national resources for future capabilities against the demand for current and near-term economic and security needs in the face of inertia, apathy, uncertainty, and change. Clearly, professional military advisors can help in this process if they provide a vision, concept of operations, and supporting doctrine to show how the fusion of air and space power will give the political leadership new options with greater promise of success. Of equal importance are proponents and visionaries who understand the value of space exploration to stir the imagination of the public and stimulate the commercial sector. This leadership and vision must come from the very top.

The Vision

Whether you are approaching the subject from a global or regional perspective, the two overriding military advantages of fusing air and space—(1) seizing the ultimate in high ground and (2) providing continuous presence and rapid access to the entire battle space—will allow you to dominate an adversary. As has been noted in the past, the Israeli experience and practice of looking to its Air Force as its decisive halting force, unfortunately, is not widely appreciated or accepted. Based on geography, demographics, and limited resources, the leadership of the Jewish state recognized early on the fact that the inherent characteristics of a well-equipped and -trained Air Force could serve as a substitute for large standing surface forces.

Much of the supporting air-breathing architecture, which made this possible in a limited geographical area for the last 50 years, has now become a reality on a global basis by the fusion of air and space power. At the heart of this development are the global awareness and response options provided by space-based sensor and command and control systems. There are several reasons for this.

- 1) Presence is a prerequisite for global view and global view is a prerequisite for global awareness and knowledge.
- 2) Knowing what is transpiring in near real time is a tremendous advantage for effectively maintaining security ... a prerequisite for everything else.
- 3) More importantly, having others know that we can know what is occurring creates a powerful deterrent capability and adds to the value of the knowledge itself.
- 4) Space-based sensors ... can in many cases, but not all, substitute for forward deployments of military forces. This can diminish the logistical problems of transportation and sustainment and the risk [to] human lives.
- 5) Should conflict become a reality, the capacity to combat adversary forces by using our superior knowledge and information derived from ... space systems enables new methods for the war fighter to use to engage opponents.
- 6) The quantity and quality of information that can be gained from space ... enhances the power of existing terrestrial forces both

⁴"Executive Summary," *Report of SPACECAST 2020* (Air University Press, 1994), p. 5.

conventional and unconventional by providing more and better information more rapidly. Command and control and dissemination of this information are critical.⁵

The 1990s saw the widespread use of the term “revolution in military affairs” (RMA), an idea enabled by tremendous strides in the areas of increased computational power, miniaturization of avionics, and IT. The impact of these advances, when combined with the traditional characteristics of air forces—speed, range, and flexibility—led USAF to undertake a long-range planning effort to prepare itself for 21st century warfare. In this process, we defined core competencies as a means of articulating the contributions of air and space forces in support of our national security strategy. Air and space superiority is at the top of the list of competencies because it is the enabler for all other competencies and capabilities of air forces, as well as surface forces.

In my view, our vision in this area should be one of desiring dominance, a situation wherein you own the adversary’s air and space mediums. The goal should be to have the capability to rendezvous and inspect—with the ability to monitor, disrupt, and/or destroy as required. It goes beyond defending your own assets to a situation where you take away an adversary’s sanctuaries and freedom of maneuver and action. You want to be all-seeing and all-knowing while the foe is blind and vulnerable.

In an effort to describe the desired end state of such a vision, USAF made the assertion that in the early 21st century its goal would be to be able to find, fix, track, target, and engage anything of consequence on the face of the earth or moving through air or space in near real time. This can be done today, but not in near real time. The idea behind setting such a goal is to force the system to look at what kind of investments are needed in the near term to achieve this capability in the opening decades of the 21st century. As this real-time capability becomes a reality, national command authorities will be given more and better options to choose from during periods of crisis.

Another reason for developing and promulgating a vision for the fusion of air and space power is the requirement to deal with the personnel dimension of the challenge. In the past, we were content to allow people to grow up in professional stovepipes as space personnel or as operators involved with more traditional forms of air power. As we look to the future, it is clear that we need to do a better job of integrating space forces into the mainstream of the Air Force and to recognize that in the future a larger percentage of the mainstream will be space related. At the same time, we must recognize the uniqueness of space and the requirement to recruit, train, nurture, and grow a cadre of civil and military space experts. This was a major conclusion of the Rumsfeld Commission, and a specific recommendation was made to move us in that direction.

⁵Richard P. Hallion and Michael Irish, “Air and Space Superiority,” in *Air and Space Power in the New Millennium* (CSIS: Washington, D.C., 1997).

The Legal Issue

In a paper prepared for the Rumsfeld Commission, Peter Breier described the present and likely future this way:

The militarization of Outer Space is as inevitable as the commercial exploitation already underway. Humankind has successively exploited mediums of land, sea and air for military purposes. If Outer Space offers either a strategic or tactical military advantage it will be militarized for such purposes.

Military forces defend national interests, both military and economic. Outer Space has already been militarized to the degree that nations utilize the once inaccessible medium for communications, reconnaissance, surveillance, warning, and imaging and as a medium through which weapons may occasionally traverse.⁶

As Breier points out, militarization of space is a fact of life. However, the legal and regulatory issues relating to the use of force and commercial operations are just beginning to be recognized. There is much at stake. As private ventures launch large constellations, the liability issues relative to eventual disposition and de-orbit loom large—and will be more so once the first incident involving loss of life and/or property damage occurs.

A concern of the Rumsfeld Commission was one of the unintended consequences of seemingly well-intended protocols and agreements entered into without much thought and coordination. The potential impact of such actions should be a concern to all nations just starting to build future capabilities through the fusion of air and space. I am particularly pleased to see it being addressed by this conference.

The Civil Space Sector

Beginning with the National Aeronautics and Space Act of 1958, the United States has had a policy that separates space exploration and commercial activities from “activities peculiar to or primarily associated with the development of weapon systems, military operations, or the defense of the United States.” However, to avoid unnecessary duplication of effort, facilities, and equipment, as well as to fully use available scientific and engineering resources, the policy provides for sharing “with national defense of discoveries that have military value and significance.”⁷

In the United States, NASA is the lead civil agency charged with exercising control over space activities sponsored by the United States in the international arena. NASA’s three primary areas of interest are

- to advance and communicate scientific knowledge and understanding of the earth, the solar system, and the universe;

⁶Peter T. Breier, “Legal Proscriptions Pertaining to the Use of Force in Outer Space,” paper prepared for the Commission to Assess United States National Security Space Management and Organization (November 2000), p. 2.

⁷G. Randall Seftas, “The Civil Space Sector,” a paper prepared for the Commission to Assess United States National Security Space Management and Organization (January 2001), p. 1.

- to advance human exploration, use, and development of space; and
- to research, develop, verify, and transfer advances in aeronautics and space technologies.⁸

Under Dan Goldin's leadership they have done a superb job of supporting these objectives. However, in my view they play an unstated role which, for the United States and much of the world, is much more important. That goal is one of generating and sustaining public interest, support, and imagination for the true potential of space. The international space station is an example of cooperation among nations in pursuit of peaceful uses of space. The planetary exploration program reminds us how privileged we are to live in exciting times—a time of opportunity and advancement in near and far space.

In the foreword of his book *This New Ocean: The Story of the First Space Age*, William E. Burrows quotes a 1970 lecture given by noted astronomer Carl Sagan, in which Sagan says, "In all the history of mankind there will only be one generation which will be the first to explore the solar system, one generation for which, in childhood the planets are distant and indistinct discs moving through the night, and for which in old age the planets are places, diverse new worlds in the course of exploration. There will be time in our future history when the solar system will be explored and inhabited by men who will be looking outward toward the first trip to the stars. To them and all who come after us, the present moment will be a pivotal instant in the history of mankind."⁹

Many of us alive today will experience the first space war. Some among the living will be the first humans to set foot on another planet. This is an endeavor for all mankind, from small, medium, and large powers. Cooperation and shared participation will be necessary and desired. Gatherings such as this offer us the best hope of succeeding.

Thanks to our hosts for making it possible for us to be a part of it.

⁸Ibid, p. 2.

⁹William E. Burrows, *This New Ocean* (New York, 1998).

MILITARY AND COMMERCIAL SPACE REALITIES

INTERNATIONAL MILITARY SPACE OPERATIONS AND INTEGRATION

Colonel James D. Rendleman, United States Air Force

Ladies and Gentlemen:

I would first like to thank the Fisher Institute and RAND for inviting me to speak today.

Today, I have two goals. First, I want to describe for you the assumptions and principles upon which the United States Air Force is developing concepts for operating in space. I will then briefly discuss U.S. law and policy that applies to international space operations. Collectively, I hope this will give you insight on how best to engage the United States in cooperative space efforts. I want to do this because such engagement provides the opportunity to build constructive security relationships and support and promote the development of democratic institutions around the world.

The United States will never again develop or execute any war plan, or any national or international military operation, without the benefit of some space-related capability. We all know space capabilities are pivotal to the success of U.S. military commanders, both in peacetime and in war.

“Space power” is the capability to exploit space forces to support national security strategy and achieve national security objectives. It involves the exploitation of civil, commercial, intelligence, and national security space systems and associated infrastructure to support national security strategy and national objectives from peacetime through combat operations. With space power, a nation has the ability to operate in, to, and through space and to protect its and allied space systems, all the while preventing hostile use of space assets by our enemies.

The United States’ use of space power will grow in the coming years because it provides a “reachback” capability, especially important as the Air Force completes its organizational shift from a garrison force to a posture centered on the Aerospace Expeditionary Force. “Reachback” provides the opportunity to have a smaller forward footprint of forces as space assets connect forward forces to commanders in real time. In an era of declining manpower and resources, space-based resources enable

information dominance—bringing information directly to the warfighter, enabling a smaller, more lethal force on the battlefield, with fewer casualties.

The United States' use of space power will grow because it also provides "access." This is important because there has been a reduction in U.S. bases worldwide since the end of the Cold War. Access to forward basing may be restricted in a future crisis or conflict, limiting options for our national leaders. In the coming decades, our aerospace forces will need to engage adversaries and respond to crises anywhere on the globe—within minutes to hours. By providing immediate global access, space allows the United States to have vigilance, presence, and situational awareness of the battle space. Thus, our space forces can be the "first-to-the-fight."

The United States' use of space power will continue to grow because it provides "precision." Precision location, rapid delivery, and precision strike are fundamental to U.S. military operations and our ability to project force and defend the interests of the nation. Space capabilities and assets enable unsurpassed warning and target identification/selection, and facilitate precision strike. By providing capabilities such as geo-location and beyond line-of-sight tracking and reporting to commanders and forces in the field, decisions can be made to dynamically control combat operations.

The United States' use of space power will grow because it provides for "full-spectrum operations." History and experience have demonstrated the efficiency and effectiveness of employing aerospace power through fully integrated air, space, and information operations. Space forces have the unique capability to operate simultaneously at several levels of conflict from peace to crisis to war. Continued migration of command and control systems to space will facilitate full integration and fusion of space data and information.

True "aerospace power" will be achieved by getting the right military information to the right forces, at the right place, at the right time. With space, future air-component commanders will have the ability to access battle management systems with timely, reliable, and fused data, providing surveillance, targeting, communication, navigation, reconnaissance, and early warning capabilities. These warfighters will then have the situational awareness needed to conduct effective, measured, and lethal operations.

The United States' use of space power will also continue to grow because space will play an increasingly vital role in serving the needs of the national and international community. The United States is the leader in using military space capability for the common good, such as for global navigation, communication, emergency management, and environmental purposes. We assist civil, commercial, and cooperative space agencies by maintaining a catalog of objects in space and monitoring the space environment.

Our national strategy will require us to maintain a "freedom to operate" between and above areas of critical interest. Aerospace forces have to operate in and control the "high ground," the air and space above the battlefield. Furthermore, the assured ability to operate in and through space will require responsive, assured space launch, as well as common system command and control capability.

Finally, the United States' use of space power will grow because U.S. national strategy will continue to emphasize deterrence as a fundamental means to prevent aggression. Incentives will increase for adversaries to exploit space power or deny the United States its use of space. In turn, this will require the United States to conduct real-time surveillance of space, protect U.S. and allied space assets from attack, prevent adversary uses of the space medium, and prepare to negate the space systems of our enemies. This will require us to develop new defensive/counter-space measures and rules of warfare. Thus, developing and fielding space control capabilities will be fundamental to our deterrence of aggression. Fostering a space control capability will provide a powerful disincentive to those who seek to challenge U.S. interests and forces at any level of conflict.


International Cooperation

USAF plays a critical role as the controller, maintainer, and protector of U.S. national space assets. This role must be framed, however, within the context of rapidly expanding coalition space operations, with each nation seeking to exploit orbital space for commercial and military gain. This poses both a challenge and an opportunity for the Air Force.

USAF strategy and assumptions for employing space power do not ignore the international context in which such operations are conducted. Indeed, the United States has a national military strategy that places great emphasis on coalitions and international cooperation (see figure on page 18). This strategy has increasingly emphasized cooperation in R&D, cooperation in the acquisition of weapons systems and defense technology, and cooperation in the integration of space capabilities into full-spectrum aerospace operations.

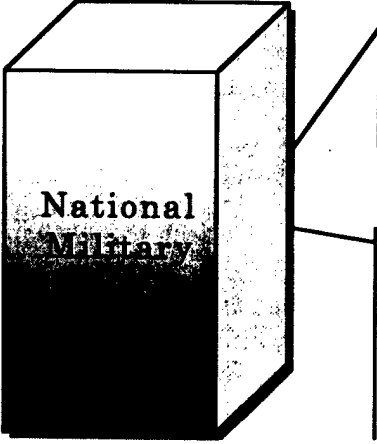
What are the reasons for this emphasis? According to our national military strategy:

Engagement activities, including information sharing and contacts between our military and the armed forces of other nations, promote trust and confidence and encourage measures that increase our security and that of our allies, partners, and friends. By increasing understanding and reducing uncertainty, engagement builds constructive security relationships, helps to promote the development of democratic institutions, and helps keep some countries from becoming adversaries tomorrow.



U.S. AIR FORCE

US National Military Strategy



...applying military power as directed to help shape the international environment

...information sharing and contacts between our military and ... other nations, promote trust and confidence

10 18 01 Integrity - Service - Excellence

**The U.S. National Military Strategy Places Great Emphasis on
Coalitions and International Cooperation**

There has been a drawdown of U.S. military bases worldwide as result of the end of the Cold War. The U.S. Air Force is now faced with a dramatically revised global environment. With reduced in-country footprints, the Air Force must seek to leverage its technologies and operational resources. Similarly, the Air Force must leverage the technology and operational resources of allies and those of potential hosts in theaters of interest in order to sustain its strategic and tactical missions.

Technical solutions to aerospace operational challenges will involve increasingly interoperable systems, planning, and operations. Achieving these solutions will be difficult—more difficult because U.S. law and policy imposes controls on the disclosure of sensitive technologies and operations. U.S. law and policy requires that military planners and system designers reduce the risk of compromise of important technologies and information to potential adversaries.

U.S. law and policy requires that the Air Force be involved in classified transfers, unclassified transfers that might lead to classified disclosures, transfers of unclassified technical information and equipment, and transfers of dual-use information and equipment. What types of releases are involved? The gamut of international military relationships: foreign military sales, direct commercial sales and programs, cooperative programs, officer exchanges and liaison officer relationships, visits including disclosure and briefings, and operational activities including exercises and intelligence information.

U.S. law requires that any proposed international space operation, cooperative effort, or technology transfer be examined in its entirety. U.S. government officials are charged to weigh the political and/or military advantages expected to accrue to the United States against the damage that could potentially result from the possible compromise of the information disclosed.

What laws, orders, and directives apply?

The Arms Export Control Act (AECA) governs the sale and export of defense articles and services and related technical data. It also serves as the U.S. legal basis for most international programs.

The AECA requires U.S. exports of defense articles and services and related technical data to meet U.S. national security interests. It also requires the President to receive assurances from a proposed recipient. What assurances are we talking about? First, the recipient nation must agree to not transfer the articles, services, or data to third parties without prior U.S. government consent. Second, the recipient must agree to use the articles, services, or data only for purpose for which they were furnished. Third, the recipient must agree to maintain the security of the defense article and services and provide substantially the same degree of security as the U.S. government.

The AECA covers commercial and government sales programs. Under the AECA, the Secretary of State, acting for the President, in consultation with the Secretary of Defense, designates which articles and services are subject to export control. The

designated articles comprise the U.S. Munitions List (USML), which is contained in the International Traffic in Arms Regulations (ITAR).

Other U.S. laws and regulations apply to exports of military data, hardware, and services. For example, the **Export Administration Act of 1979 (EAA)** governs the export of most unclassified articles and services not covered by the AECA. The EAA controls exports on the basis of their impact on national security, foreign policy, or supply availability.

National Security Decision Memorandum (NSDM) 119, entitled "Disclosure of Classified United States Military Information to Foreign Governments and International Organizations," also applies to exports. NSDM 119 sets the basic policy governing disclosure of U.S. classified military information to foreign governments and international organizations and their representatives.

Executive Order (EO) 12958 also applies to exports. EO 12958 provides the basis for the U.S. government classifying information as CONFIDENTIAL, SECRET, or TOP SECRET. It applies to all decisions on access to classified information, including foreign disclosure decisions, and this has special import to sharing U.S. information since some space capabilities proposed for sharing are classified.

EO 12958 prohibits the release of classified information outside of the U.S. Executive Branch without specific assurances it will receive equivalent protection. Second, it requires a determination that prospective recipients are trustworthy and have a need-to-know to accomplish a lawful and authorized government purpose. Third, it requires the originator's consent for further dissemination. Fourth, it provides for safeguarding information received in confidence from foreign governments and international organizations. It also provides for holding in confidence, by mutual agreement, information jointly produced with other foreign governments.

U.S. policies relating to disclosure of classified information are driven by four guiding principles:

First: If classified military information is disclosed, the *disclosure must result in benefits* to the United States at least equivalent in value to the information disclosed and the disclosure must be consistent with U.S. foreign policy and national security objectives.

Second: Classified military information must not be disclosed to foreign nationals until an appropriate designated disclosure authority receives *security assurances from the recipient foreign government*.

U.S. national interest requires recipients of classified military information to provide an "adequate degree of security." This standard is established, evaluated, and adjudicated by U.S. officials, not by the foreign recipients. Foreign governments and international organizations are required to report compromises of information and take corrective actions to preclude recurrence of the compromise. Provisions must be made for reciprocal on-site security surveys.

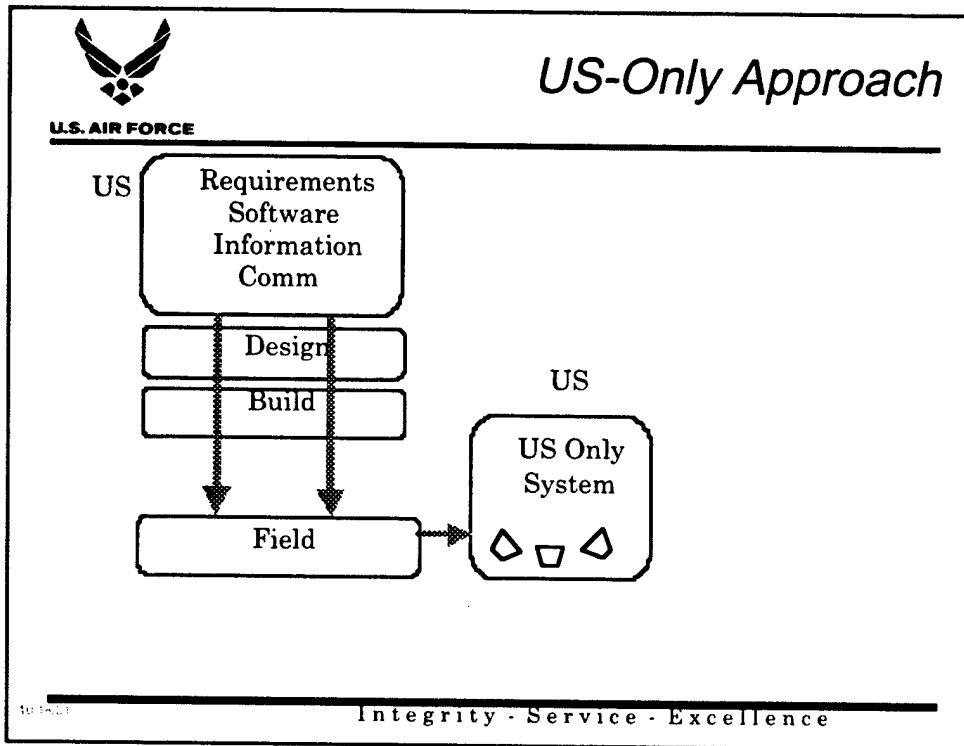
Third: False impressions of U.S. willingness to make available classified military information, material, or technology *must not be created, given, or implied.*

This doesn't mean planning can't take place. Planning may be conducted with foreign governments and international organizations concerning contemplated space operations and information disclosure that might involve eventual disclosure of classified military information. However, this planning may take place only if it is explicitly understood and acknowledged that *no* U.S. commitment to furnish classified information or material is intended or implied by that cooperation.

Fourth: U.S. officials who make disclosure determinations must have cognizance over the information. For example, an Air Force-designated disclosure authority cannot authorize release of information under the Navy's cognizance without the Navy's permission.

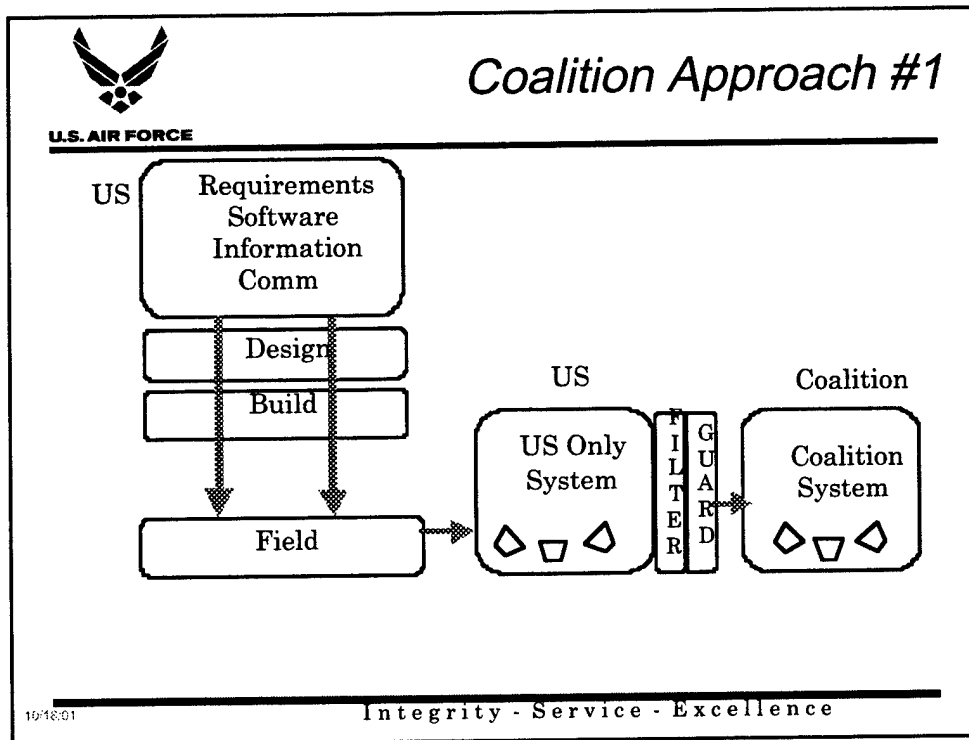
Achieving aerospace dominance will require truly interactive operations. Still, specific information relating to some space operations and technologies may be determined by the U.S. government to be unreleasable to all coalition allies. This has important logistic, operational, and planning consequences. Our space system architects must therefore consider these differing levels of access when designing and evaluating space systems and operational concepts.

One way to analyze the international operations issues and concerns associated with coalition command and control disclosure issues is to analyze operational relationships on a macro-level model. We will begin with a U.S.-only model, illustrated in the figure below. Under this model, the command and control system requirements are U.S. based, relying on U.S. software and U.S. information and intelligence, and using U.S. communications, where we then design, build, and field a U.S.-only system. Not too long ago, the "U.S." approach was also broken into parochial service (Army, Navy, Air Force) approaches. A system designed to be "U.S. only" is often degraded or stressed by adding coalition partners to achieve interoperability.



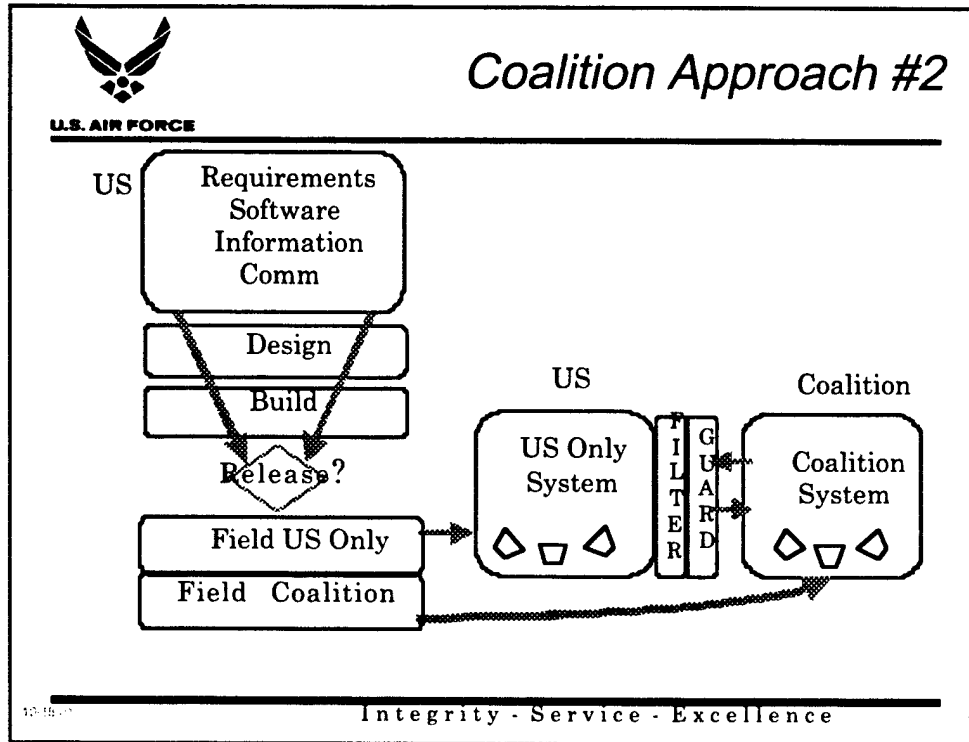
A U.S.-Only Approach to Designing and Evaluating Space Systems and Operational Concepts

The challenge of adding coalition partners to a U.S.-only system is shown in the figure below. Additions made after system design and fielding often result in a less-than-optimal system solution. Typical solutions involve developing "workarounds" that allow for certain information disclosures.



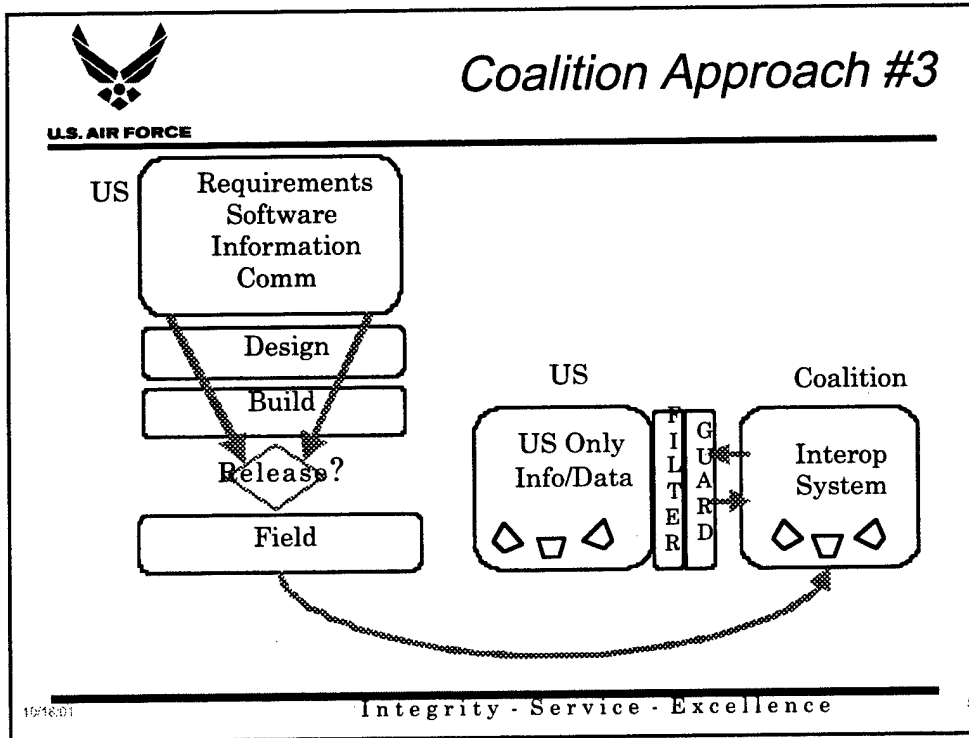
Alternative Coalition Approach #1

In our second common scenario (illustrated below), the request for release occurs after the system is built. It is too late to change system designs, but the request for access or partnering is received before fielding. This has oftentimes resulted in a decision to field two systems. The costs of maintaining separate configuration control regimes and logistics could be staggering under this approach.



Alternative Coalition Approach #2

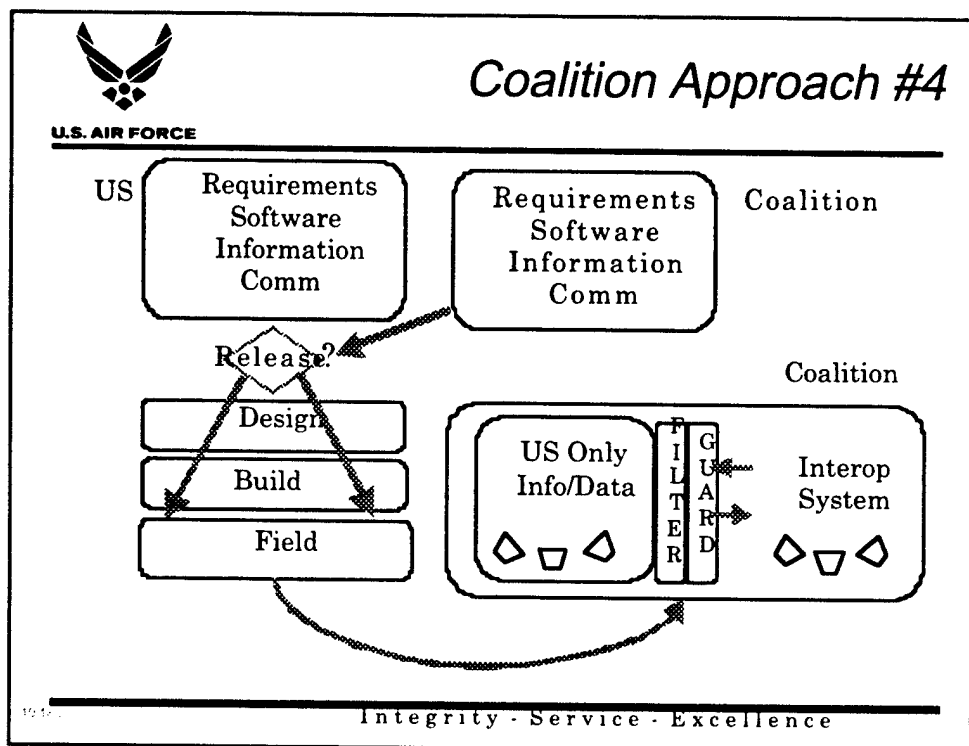
In a third option (shown below), we see one fielded system. It's a releasable coalition system, not a U.S.-only system. U.S.-only information is still separately generated from the basic system. Recent U.S. budget constraints have made support for this type of solution more tenable.



Alternative Coalition Approach #3

Inevitably, as coalition command and control approaches evolve, there will be an acknowledgment and recognition of systemic "coalition" requirements for software, information, and communication links. Responding to a need to develop coalition requirements, this approach attempts to adjudicate release issues up front.

Under this fourth approach, illustrated below, the system is developed as a coalition-releasable system within the coalition environment and the U.S.-only information is but a subset to the total system activities. To comply with U.S. laws, policy, and national disclosure principles, this approach still provides guards to protect information much like the last model, but U.S.-only information here is treated as a subset within a larger system.



Alternative Coalition Approach #4

Today, I have described the U.S. Air Force views toward space operations and described the impacts associated with U.S. laws and policies as it seeks to expand international cooperation and operations.

The space system designer and operator should be aware that, time and time again, the Air Force has expressed concerns or has been involved in opposing transfers of systems, information, and data that ultimately require release of the following:

1. Weapon and command and control system software source codes;
2. Intelligence information obtained from non-U.S. sources or where the originator has imposed stringent release controls;
3. Weapon systems that introduce destabilizing military capabilities to a nation or region; and
4. Capabilities of U.S. systems where the information release results in compromise or negation of the U.S. weapon or command and control system capabilities.

USAF has also expressed concern in cases where release generates significant congressional opposition.

The technology transfers, and cooperative research and operations, and disclosure process will not always be as easy. The system architect helps him or herself by developing and presenting a program responding to and addressing disclosure issues. If potential concerns are not resolved up front, at the beginning, you can be sure that the issue will ultimately be raised, with increased costs and risks and chances for political/diplomatic embarrassment for the program.

To ensure the success of potential international space operations, the Air Force believes politico-military policy considerations for space systems should be addressed as early in a program as possible. Significant harm can be caused to the interests of the United States, and its allies as well, if these concerns are ignored.

Prospective partners should be aware they can assist the U.S. government process as it works policy approval for prospective space system operational or other cooperative efforts. They assist by helping the U.S. government to answer the following questions:

- How does the proposed transfer support the U.S. plans and military-to-military contacts?
- How does the transfer impact mutual defense and security objectives?
- How does the transfer facilitate the coalition partner's participation in combined operations?
- How does the plan for the proposed transfer mitigate technology transfer concerns? and
- How does the transfer contribute to or destabilize regional stability?

Evaluations of proposed coalition partners are also appropriate:

- Will the partner be able to accept missions performed by U.S. forces?
- Will the partner be able to employ the transferred system's capabilities?
- Will the partner be able economically and politically to absorb the transferred system's costs?

In helping the U.S. Air Force answer these questions, you help us improve the potential for future collaborative operations and acquisitions. To be sure, there will be difficulties and challenges in achieving approved coalition force operations, and, sometimes, technical solutions will not achieve truly integrated operations because of important policy considerations. These difficulties and challenges must be understood. With that understanding, our U.S. and allied program system engineers will ultimately be able to successfully define international space system operational requirements, improve system interoperability, and meet the challenges of developing and fielding space systems.

Let me close by saying this: The Air Force wishes to foster both coherence and relevance in our plans for an international space future. Fielding effective space forces will increasingly be essential to our national warfighting and economic capabilities, and we will continue to integrate them into allied and coalition air force operations to achieve mutual defense, humanitarian, and economic needs. Understanding our assumptions for the growth of space power and the impacts of international policy will help the United States and its friends and allies maintain a technological superiority in the face of evolving and emerging threats and allow us to seize opportunities for peaceful coexistence as they arise.

I would like to thank the Fisher Institute and RAND for the opportunity given to speak today. I hope my quick outline of the implications of U.S. policy and law for space operations has been helpful.

COMMERCIAL APPLICATIONS OF PAYLOADS AND SERVICES:

REMOTE SENSING

Kevin O'Connell, RAND, Arlington, Virginia

While most discussions about remote sensing center on its technical details or security implications, it is equally important to consider its emerging commercial context. In fact, while it is counterintuitive, it is arguable that the best way to think about remote sensing these days is as a market, within which nonmarket activities such as government programs and scientific cooperation operate. This is a different perspective on remote sensing that has implications for governments, firms, and users of remote sensing data.

Even commercial providers are shifting perspective. Rather than focus exclusively on corporate core competencies or technical distinctiveness, firms are increasingly concerned about new applications for remote sensing—in this case, information vice imagery—to support the expanding range of information needs in the market. Although it relates heavily to technologies traditionally held in the control of governments, imagery is becoming “commoditized.” To discuss the market for commercial remote sensing (CRS) as a commodity, we need to first step back and look at the basic characteristics of the market, before considering how competition will rise and be resolved in this market. For example, within this market framework, the production and sale of data itself is as important as the issues of technology that arise in satellite design, licensing, and deployment.

For most of the period since the early 1960s, developments in remote sensing were fueled by the Cold War space competition between the United States and the Soviet Union. Arguably, more than a trillion U.S. dollars have been spent on remote sensing capabilities, first, for intelligence and military purposes and, over time, for scientific purposes. During this discussion today, we will move beyond those security and scientific dimensions to discuss the role that remote sensing potentially plays in the broader information market, including how remote sensing data and capabilities can be imbedded in other information systems.

PDD-23: Setting the U.S. Policy Framework

On March 24, the United States celebrates the anniversary of one of the central policy documents on remote sensing commercialization, Presidential Decision Directive 23 (PDD-23), entitled “Foreign Access to Remote Sensing Data and Technology.”¹ Under bipartisan U.S. consensus, PDD-23 was developed in March 1994 in response to a number of circumstances in remote sensing: (1) declining U.S. investment in U.S. space systems for military and scientific purposes; (2) concerns related to the suc-

¹ On March 10, 1994, the White House's Office of the Press Secretary released a statement describing the new U.S. government policy for the sale of space imagery and related technologies. It can be accessed at <http://clinton6.nara.gov/1994/03/1994-03-10-statement-on-export-of-satellite-imagery-and-imaging-systems.html>.

cessful commercialization of France's SPOT program and the sale of Russian satellite data (e.g., Russian sale of newly declassified satellite imagery in search of hard currency); and (3) a belief that remote sensing data could represent another important information tool in a growing market for data and information.

America's aerospace industry was also concerned. A principal concern was that it was being left behind in a global remote sensing market newly invigorated by the end of the Cold War and successful application of dual-use space-based technologies in Operation Desert Storm. As space-sensed data seemed on the verge of becoming a vital segment of the growing information-based economy, U.S. companies sought federal guidance as to their regulatory rights, responsibilities, and restrictions. PDD-23 allowed for the commercialization of remote sensing data and technology under a licensing regime that encourages data sales, protects technology, and gives the U.S. government enhanced controls during periods of crisis.

Changing CRS Market Expectations

As CRS companies would learn in the 1990s, there is a very diverse slate of products and services that can be provided by the space-based remote sensing industry. Image data sales, collection time-sharing, processed imagery, and analytic products are among these services. This diversity, however, can be both a strength and a weakness, as the business imperative drives toward a select range of products and services from which maximum profit can be derived.

No "killer application" for CRS has been identified, and developments in recent years have greatly expanded the number of potential substitutes to remote sensing, both from space (e.g., GPS) and on the ground (e.g., terrestrial sensors). So those who would raise capital to enter the industry may have great difficulty deciding which satellite design and package of services offers the best chance of providing a return on their investment. Furthermore, CRS firms must make this determination while predicting which areas of the information economy will be most in need of their data, not only at the time of deployment of their imaging satellite but also several years hence. Given the expense of designing, constructing, and deploying satellite platforms, to do anything less would be to invite obsolescence in only a short time, particularly given the speed at which the information technology (IT) and the associated market is progressing. Of course, the business model is not the lone consideration related to success in the market; equally important is the slate of government regulation, given the dual-use nature of the data potentially sold and technologies involved in creating space-based platforms.

These challenges have been reflected in the progress of CRS to date. As a sign of the early optimism about the size of the CRS market, a mid-1990s *Wall Street Journal* article projected that by the year 2000, space-based remote sensing would alone account for some \$20 billion of a predicted \$200 billion per year remote sensing

industry.² However, a more recent Frost & Sullivan projection provides more precise context as to the actual size and shape of the CRS market in 2001.³ This study shows that the space-based portion of the remote sensing industry accounts for some \$300 million to \$400 million, and is quite dwarfed by the much larger airborne segment of the industry. French data on SPOT also reflects the increasing importance of the information services, vice collection, and dissemination of imagery data.

Competition with Non-Space Information Sources

This “sanity check” on the CRS market reflects what I would call the reality of two competitions: a competition in space, not only between national providers of data (e.g., SPOT and Ikonos) but also between commercial and government systems (e.g., Ikonos and LANDSAT); it also reflects an intense competition on the ground, between space-based remote sensing and other information sources, whether of a remote sensing nature (e.g., airborne) or not (e.g., graduate students). Indeed, while most people focus on the space segment of remote sensing, it is my contention that the real action in the CRS industry is taking place on the ground, not in space.

To be commercially successful, the CRS industry must satisfy the wider needs of the information and technology economy—which is itself mammoth in size, and by some accounts experiences growth of 20–30 percent per year as a whole. Put another way, space-based remote sensing data must be “integratable” with other forms of data sets and must be easily stored and disseminated to the various users who would exploit the data, particularly among the rapidly growing users of information generated by geographic information systems (GIS).⁴ Other competitive pressures on the CRS industry have constrained the once tremendously optimistic projections for market growth, and must be dealt with by any company seeking to establish itself as a vital player in the space-based segment of the industry.

To date, space-based services have had their fiercest competition with the aerial photography (or ground-based) market. There are several reasons for the strength of the airborne photography market, not the least of which is the length of time it has been around. Having existed for some decades at this point, the airborne photography firms have had ample time to work out market mechanisms to ensure their cost competitiveness and learn the intricacies of customers’ needs and how to address them. They have also precluded an easy “ramp-up” period for space-based remote sensing by making major improvements in their business models and adopting modern technologies to improve their efficiencies as overhead data collectors. Thus, space-based remote sensing companies have some catching up to do before they can

²Bryan C. Gabbard, Kevin M. O’Connell, George S. Park, and Peter J. E. Stan, *Emerging Markets of the Information Age: A Case Study in Remote Sensing Data and Technology* (Santa Monica, Calif.: RAND, DB-176-CIRA, 1996).

³*World Remote-Sensing Data and GIS Software Markets* (Mountain View, Calif.: Frost & Sullivan, 1999).

⁴Kevin O’Connell and Beth E. Lachman, “From Space Imagery to Information: Commercial Remote Sensing Market Factors and Trends,” in John C. Baker, Kevin M. O’Connell, and Ray A. Williamson, eds., *Commercial Observation Satellites: At the Leading Edge of Global Transparency* (Santa Monica, Calif.: RAND and the American Society for Photogrammetry and Remote Sensing, MR-1229, 2001), pp. 53–78.

penetrate into the tightly knit customer–seller relationship maintained by the aerial sensing companies.

Space-based remote sensing firms have additional challenges as they begin to satisfy the market. Cost and price, and the relationship between them, are very important, as well as licensing issues and the flexibility they allow within certain licenses. For example, the notion of how to license an image or image data for government use in coalition warfare, where partners may change in detail and number over time, can be complicated and costly.

There is also the very practical technical difficulty of launching satellites into space—the 1990s witnessed several high-profile launch failures by CRS companies, and this inability to successfully deploy their platforms has quite obviously slowed the growth of the space-based segment of the industry.

A number of other technical and business model risks apply to companies that are trying to provide commercial services in space-based remote sensing, several of which are discussed in a RAND study written for the U.S. Department of Commerce.⁵

Competition from Government-Sponsored Space Information Sources

Consider the issue of competition in space, or the “competition from above”—i.e., the creation, partnering, and other alignment of foreign government and commercial actors to supply space-based remote sensing services on their own. Central to PDD-23 was an assumption, since proven incorrect, that a proliferation of U.S. commercial entrants into the market, freed to provide data services to foreigners, would strongly discourage foreign interests from developing indigenous capabilities in the CRS industry. Governments and other commercial actors around the world are, indeed, seeking to develop myriad capabilities on their own. Motives from national security to resource management to national pride dominate foreign interest in space systems, whether government funded, commercial, or of a hybrid nature.

Global competition in remote sensing, in other words, is here and will continue evolving in a varied landscape that includes purely commercial actors as well as hybrid companies that are at least partly government funded, and even among governments that themselves choose to sell or license state-produced data in the expectation of limited cost recovery for their expensive space activities. The wild cards in this landscape include the extent to which there may be greater innovation and thus cost-effectiveness within and among purely commercial sectors; the awareness by government-funded programs that most countries do not require a global surveillance industry to satisfy their more limited remotely sensed data needs; and the inherent regulatory and security-based tension between imagery data and imaging technology, which affects the willingness of governments to license or provide others with access to turnkey systems—that is, satellite imaging platforms with tasking capabilities that can be delegated to clients or other actors.

⁵Kevin M. O'Connell et al., *U.S. Commercial Remote Sensing Satellite Industry: An Analysis of Risks* (Santa Monica, Calif.: RAND, 2001), which can be accessed at <http://www.rand.org/publications/MR/MR1469/>.

Governments affect the market in other ways. In many countries, for example, governments have exclusive legal rights to remote sensing data at the level of precision that commercial interests are now trying to provide. Often this is portrayed as a national security concern, thereby precluding both buyer and seller from fulfilling the market. Thus, there is clearly a strong potential for conflicts between commercial and national security interests.

Returning to market terms, as companies seek to succeed financially, they must no longer think of themselves strictly as imagery data providers. They must adopt a role as truly information-age companies with access to multiple types of data and provide their customers with the value-added benefits of superior storage, cataloguing, and information application integration. They must also have flexible pricing and access policies, which is difficult to implement given the reluctance of governments to totally liberalize access to remote sensing technologies.

The Challenge of Government Controls

Progress has been very slow for several reasons. As discussed earlier, governments have been ambivalent about fully commercializing the industry, largely for national security reasons. (Ironically, while the United States was responsible for leading commercialization with PDD-23, its own national security concerns resulted in a policy and regulatory framework that was much more restrictive to the industry than intended in the PDD.) Even as governments consider how much leeway to give these commercial companies on the technologies they employ, there is also confusion within the companies themselves on how best to employ these technologies in a cost-effective way.

Deciding how best to integrate remotely sensed data into a coherent IT or services package has been very difficult for commercial firms. Likewise, it has been difficult for these companies to deal with the intricacies of the IT market that they are a part of. There are rules both of practice and statute that are inherent to the IT business that these companies are only now becoming truly familiar with, and they must learn to navigate these eddies if they are to be successful in the market.

Government controls are also important, such as the "shutter control" provision reserved by the United States under the current licensing regime. Given the clearly dual-use nature of space-based imagery data—born after all in the military and intelligence competition of the Cold War space race—it is a great concern among commercialized imagery companies that their platforms and products may be taken over by governments in times of national crisis, or at least under the guise of national security interests.⁶ With the legal soundness of private companies' ultimate authority to task their own satellites without government interference yet unclear, the issue of how "shutter controls" may be structured and implemented by states, already jeal-

⁶Ibid., pp. 75–83; see also John C. Baker and Dana J. Johnson, "Security Implications of Commercial Satellite Imagery," in Baker, O'Connell, and Williamson, eds., *Commercial Observation Satellites*, pp. 101–133.

ous of space-based capabilities, is a vital one to the industry. Shutter control can be a market inhibitor, both in a short- and long-term sense.

Both countries and companies alternatively bemoan both the language and even absence of language in American policy documents regulating the nascent CRS industry; however, it is worth noting that the United States does, at least, have a documented and accessible policy landscape. The Land Remote Sensing Policy Act of 1992, PDD-23, and other policy documents provide some guidance as to the American position toward the industry, and therefore provide us a framework under which to discuss future options. The same cannot be said of most other countries, which have tended toward constructing quasi-governmental or "parastatal" CRS companies, and therefore have released little public regulatory guidance to their industry or their international partners.

The pace of technology and markets also challenges regulation and policy. Creating a coherent policy is extremely difficult in the face of a constantly changing environment for remote sensing, including rapid technological advances in radar, hyperspectral, GIS, and other technologies; emerging foreign partnerships in remote sensing, whether government or commercial in nature; continued concerns that use of technologies should generally be kept controlled for national security reasons; and the development of a wide range of intellectual property and security issues impacted by concurrent changes in technology and the international legal landscape.

Conclusions

The commercialization of remote sensing has been both dynamic and volatile. It is dynamic in terms of the large number of shifting strategies among corporations seeking to enter the market, and how those business strategies are dealing with explosive developments in data management systems like the GIS and the information markets writ large. It is also volatile (a) because governments still do not know how best to regulate this evolving industry and (b) in terms of the technological and market-based concerns that may cut to the heart of the industry's effectiveness. If the CRS industry is to be successful in the 21st century, it must find its proper niche as a part of the broader information technology market and enjoy both greater technological success and—if not greater support by government regulation—at least more certainty as to the limits to its freedom of action.

U.S. LEGAL, REGULATORY, AND POLICY FACTORS IN MILITARY AND COMMERCIAL SPACE

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The United States considers the military and civilian implications of space as some of the most critical elements in determining U.S. export licensing policy for high-technology goods and services. This paper reviews the legal, regulatory, and policy factors that determine U.S. approaches to space-related exports.

It is important to recognize that the administration continues to conduct a review regarding many of its export-related policies for space equipment and technology. This paper will not explore which policies will continue and which, if any, the United States may decide to revise.

Instead, it will review some of the factors and legal requirements that the United States takes into account when companies seek to export space-related items through the U.S. licensing process. It will also review the importance of compliance for exporters and look at a case study on U.S. approaches to licensing of space-based remote sensing technology.

U.S. Licensing Policy

U.S. licensing for commercial space exports focuses on two areas:

Munitions Licenses. These cover items designed primarily for military applications such as space launch vehicles and missiles, fighter aircraft, tanks, and artillery. This category also includes items that share a number of critical technologies with military items but are used for commercial purposes, such as communications satellites. The United States considers these items inherently dangerous and thus scrutinizes particularly carefully any export of these items or their associated goods and technologies. The United States will not approve export of these items or their associated technology if the export would contravene U.S. national security and foreign policy.

Dual-Use Items. These are items designed primarily for civilian applications but which could have a military use. They would include items such as machine tools, computers, civilian aircraft components, and sophisticated electronics. The United States reviews these items carefully for export, but it will take into account in its licensing decisions the availability of the product in the mass market and abroad in determining whether or not to approve the export of these goods and technologies from the United States.

Framework

The United States considers the following issues when reviewing license applications for foreign launches of U.S. satellites/satellite technology, and space-related exports of controlled items:

Are There Any Legal Prohibitions? The United States will first ask if there is any embargo, sanction, or other legal bar or prohibition against trade with that country or end user that would preclude the export. Some prohibitions may have waivers available. An example of this could be the launch of a satellite on the vehicles of a country that would normally not be eligible to receive U.S. defense exports (e.g., China). The United States will review waiver requests to U.S. agencies and to the president on a case-by-case basis.

Are There Any U.S. International Commitments? U.S. international commitments also rank high in the consideration for approving exports. The United States goes to great lengths to make certain that our actions are consistent with U.S. commitments under international regimes and arrangements such as the Missile Technology Control Regime and the Wassenaar Arrangement, which covers arms and sensitive dual-use goods. Commitments under these arrangements might preclude the export of certain space-launch vehicle technology to even close friends and allies because of U.S. obligations to international regimes and the need to provide a basis for ensuring that exports from other countries within the regime do not harm U.S. national security interests.

Is The Export Consistent with U.S. Policy? The United States will look closely at the impact of any export on U.S. national security and foreign policy, including what effect the transfer will have on regional stability. The United States will also consider the effect an export or a denial of an export will have on the U.S. defense industrial base. Finally, the United States will also consider the effect that a license denial will have on the economic interests of U.S. producers as well as on U.S. friends and allies. U.S. licensing officials often give these factors particular weight given the complex supplier, insurance, transport, and other relationships that U.S. firms have with foreign companies.

Compliance Issues

Export control regimes often focus solely on licensing. But an even more important aspect of the U.S. system is compliance and enforcement requirements associated with the licensing, as well as the vetting of firms applying for licenses.

Compliance requires a government commitment supported by an enforceable legal framework that provides oversight and record-keeping requirements on non-government entities. These include both private corporations and individuals. Compliance requires a government commitment to educate companies of their compliance responsibilities and the legal requirement to report export problems when they occur. Compliance may involve visits to private companies by government officials to validate their systems or a governmental request for the company to

conduct an export system review and prepare a detailed report back to the government. Compliance also is directly linked to law enforcement that has the authority and capability to investigate both civil and criminal violations of export control laws and regulations. Finally, government must have the means to know who is engaged in the business, whether they be manufacturers, exporters, or brokers.

To ensure appropriate compliance, the United States requires that companies empower individuals in their organization to fulfill government directives. Compliance is complicated and expensive, but it is always more expensive *not* to comply. Companies that fail to take compliance seriously can risk disruptions in their licensing and exports. In the worst case, they can face fines and criminal sanctions.

Often, the greatest risk from failure to take compliance seriously lies in its potential to hamper a company's ability to do business. Some U.S. space firms have developed a reputation for failing to take national security concerns seriously. Not surprisingly, processing of licenses for these companies has suffered. Other companies have gone to great lengths to implement comprehensive internal compliance programs. The more successful licensing history for these companies reflects the fact that when government officials receive applications from these companies and their counsel for export, they know that they can trust the applicant to uphold U.S. law based on the strong internal controls of the company.

Case Study—Remote Sensing

The export of goods and technologies for commercial remote sensing illustrates the balancing approach the United States takes in deciding whether to approve exports and under what conditions. U.S. policy calls for support of U.S. industry while protecting national security and foreign policy interests. It also requires a government-to-government agreement (GTGA) for exports of particularly sensitive and advanced remote sensing technology and systems.

GTGAs generally provide for safeguards to protect U.S. technology against unauthorized retransfer and specify conditions regarding the use of commercial imagery. Legislative restrictions and U.S. regulations also apply to domestic operators of remote sensing systems. For example, the restrictions outlined in the Kyl-Bingaman amendment to the Defense Appropriations Act passed in 1996 continue to apply. These restrictions provide that U.S. operators may not collect or distribute imagery of Israel that is more detailed and precise than that which is commercially available on the worldwide market. The United States does not anticipate any change in application of the amendment although it expects that the current 2-m restriction will inevitably change over time as the resolution levels of systems operated in other countries improves. As a policy matter, the United States will apply to the export of commercial systems for commercial use many of the same restrictions that it applies to U.S. operators.

Conclusion

The U.S. licensing system is one of the most complex in the world. U.S. officials take their responsibilities particularly seriously for space-based exports. The United States continues to be one of the primary exporters of space-based components and technology and strongly supports these exports when they are consistent with U.S. national security and foreign policy. Companies with the strongest internal compliance programs will have the best opportunity to satisfy licensing requirements in a timely manner.

EMERGING CHALLENGES: NATIONAL SECURITY REQUIREMENTS AND ECONOMIC/COMMERCIAL INTERESTS

Scott Pace, RAND, Arlington, Virginia

The focus of this briefing is on emerging challenges for national security policy-makers and planners created by increasing commercial space capabilities. Such capabilities are creating opportunities for—as well as potential threats to—national security objectives. In particular, the definition and fulfillment of national security requirements can be in conflict with economic and commercial interests.

Revenues from commercial space activities such as satellite manufacture, space launch, ground equipment, and services have been estimated to exceed \$100 billion per year.⁷ While some sectors are growing faster than others, the overall average compound growth rate has been about 9 percent per year.

Growth of Space Commerce

- **Global revenues of more than \$100B**
 - Compound annual growth of 9 percent
- **Commercial revenues outpacing government expenditures in the United States**
 - Resulting cultural changes in industry
- **Major sectors unexpected a decade ago**
 - GPS, DBS-A, and MSS versus MPS

⁷International Space Business Council, *1999 State of the Space Industry* (with KPMG Peat Marwick, Space Publications, Arlington, Va.), 1999.

In contrast, U.S. government expenditures, civil (NASA, National Oceanic and Atmospheric Administration), and military (Department of Defense) space activities have been relatively flat in real-dollar terms. Thus, over time, the relative size of public and private space activities has shifted with commercial activities becoming more important. This has resulted in important cultural changes in the U.S. space industrial base, which is becoming more responsive to global market forces than government contracts alone.

The record of predicting where and how commercial space markets will develop is a poor one. Over a decade ago, there were predictions that material processing in space would be a primary commercial driver of space infrastructure.⁸ This did not occur; instead, unexpected developments such as the Global Positioning System (GPS), direct broadcast audio, and mobile satellite services (MSS) have attracted—and sometimes lost—billions of dollars in capital.

The next few charts provide a quick overview of the major issues in the major sectors of space commerce today—albeit from a U.S. perspective.

⁸CSP Associates, *Commercial Space Industry in the Year 2000: A Market Forecast* (Cambridge, Mass.: Center for Space Policy Inc., June 1985).

Space Launch

- Slowing demand — global competition
- Underinvestment in R&D — excess capacity
- Risks of Missile Proliferation
 - Launch trade agreements with China and Russia ending?
 - Ukraine agreement has expired
 - U.S. and multilateral export controls useful
 - But launch experience is the best teacher

In space launch, the collapse of MSS ventures has led to excess capacity and pressures on profit margins as a result of strong international competition between the United States, Europe, and Russia. Space launch technology has stayed relatively stagnant for decades, however, because of underinvestment in R&D for improving current expendable launchers and developing next-generation reusable/partially reusable launch systems.

Space launch is a dual-use (or as our Russian colleague put it, a double-purpose) technology and thus commercial space launch carries the risk of ballistic missile proliferation. Export controls and multilateral agreements such as the Missile Technology Control Regime are useful for stemming the spread of specific technologies. However, as in many other areas of high technology, experience is the best teacher and more experience in space launch translates into improving national capabilities for creating ballistic missiles. Launch trade agreements between the United States, China, and Russia are ending, and it is uncertain whether they will be renewed. This may result in no further restrictions on U.S. payloads or no ability to secure export licenses at all for use of launchers from these countries. The primary issue is compliance with other arms control and nonproliferation agreements. For example, restrictions on using Ukrainian launchers (e.g., the Sea Launch joint venture) were removed in recognition of Ukrainian observance of arms control agreements.

Satellite Communications

- Growth of fiber and wireless networks
 - Data overshadows voice traffic
- Failure of LEO Mobile Satellite Services
 - Regional GEO MSS (e.g., Thuraya)
 - Direct Broadcast TV and Radio
- Competition for global spectrum
 - Public versus private interests
 - Regulatory congestion at the ITU

Satellite communications represents the largest source of commercial revenues. Over the past decade, however, traditional fixed satellite services from geosynchronous orbit have faced intense competition from fiber-optic cables and wireless networks. The composition of traffic flows has also changed, from being primarily voice traffic to data (e.g., faxes, Internet).

The growth of terrestrial services in the most attractive commercial markets led to the failure of mobile satellite service ventures such as Iridium, ICO Global, and quite likely Globalstar as well. Instead, satellite firms are looking to regional MSS services in areas not well served by terrestrial infrastructure, direct broadcast of television and radio, and even broadband Internet services to areas without direct access to high-speed links.

Satellite communications face both regulatory and economic pressures. The spectrum used by satellites is sought by terrestrial wireless firms, and commercial users of all kinds are seeking use of spectrum now reserved for public safety and security purposes (e.g., GPS). This results in complex conflicts of inter-commercial and public-private interests. Resolution of these issues is made more difficult by existing regulatory congestion at the international level. This includes the problem of "paper satellite" filings at the International Telecommunications Union (ITU), which require technical coordination even if they are unlikely to ever be built. The ratio of filings to actual deployed systems is roughly 10:1 today and is getting worse.

Satellite Navigation

- Global Positioning System Applications
 - Augmentations provide cm-level accuracy
- GPS Modernization, GLONASS, and Beidou
- US-EC discussions of Galileo
 - Interoperability, regulatory, and security issues
- Spectrum at risk from rising noise floor and emerging technologies (e.g., UWB)

Applications of satellite-based navigation systems, notably the GPS operated by the United States, are the fastest-growing commercial space applications. While basic GPS provides positional accuracy to 5–10 m, augmentations from fixed reference sites can provide accuracy to the centimeter level or better. The Land Survey Department of Hong Kong provides a reference network accurate to 5 mm.

The GPS is being modernized with additional civil signals and new, secure military codes. At the same time, Russia is attempting to repopulate its aging Global Navigation Satellite System (GLONASS), and China has launched two test satellites for a two-way communications system (Beidou) that can perform position location.

Europe is seeking to build an independent satellite navigation system of its own called Galileo. The United States is in the midst of discussions with the European Commission on a range of issues of common concern, such as interoperability with GPS, trade rules, and security issues that could arise from hostile military exploitation or criminal misuse.

As with satellite communications, the spectrum used by GPS and other satellite navigation systems is at risk from competing services. Efforts to reallocate spectrum used by GPS to MSS were defeated at the 1997 and 2000 World Radiocommunication Conferences. Technologies such as ultrawide-band communications threaten to raise the background noise floor across wide segments of spectrum. This would harm GPS and other sensitive services.

Remote Sensing

- Deregulation of information technology
- Sophisticated airborne sources and GIS
- Competition from governments
 - For capital and addressable markets
- Policy and regulatory debates
 - Over emerging commercial capabilities
 - International security and trade environments

Remote sensing from space was originally developed for military and scientific purposes. With the end of the Cold War, it became possible to create a streamlined process for commercial operating licenses of remote sensing systems (with export controls on the underlying technology still being in place).

In combination with GPS, high-speed computers, and other information technologies (ITs), remote sensing found practical applications in geographic information systems (GIS). Remote sensing data is not exclusively from space. In both dollar and data volume, remote sensing from airborne platforms is larger than from space-based sources.

Governments continue to find remote sensing useful for military and scientific purposes and consequently seek to acquire and own their own space systems—with the option of selling some types of data in international markets. Thus, commercial remote sensing (CRS) faces competition from governments in terms of capital to fund such systems and access to addressable markets.

Governments may find purchase of CRS data attractive in some cases, but also have concerns about how such data might be used. These conflicting interests have resulted in extensive policy and regulatory debates over emerging capabilities. In some cases, restrictions are sought on the quality and coverage of data sold (e.g., the United States restricts the resolution of commercial imagery taken of Israel). In other cases, questions arise as to how the intellectual property of remote sensing data is to be treated in international scientific cooperation where data exchanges are common.

Seeking Security and Commerce

- The information revolution extends to space
 - Risks and benefits from global transparency
- Conflict and cooperation among public and private interests in dual-use technology
 - In patterns of domestic and global commerce
 - In shaping the space industrial base
- Autonomy in space capabilities is not the same as profitability

The information revolution represented by the Internet and personal computers also extends to space with satellite communications, GPS, and remote sensing. This has created what some analysts term a new form of global transparency whereby people and organizations are able to acquire and communicate across political and geographic borders much more easily than ever before. While this has benefit for global trade social cooperation, it also creates security risks through exposure of military operations and sensitive facilities.

Space-based ITs are dual use, with potentially conflicting public- and private-sector interests at multiple levels. Conflicts occur over what governments wish to allow for domestic use and export. These conflicts can in turn shape the underlying space industrial base. Current U.S. market share losses due to satellite export controls is a case in point.

Most importantly, it should be understood that autonomy in space (e.g., independent satellites and space launchers) is often in conflict with simple commercial profitability. Profit margins tend to be larger for ground-based, value-added equipment and services rather than for the space-based infrastructure itself. Thus countries need to decide what are their priorities are—and should not assume that autonomy will result in commercial space profits.

National Security Impacts

- Space power includes all sectors
 - National security, civil, and commercial
- National security requirements driven by individual circumstances
 - Policy, geography, threats, levels of conflict
- Space and information technologies highlight possible dependencies
 - Alliances, industry, interoperability, spectrum

Another important point to keep in mind is that “space power” is not just about national security space capabilities, but includes other sectors, including civil (scientific, meteorological, etc.) and commercial.

National security requirements are naturally driven by individual circumstances, such as global and regional interests, potential threats, and fundamental national policies such as neutrality or alliances.

Attention to space and information technologies can highlight important dependencies in a nation’s space power. These dependencies may or may not be acceptable, depending on a nation’s overall national security strategy.

Example considerations include reliance on allies for space support, capabilities of the domestic industrial base, degree of interoperability between civil and military or domestic and allied space systems, and the state of common resources such as international space allocations. Like the air through which aircraft transit, space systems rely on clear, stable electromagnetic spectrum for the receipt and delivery of information.

Some Issues for the United States

- Maintaining military advantages necessary to national security strategy
 - Budget limits impose hard choices
 - Coping with and using global transparency
- Will the right industry base be there when needed — now or in the future?
 - Global commercial forces driving divergences
 - Spectrum, R&D, key components, skilled labor

From a U.S. perspective, maintaining the military advantages through the use of space systems is crucial to the execution of national security strategy. The realities of limited budgets have forced and will continue to force hard choices among acquisition, readiness, and R&D efforts. Along with other countries, the U.S. military must cope with and be prepared to exploit increasing global transparency created by information technologies.

In the past, the United States generally assumed that it could procure whatever it needed, subject to budget limits. Today, the increasing importance of global markets and divergence between commercial and military requirements raise questions as to whether the “right” space industrial base will be there when needed. Global commercial forces have created diverging sets of interests across a range of issues. There is competition—and sometimes cooperation—for radio spectrum, skilled labor, and key components, and there are arguments over emerging technical standards and R&D priorities.

The military finds that high technology creates vulnerabilities off the battlefield as well as advantages on the battlefield. This means that in looking at all aspect of national space power, the United States must consider how to create incentives for commercial firms to reduce the gap between military and commercial requirements in space. Deterring conflict or prevailing should deterrence fail requires attention to the underlying commercial and technical forces that increasingly determine advanced military capabilities.

Some Issues for Regional Powers

- Access to space-based information to support warning and crisis management
- Access to low-cost launch services while deterring the proliferation of delivery systems for weapons of mass destruction
- Multilateral cooperation in dual-use space applications for economic and social development
- Identifying and exploiting global market niches and opportunities in space

For regional powers, security requirements may not be global, but budgetary limits are likely to be more severe than for the United States. Yet the security-related space issues can be very similar (e.g., access to space-based information for warning and crisis management, especially in areas where threats may come from many directions). Access to space information need not require autonomous launch capabilities, but access to affordable space launch services from multiple competitive sources needs to be balanced against the risks of proliferating ballistic missile technology to more areas of the world.

While recognizing the risks of some space technologies, such as space launch, there are significant social-economic benefits from applying dual-use space technologies such as remote sensing, satellite navigation, and satellite communications. Multilateral cooperation in practical civil applications of space technologies can strengthen alliance relationships as well as build ties among potential adversaries—thus enhancing regional stability.

Finally, the challenges of working in space and with space technologies can be a form of technical education that helps a regional power develop areas of commercial expertise to diversify its economy and enhance its global competitiveness.

Emerging Challenges for All

- Asymmetric threats by state and nonstate opponents using space “utilities”
- Interoperability with allies and “coalitions of the willing” in space operations
 - Need for doctrine, organization, and training
- Shaping the future “battle space”
 - Addressing dual-use R&D and industrial base dependencies domestically and internationally

For both regional and global powers, space “utilities” such as GPS and satellite communications can be exploited by opponents in asymmetric threats across the spectrum of conflict. Asymmetric threats include conventional terrorism and attacks on information infrastructures as well as more subtle information denial and deception measures to shape elite and public opinion.

The increasing technical gaps between the conventional forces of allied countries pose a special problem for the use of space systems for C3I. Lower-scale crises—such as humanitarian and peacekeeping crises—do not fit easily into existing alliance patterns, and international responses are often “coalitions of the willing” rather than formal allies. The resulting interoperability problems highlight the need for more attention to doctrine, organization, and training in using space in addition to acquiring technical capabilities per se.

Greater use of commercial capabilities can enhance standardization and interoperability at an affordable cost—if potential vulnerabilities from commercial dependency are understood and managed. Efforts by national security communities to address domestic and international dependencies stemming from dual-use space technologies are a necessary part of shaping the future “battle space.” This shaping—via public-private partnerships, targeted R&D, and negotiation of technical standards and spectrum allocations, etc.—requires new, nontraditional skills for our military and national security communities.

**“To be in hell is to drift;
to be in heaven is to steer.”**

- G. B. Shaw

I would like close with this quote from George Bernard Shaw's "Man into Superman." While we face many difficulties, it is surely worse to simply drift than to attempt to look ahead and steer among the conflicts briefly touched upon today.

A QUESTION OF BALANCE: FRENCH SPACE POLICY IN THE GLOBAL AGE

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As is the case in most space-faring countries, space policy in France appears to be facing a number of the emerging issues that make our world characterized by the so-called “global age” evolution and thinking.

Namely, the emergence of more and more widespread space-faring countries with ambitious space programs, corresponding with more and more diversified and/or flexible commercial or technical offers by private actors—all of which is connected to an unprecedented evolution in the information technologies domain (either at the data-collection level with the emergence of high resolution in the private sector, or in the telecommunication field with the advent of a number of private low Earth orbit (LEO) satcoms projects, even if difficulties have arisen here and there)—may have made this last decade more challenging for the traditional space powers than the previous 30 years.

These pioneering times were largely defined by national interest-driven policies built around Cold War issues or related to national sovereignty (as in the case of France) or to political identity-building processes (as in the case of Europe). With the vanishing Cold War context as a structuring factor that supported national space programs—and considering the emerging European political will to provide the European Union with a catalyst role beyond the traditional leading role of some member states, among which France is in the first place—time has come for France to review its national space program, in both the military and civilian areas. By doing so, and considering its means and objectives, France has to balance its approach very carefully along a narrow path, which must be kept with the following limits:

First Balancing Factor: The Franco-European Relationship in the Programmatic Domain

First and foremost, the French space policy is now living in a European context that will impose more and more its political substance and its specific strategic objectives to the national level of decisionmaking. Because the conviction exists in France that only a united European policy makes sense today—both in terms of the (ever

increasing) budgets required and in terms of industry and user community base—enlarging the national space effort to the entire European community is clearly viewed today as a prerequisite for starting any new big space program.

The time has passed since almost only national political wills were behind any great space undertaking such as Ariane, for example. Ariane today is widely recognized as a technological and industrial success throughout Europe, although it had to prove itself when it was debated some 30 years ago. Today, France—which has played a key role in promoting the idea of an autonomous European launcher and in translating it into facts—has to keep this initiative capability, this “idea-pushing” capability, not only by translating it at the European level but also by making it a positive driving force behind new, authentic European space undertakings such as Galileo and the Global Meteorological Environmental System (GMES).

Global in scope, these programs must draw sufficient European political interest to help promote a genuine European construction at a sufficient level, so that in reverse it can become a national objective for France.

The challenge then remains to make this objective sufficiently ambitious to foster interest at the national level without having it become a specifically national type of program unable to keep its European identity. As noted before, this balance constitutes a prerequisite nowadays for any successful national and European space endeavor. In other words, any new program must be balanced between national and European motivations; i.e., encompassing traditional national as well as global purposes.

Second Balancing Factor: The Military–Civilian Relationship

This same specific, and maybe even narrow, path explains the current trends in the military field in France as well as the evolving relationship between military and civilian space. The French space policy appears to be in the process of making a larger number of military space activities that rely on the civilian developments, in ways that are similar to what has been envisioned in the United States in the same domain.

The Pléiades program provides quite a significant example in this respect. Pléiades is designed by the French space agency CNES (Centre National d'Etudes Spatiales) as the future civilian French Earth observation program based on the use of two small platforms. The program is clearly seen today as an opportunity for the national security users even if Pléiades has as a prime objective to be the successor system of the SPOT series, with the traditional objectives and constraints attached to such systems. Even more than that, the Franco-Italian agreement signed in January 2001 about phasing of the French program Pléiades and the Italian high-resolution radar program Skymed-Cosmo has oriented this program toward a greater international cooperation phase. Despite these facts, which contradict the idea of the traditional independence attached to any military space program, Pléiades is commonly accepted as also presenting potential interest for military purposes, especially in the framework of a nascent European military force. From the military point of view, these kinds of

undertakings are now seen as complementary to the Helios program, which will remain the cornerstone of the French strategic observation capabilities.

This also takes into account the European context of building authentic, European "rapid reaction forces" able to deal with the so-called Petersberg missions (mainly for peacekeeping). In this respect, relying on civilian programs may be seen as a "cheap" way to provide consistency to the political and technical effort of building such a force from the part of a nation that has not decided to put space at the forefront of its military effort. In this particular respect, apart from the classical difficulties linked to limited budgets, this national position on military space also reflects French-specific approaches and evaluation in terms of doctrines or military organization and tools best suited to what the military authorities envision as the most probable conflict scenarios the country might encounter. In brief, space has regularly been put in perspective with realistic resources models for the future and specific military organization and needs derived from the evaluation of the threat. Developing space military capabilities beyond this line is not considered a priority, judging by the recent budgetary evolution, for example.

These evaluations have not led France to consider space applications as having a priority status over, say, transport capabilities or other armaments programs. But paradoxically, this recognition is certainly helping to devise some military use-of-force concepts that can include new space programs under way in the civilian sector with a military interest. Once again, the key notion here remains for France to be able to build a coherent approach at the European level that provides sufficient autonomy to any European military endeavor both without building unnecessary new military tools that may duplicate those existing through NATO, for example, but also without giving up completely the military type of capability that remains at the heart of the national sovereignty as seen from the French perspective.

As a consequence, new capabilities in remote sensing or in the telecommunications field appearing on the civilian "market" can clearly be conceived as positive factors that help enlarge the national security use opportunities without competing for core missions embodied in the national armed forces, which use dedicated systems by necessity. Again, from the French point of view, a balance between these two categories of systems, civilian and military, very different at first glance, can be achieved by abiding by the classical motto for France of "sufficient strategic capabilities," this time applied to space and information technology:

- Below this level, and its appreciation is very much linked to how the needs are evaluated and then expressed (specific threat assessment, resources, doctrines, warfighting techniques, etc.), national dedicated military systems will remain the rule (this is the case for Helios II or Syracuse III, for example).
- Beyond this level, any new commercial or civilian, or dual-type, system can be seen as an opportunity to flesh out an ongoing European military structure, in complement to the more classical sharing of national military programs.

Third Balancing Factor: The National–Global Relationship

This raises the issue of interoperability which appears more and more as a crucial interface that must help manage the national–global levels relationship. This is where a country like France might have to find a balanced approach.

In this case also, space resources (especially remote sensing and telecommunications resources) must address the national needs according to this “sufficient strategic capability” criteria, while being at the same time able to interoperate with (at best) or be complementary to (at least) existing or planned systems, both in the civilian and the military field. In the civilian area, this may prove a good basis for the intended architecture in such programs as GMES, which require a world system to address truly global environmental issues, as already pointed out in a number of multilateral environmental agreements (MEAs)—e.g., Kyoto Protocol, Vienna Convention, etc.

As for the military, national systems designed both to become regional resources usable for some level of military action and to play a complementary role in a larger military architecture will appear more and more as a key element in programmatic decisions. For France, this logic naturally fits in the NATO–ESDP (European Security and Defense Policy) architecture issue as demonstrated by the Syracuse III–NATO satcom possible coevolution. It could also solve more concrete and relatively short-term problems experienced by coalition military operations by making existing national systems to fit with strategic or operational common needs. Again, at this level, French space policy must follow a very narrow path (as in the case of satcoms, for example, especially in terms of frequency use and management). And at the European level, France, with all the member states involved, will have to make sure that undertakings such as Galileo also fulfill these kind of needs.

Conclusion

The French space program today relies on several efforts very different in nature at first glance, namely,

- Ariane launchers, which has expressed from the beginning a quest for autonomy at the national and at the European levels;
- The SPOT and now Pléiades–Skymed Cosmo undertakings, which evolve toward a sharing of responsibilities and capacities between states with dual implications; and
- Galileo (and maybe later GMES), which can be considered one of the first authentic “European” programs (i.e., managed at the EC level, along with the European Space Agency [ESA] and Eurocontrol) in which France and other member states participate fully while taking the position of a future user of the program rather than the traditional position of a “space country” or space technology developer.

This represents for France a new role in space endeavors, which also helps explain the internal repositioning stated earlier.

But more paradoxically, France, which has often been considered *the* example of a country that was very eager to preserve its national ability to act independently in space, can be viewed today in a position to take benefit from this long-standing involvement in narrowly focused space endeavors. Being accustomed to carefully balance its somewhat limited resources and its political interests in the national framework around the "suffisance" principles mentioned above, France could use today this experience to play a catalyst role on a larger scale in some important areas (such as environment monitoring or land and resources management) where an increasing number of programs in the world remain characterized by their diversity (and sometimes by their diverging orientations and developments), and call for more international cooperation.

Thus, the continuation of a balanced evolution for the national French space program appears to be a workable programmatic and organizational interface with other space developments abroad, and may define for this reason a new national strategic orientation for France as a first-rank cooperative partner in the global era.

REQUIREMENTS FOR INDIGENOUS MILITARY CAPABILITIES: THE CASE OF CHINA¹

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The blessing or the curse of space technology, depending upon perspective, is its inherently dual-use nature. Visionaries wax glorious about space travel in rockets that soar above the Earth. Military analysts offer threat assessments of possible scenarios for the development of hostile missiles. Most space technologies are inherently dual-use technologies, with civil space activities sometimes having direct military analogues. A communications satellite (comsat) can be used for either military or commercial uses, though some configurations are clearly better for one use than the other. Similarly, given sufficient capabilities, a remote sensing satellite has direct military application since its images identify objects and activities on the Earth's surface similar to a military reconnaissance satellite. The basic technologies required for commercial rockets and military missiles also share commonalities.² One is designed to put a payload into orbit or into space; the other is designed to reenter the Earth's atmosphere and precisely place a payload on a target. This makes threat assessments difficult and assumptions based purely on technology development, discounting or excluding considerations of a country's *intent*, tenuous at best.³

The problem with discussions on dual-use technology, however, is that they can go on ad infinitum. Technically, it is difficult to determine where the line should be drawn regarding potentially relevant military technology. By some definitions, a Sony Playstation includes potentially useful military technology. Nontechnically, complications are even more difficult. Food, if distributed to troops, can be considered "dual use." Subsequently, much of the technology deemed essential for indigenous military aerospace capabilities includes technology also deemed essential for national economic development, and vice versa. So, if a country has a technical space capability, then it will inherently have a military space capability—though intent is an issue to be dealt with separately.

¹The views expressed in this article are the author's alone and do not represent the official position of the Department of Defense or the U.S. government.

²Whether this is a recognized technical reality effectively dealt with through technology transfer regulations or a technical ambiguity deliberately hidden and often nefariously exploited depends on perspective. See Edward Timberlake and William C. Triplett II, *Year of the Rat: How Bill Clinton Compromised U.S. Security for Chinese Cash* (Washington, D.C.: Regnery Publishing, 1998), pp. 159–185; Aerospace Industries Association of America (AIA), *Commercial Satellites and China: Background Papers*, "Safeguards in the launch process: How the U.S. government guarantees the security of U.S. technology when a satellite is launched by the Chinese," June 8, 1998.

³Formerly, threat assessments in the United States were based on "probable" scenarios. The change to including consideration of "possible" scenarios came primarily after the Rumsfeld Commission report. The difficulty lies in coming to agreement in terms of how much to rely on probabilities versus possibilities for *planning* purposes. See Joseph Cirincione, "Assessing the Assessment: The 1999 National Intelligence Estimate of the Ballistic Missile Threat," *The Nonproliferation Review*, Spring 2000 (Vol. 7, No. 1); <http://cns.miis.edu/pubs/npr/circ71.htm>; Dean Wilkening, *Ballistic Missile Defense and Strategic Stability*, Adelphi Paper No. 334, May 2000, O 19 929004 0.

This paper will look at the Chinese experience developing an indigenous space capability. Specifically, it will examine the requirements, the key players, and the enabling technologies that have been focused upon. Further, it will look at areas of key focus now, and the impact of the availability of foreign technology on Chinese activities.

Requirements for an Indigenous Space Program

In retrospect, it is clear that the primary requirements for the Chinese development of an indigenous space capability have been the same as those in the United States and the former Soviet Union (FSU): political will, economic support, and development of requisite areas of expertise in not only technology but science. The differentiating factor between China and the United States and the FSU has been money. The United States in particular had the funds to allow a crash space development course in the 1960s. China's dismal economic situation in the 1960s, however, and the Cultural Revolution and extended time subsequently necessary to transform the Chinese economy, has impacted political will and prolonged the establishment of the expertise necessary for building a successful program.

Development of a wide range of Chinese space capabilities has for the most part been a slow, incremental process. There have been three periods, however, of accelerated activity. The first was between 1958 and 1964, when development of a nuclear weapon and delivery capability was a national strategic priority; after 1983 in conjunction with the U.S. Strategic Defense Initiative; and lately, for multiple reasons.

Political Will and Economic Support

As in the United States and the FSU, the Chinese space program was founded not in the hopes of exploring the heavens or even for the more mundane and pragmatic goal of economic profit, but rather as part of their Cold War strategic defense policy. The benefit of being designated part of a strategic program is that government funding requisite to meet programmatic requirements usually follows. In China that has been the case, further strengthened because the technology being developed is dual use and folds into the overarching Chinese goal of economic development. Further, People's Liberation Army (PLA) involvement in space industries has encouraged their support for dual-use space programs.

Whereas, though, the United States deliberately separated its civilian and military space programs, China and the FSU did not.⁴ The Chinese word for "space"—*hangtian*—refers to both space systems and ballistic, cruise, and surface-to-air missiles. Indeed, the Chinese themselves say, "Especially the development of the ballistic surface-to-surface missiles laid a foundation for the development of space launch vehicles."⁵ The technological aspects of defense policy in the post-World War II years

⁴Since the end of the Cold War, the United States has in many areas of space activity been engaged in "convergence" efforts, to maximize efficiency. Clearly, both the U.S. model and the FSU/Chinese model have had benefits and disadvantages.

⁵Zhang Xinzhai, "The Achievements and the Future of the Development of China's Space Technology," *Aerospace China*, Summer 1996, p. 22.

focused on both nuclear weapons development and delivery systems for the FSU and for China. In China, their weapons research and missile research was in many ways juxtaposed and singular: a strategic program. The priority of the overall strategic program, during some particularly difficult years in China, was such that it was "a magnitude equal to America's Manhattan Project and postwar missile program combined."⁶

In 1956, Soviet advisors in Beijing strongly recommended the inclusion of missile technology in the 12-year plan for scientific and technical development then under development to cover 1956–67.⁷ About the same time, Qian Xuesen (H.S. Tsien), a Chinese rocket specialist with a doctorate from the California Institute of Technology, was deported to China after accusations of Communism were levied against him during the McCarthy era. Tsien had participated in an American military survey of the German missile industry after World War II and indeed worked on the early research and development (R&D) of U.S. missiles. Upon his return to China, he quickly became one of the most powerful scientists in China and, not surprisingly, harbored considerable mistrust toward the United States as the country that had turned against him.⁸ Tsien wrote a proactive article on missile development that became a proposal to the Chinese leadership. Until the break in 1960, cooperation existed between China and the Soviet Union on missile development, primarily consisting of the transfer of two Soviet R-2 missiles, with accompanying technical drawings. After 1960, development of Chinese space technology was almost purely indigenous, led by Tsien.

Although Beijing achieved its objective of becoming a nuclear weapons state with retaliatory strike capability, the negative impact of the Cultural Revolution on space development extended beyond the so-called "ten wasted years" and was widespread. Science and technology education virtually ceased in some areas, and the economy was in ruins. Recovery was slow.

One factor in Beijing's favor during slow-growth periods was that by maintaining one space program rather than two, as the United States had, aerospace R&D was combined. Economists and technology development analysts have recognized that splitting R&D efforts to develop a technology for both military procurement and the commercial sector can lead to failure through "schizophrenic" efforts.⁹ Higher funding requirements for two-track efforts also inherently follow. Full utilization of both knowledge and experience to develop generic, dual-use space technology, and a parallel defense-industrial complex, has benefited China.

In 1983, Beijing was both able to and desiring to once again accelerate Chinese activity in space, this time in response to the U.S. announcement of the U.S. Strategic De-

⁶John W. Lewis and Xue Litai, *China Builds the Bomb* (Stanford, Calif.: Stanford University Press, 1988), p. 52.

⁷For a comprehensive history of missile/rocket development in China, see John W. Lewis and Hua Di, "China's Ballistic Missile Programs," *International Security*, Fall 1992 (Vol. 17, No. 2), pp. 5–40.

⁸See Iris Chang, *Thread of the Silkworm* (New York: Basic Books, 1996).

⁹See John Zysman and L. Tyson, *American Industry in International Competition: Government Policies and Corporate Strategies* (Ithaca, N.Y.: Cornell University Press, 1983).

fense Initiative (SDI). They feared losing their retaliatory strike capability, and hence began to evaluate potential responses.¹⁰ One result of these evaluations was the institution of the 863 Program. It (still) provides the framework for technology development for the 21st century. Managed by the Commission on Science, Technology, and Industry for National Defense (COSTIND) and the Ministry of Science and Technology (MST), projects under the 863 Program maintain budgets separate from the PLA, COSTIND, and the State Science and Technology Commission (SSTC) budgets. COSTIND has oversight on projects concerning lasers and space; MST covers the areas of automation, biotechnology, information systems, energy, and new materials.¹¹

More recently, the Chinese, like others, have emphasized the link between the space and information fields. Chinese recognition of the importance of information for strategic dominance dates back to Sun Tzu's *The Art of War*, written in the second century B.C.E. The Chinese have had centuries to master the arts and sciences of collecting, controlling, and manipulating information. Information warfare is not a new concept to the Chinese: Technology is merely a new means to a long accepted end.

Clearly, the Chinese military is engaged in a military modernization plan, which includes information dominance. In a highly insightful 1999 study for the Strategic Studies Institute,¹² nine factors are offered as driving China's strategic modernization.

Doctrine. "The most important element driving China's military modernization is an emerging doctrine which emphasizes strategic attack against the most critical enemy targets."¹³

U.S. and Russian Missile Defense Programs. "Since the late 1970s, another key driver for China's strategic modernization has been U.S. and Russian efforts to develop missile defense systems."¹⁴

China's Gulf War Syndrome. "The 1991 Gulf War was a rude awakening for the CMC and the military industrial complex."¹⁵

China's Revolution in Military Affairs (RMA). "Lessons drawn from the U.S. experience in the Gulf War are being augmented by subsequent literature on the potential RMA."¹⁶

¹⁰Dating back to Anti Ballistic Missile Treaty negotiations, compromising 20 percent of a country's nuclear force has been deemed as "threatening" their strategic capability.

¹¹The 863 Program is the Chinese counterpart to the European Eureka Program, initiated at generally the same time for the same reason.

¹²Major Mark Stokes, "China's Strategic Modernization: Implications for the United States," September 1999 (see <http://carlisle-www.army.mil/usassi/ssipubs/pubs99/chinamod/chinamod.htm>).

¹³*Ibid.*, p. 7.

¹⁴*Ibid.*, p. 10.

¹⁵*Ibid.*, p. 12.

¹⁶*Ibid.*, p. 12.

Quest for Great Power Status. "From the Chinese perspective, there are certain technologies and weapons which a great power is simply expected to possess."¹⁷

Territorial Defense. "Assessments are made as to what the threats are that China will face in the near, medium, and long term, and how China can assure the capability to defend against those threats."¹⁸

Support for the National Economy. "Strategic modernization requirements must compete, or at least support, China's overall economic development. China's overarching objective is economic development, and fostering of an environment conducive to their economic security."¹⁹

Organizational and Bureaucratic Politics Within the Defense Industrial Complex. "There is no doubt that various PLA branches and services compete for finite budgets and resources, probably with the Second Artillery, Navy, and Air Force coming out on top."²⁰

Technological Advances. "Strategic programs put on hold in the 1970s and 1980s due to technical difficulties have been resurrected due to increased access to foreign technology and expertise."²¹

While agreeing which each of the individual factors, my own research and citing some others would support more emphasis being placed on the overlapping nature of the factors rather than viewing them as discrete elements. Chinese analyst You Ji, for example, in a 1999 article²² focusing on RMA, linked several factors. He argued that lessons learned from the Gulf War propelled Chinese thinking on RMA and doctrine, reacting to both U.S. capabilities and the potential for ballistic missile defense (BMD) to provide the United States the ability to act with even further impunity than already demonstrated. Plans for an asymmetrical approach then become viewed as part of territorial defense. One might then ask if doctrine is being developed by push or pull, relevant to considerations of intent.

In my own research, I have also stressed the importance of internal politics and economic development.²³ Economic development is, indisputably, the guiding governing principle for the Chinese. Some of the most globally sought technologies by economically developing nations include telecom and remote sensing—both also critical for indigenous military space capabilities. A November 2000 white paper entitled "China's Space Activities" stated that China intended to industrialize and commercialize space to advance "comprehensive national strength" in the areas of

¹⁷Ibid., p. 13.

¹⁸Ibid., p. 13.

¹⁹Ibid., p. 14.

²⁰Ibid., p. 14.

²¹Ibid., p. 15.

²²"The Revolution in Military Affairs and the Evolution of China's Strategic Thinking," *Contemporary Southeast Asia*, Singapore; December 1999, pp. 344-364.

²³Joan Johnson-Freese, *The Chinese Space Program: A Mystery Within a Maze* (Malabar, Fla.: Krieger Publishing, 1998).

economics, state security, and technology. I would further suggest that prestige is an important benefit of space activity to be considered. This is most evident in the Chinese manned space program efforts. The yields from a manned space program are primarily political rather than technical, and at a substantial cost. Nevertheless, the Chinese are pursuing that road much as the United States and FSU did earlier.

Key Players

In any discussion about China, mass is a consideration. With a population of more than 1.2 billion, employment is a perpetual issue. Whether considering the government bureaucracy, the military, or industries, large-scale and labor-intense methods are almost assuredly a factor. Although large operations can result in efficient production through economies of scale, that is not always the case. In China, large-scale operations are most often associated with cumbersome, complex, slow-moving decisionmaking and action. Indeed: Regarding space, multiple, often stovepiped, dinosaur-like organizations compete for funds and power.

In parallel, at the top level there is the Central Military Commission (CMC) and the State Council. The CMC is roughly equivalent to the U.S. National Command Authority. The State Council handles economic planning. Beneath each are multiple functional organizations. The Chinese have a propensity for frequently renaming their organizations, primarily in external identifications, subsequently resulting in considerable (and intentional?) confusion.

Reforms were undertaken in 1998 in some cases going beyond new names for old institutions. Under the State Council, the former State Science and Technology Commission (SSTC) became the Ministry of Science and Technology (MST). It is responsible for China's overall science and technology development plan, last outlined in a 1998 white paper. Until 1998, the PLA controlled the parallel Commission on Science, Technology, and Industry for National Defense (COSTIND), with responsibility for China's defense industries. Reforms there were aimed at separating the military and civilian components of COSTIND, driven by both internal and external concerns. Internally, before restructuring COSTIND represented both the defense manufacturers and the armed forces—producers and consumers—which led to infighting over competing interests. Externally, commercial interests were often reluctant, or forbidden, to deal with a PLA-owned entity. Since restructuring, COSTIND's responsibilities are R&D; weapons production; defense conversion; and management of the arms trade. China Poly Group, which is the General Staff Department's (GSD) primary arms trading and business conglomerate, was also transferred to COSTIND.²⁴ Key industrial entities include China Aerospace Corporation, with its multiple research academies, the Ministry of Electronics Industry (MEI) and the newly formed Ministry for Information Industry (MII).²⁵ Additionally, a government mandate for the PLA to divest itself of many of its business holdings, and the breakup of many of

²⁴"Industry Embraces Market," *Jane's Defence Weekly*, December 16, 1998, p. 1.

²⁵Joan Johnson-Freese, "China's New Ministry of Information Industries (MII): A Chance for Real Change," *Pacific Telecommunications Review* (Vol. 20, No. 1), 2nd Quarter 1999.

the State-Owned Enterprises (SOEs), affects internal dynamics. Clearly, a powerful defense-industrial complex exists in China. Just as clearly, its structure and clout is undergoing change.

Militarily, the 2nd Artillery, headquartered outside Beijing, is responsible for China's strategic nuclear force. The 2nd Artillery Corps is under the operational control of the GSD, but is directly controlled by the CMC, and has been an independent arm of the Chinese armed forces since 1974. In addition to its combat formations, the signal unit of the 2nd Artillery Corps operates communications systems to provide communications support capabilities for launch operations. The headquarters complex maintains contact with subordinate units through its own communications regiment.²⁶

Enabling Technologies

Until 1985, when China initiated commercial launches, Chinese space activities were closed to the outside, and the outside for the most part refrained from working with China on space activities. Now, that has changed. Countries and companies are posturing for position, eager to reap the potential benefits of the Chinese market of more than 1.2 billion people. That has meant that China is no longer forced to work alone. In many cases, China is pursuing a course of joint ventures in the near term to develop indigenous capabilities in the longer term.

The technology used in the Chinese Long March family of launchers is basically derived from China's earlier work on long-range missiles (their Dong Fang series). The Long March family of vehicles provides China access to space.²⁷ Plagued by a series of accidents in the 1990s, the Chinese have been constantly striving to improve its accuracy and reliability to gain and hold a portion of the commercial launch market. There is no evidence, however, that it is developing the capability to conduct launch-on-demand operations (ability to launch within 24 hours of a decision to do so), which would have significant military implications. A major aspect of the 1997 Cox Committee hearings in the United States, and multiple related hearings, focused on whether launching commercial satellites on Chinese vehicles inherently improved Chinese missile capabilities, if only through paid practice.²⁸ Strong Chinese capabilities in the areas of ballistic missiles, as well as ground-based radars and information denial, are well accepted. In other areas, however, their competencies are far more lacking.

The focus of Beijing's attention in terms of technology development is microelectronics. Since 1991, China has considered the development of an indigenous microelectronics industry as a strategic priority. The dual-use nature of both microelectronics and telecommunications equipment particularly make support for these

²⁶See <http://www.fas.org/nuke/guide/china/agency/2-corps.htm>.

²⁷For more information, see Brian Harvey, *The Chinese Space Program* (Chichester, UK: Praxis, 1998).

²⁸Henry Sokolski, executive director of the Nonproliferation Policy Education Center in Washington, D.C., has been the primary proponent of this line of reasoning. See *Space Technology Transfers and Missile Proliferation*, Testimony Before the Commission on the Ballistic Missile Threat, April 10, 1998.

industries possible, for both economic development and military modernization purposes. Information technology has been the fastest-growing segment of China's economy, increasing at an annual rate of 30 percent.²⁹ China has been able to cut its dependence on foreign sources (including the United States, Japan, and Korea) for integrated circuits (IC) from 80 percent in 1993 to less than 50 percent in 1995.

China's national teledensity remains low at 17.7 percent; urban 38 percent and mobile teledensity 5.1 percent. In September 2000, China's MII announced that Chinese telephone subscribers had topped 200 million—from 2 million in 1979.³⁰ Beijing has made connecting the population, especially rural and urban, a national priority. With companies from Europe, Japan, and Israel competing to sell telecommunications technology, hardware, and software, in China, the PLA has primarily ridden the coattails of this commercial push.³¹ This will likely continue, although foreign investment is still inhibited by a lack of rules and regulations in China deemed necessary to protect the investments.³² U.S. satellite companies have to a large extent been preempted from competing in China by explicit and implicit U.S. export control regulations.³³

The PLA certainly recognizes the need for development of an integrated national information infrastructure. They are working with the Ministry of Post and Telecommunication (MPT) in that regard. Indeed, since the commencement of the 863 Program, Chinese investment into the dual-use telecommunications sector has totaled more than \$200 billion, compared with, for example, the Chinese defense budget of \$17.195 billion announced in March 2001.³⁴

Imagery is another area of space systems that is part of a broader network of capabilities being developed, some of it through the 863 Program (specifically, the 863-308 Project). The National Remote Sensing Center provides oversight for China's remote sensing community. Under its coordination, the electronic and space industries are developing an array of ground-based, airborne, and space-based sensors, for example, as part of bolstering their information dominance capabilities—civil or

²⁹Stokes, p. 30.

³⁰"China's telephone subscribers top 200 million," *BBC Monitoring*, September 25, 2000, from Xinhua News Agency, Beijing, in English 1152 September 25, 2000.

³¹C4I modernization and updating has been a priority since at least 1979. With the exception of the 2nd Artillery, which is better equipped than others, most installations rely on microwave communications equipment. Teleconferencing and what was described as a "military information superhighway" are recent innovations. Generally speaking, "China still lags far behind Western standards for controlling complex joint operations and lacks the robust C4I architecture required to meet the demands of the modern battlefield" (Report to Congress, Pursuant to FY2000 National Defense Authorization Act). See <http://www.defenselink.mil/news/June2000/china0622000.htm>.

³²Lynnette Luna, "Risky business," *Telephony*, Chicago; January 1, 2001, p. 20.

³³Joan Johnson-Freese, "Alice in Licenseland: U.S. Satellite Export Controls Since 1990," *Space Policy*, August 2000; Joan Johnson-Freese, "Becoming Chinese: Or, How U.S. Satellite Export Policy Threatens National Security," *Space Times*, January/February 2001.

³⁴John Pomfret, "China Plans Major Boost in Spending for Military," *Washington Post*, March 6, 2001, p. 1. That was a 17.7 percent increase from 2000. The 2000 defense budget was an increase of 12.7 percent from 1999. It should be noted that it does not include either weapons procurement or military R&D, and some analysts estimate the defense budget to actually be up to three times the official figure. Matt Forney, "China Heralds Budget That Trims Deficit—Plan Veers from Practice of Using State Spending to Juice Up Economy," *Wall Street Journal*, March 7, 2000, p. A21.

military. China has used both indigenously developed space reconnaissance platforms and imagery from foreign sources.³⁵ Generally, work is being consistently supported and conducted (sometimes jointly with other countries) in the areas of electronic reconnaissance satellites, electro-optical satellites, synthetic aperture radar satellites, and weather satellites. Again, however, the dual-use nature of the technology makes strictly categorizing some efforts as military or civilian difficult.³⁶

Indigenous Chinese reconnaissance satellite technology is outdated by Western standards. That is not to say, however, that they are not working to improve it, both indigenously and through joint ventures. China has worked with Canada, for example, on various RADARSAT and synthetic aperture radar (SAR) programs since 1993. China has announced plans to deploy four optical satellites and two radar satellites. The orbiters will belong to a class known as Small Multi-Mission Satellites, because of their versatility. So it is not surprising that the satellites are referenced both as being able to provide round-the-clock environmental and disaster management monitoring and as militarily significant for their surveillance capabilities.³⁷

China, like other countries, has access to the U.S. Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS). It has developed a 12-channel GPS/GLONASS receiver. There are indications that GPS is being incorporated into all of China's new fighters. It is also believed that GPS is being integrated with commercially available satellite imagery to develop digital terrain maps for targeting, missile guidance, and planning. This raises the entire issue of dual-use global utilities, such as GPS, and the capabilities they will inherently provide.

China's R&D strategy, dating back to the 1960s, has three general phases: preliminary research, model R&D, and production. There is strong emphasis put on the first, with two alternative approaches; they reason that an up-front investment can save time and money later. One approach is to work on technology applications for specific systems, such as propulsion for a specific missile. The other is generic research for application to multiple systems, such as GPS exploitation. Therefore, it can be expected that China will be fully maximize GPS utility.

Besides those areas already mentioned, there is clear indication that China has put priority on development of missile early warning satellites, navigational satellites, space surveillance, SIGINT, and ELINT. Again, because of the dual-use nature of many of the technologies concerned, they are even working with other countries on component aspects. Clearly, however, China continues to adhere to its two-decade-old policy of giving priority to economic rather than military development needs. Hence, few of these programs are fast-tracked in the same way as telecom.

³⁵China has received data from, for example, the U.S. Landsat platform, Russian remote sensing platforms, and the French SPOT satellite.

³⁶The same is true in other countries as well. See Joan Johnson-Freese and Roger Handberg, "Changing Parameters of Japanese Security Policy: The Advent of Military Space in the Post-Cold War Environment," currently under review for publication with *East Asian Review*. Condensed version, as Commentary, in *Space News*, February 12, 2001.

³⁷"China to launch optical satellite network," Reuters (Beijing), November 19, 1998; Richard D. Fisher, Jr., "China Rockets into Military Space," *Asian Wall Street Journal*, December 1998, p. 6.

Conclusions

China's development of a comprehensive, indigenous space capability has been a slow, incremental process. That process can be accelerated, as shown retrospectively, accordingly to internal and external factors. Internally, political will (influenced by internal and external factors) and subsequent funding, as well as a science and technology base, are key determinants. Externally, the availability of commercial technology allows gaps to be supplemented while focusing efforts elsewhere or while indigenous capabilities are being pursued. With so much commercial space technology available from multiple suppliers around the globe, other countries that commit to a space-sector development now can begin further up the learning curve. The dual-use nature of space technology makes civil-military hardware differentiations sometimes difficult. Hence, consideration of probable intentions must be maintained toward making meaningful assessments of potential technology use.

ADDITIONAL DILEMMAS AND OPPORTUNITIES

REVOLUTION IN MILITARY AFFAIRS: CHOICES FOR A SMALL NATION
Lieutenant General Johan Kihl, Director, Strategy, Plans, and Policy,
Swedish Armed Forces, Sweden

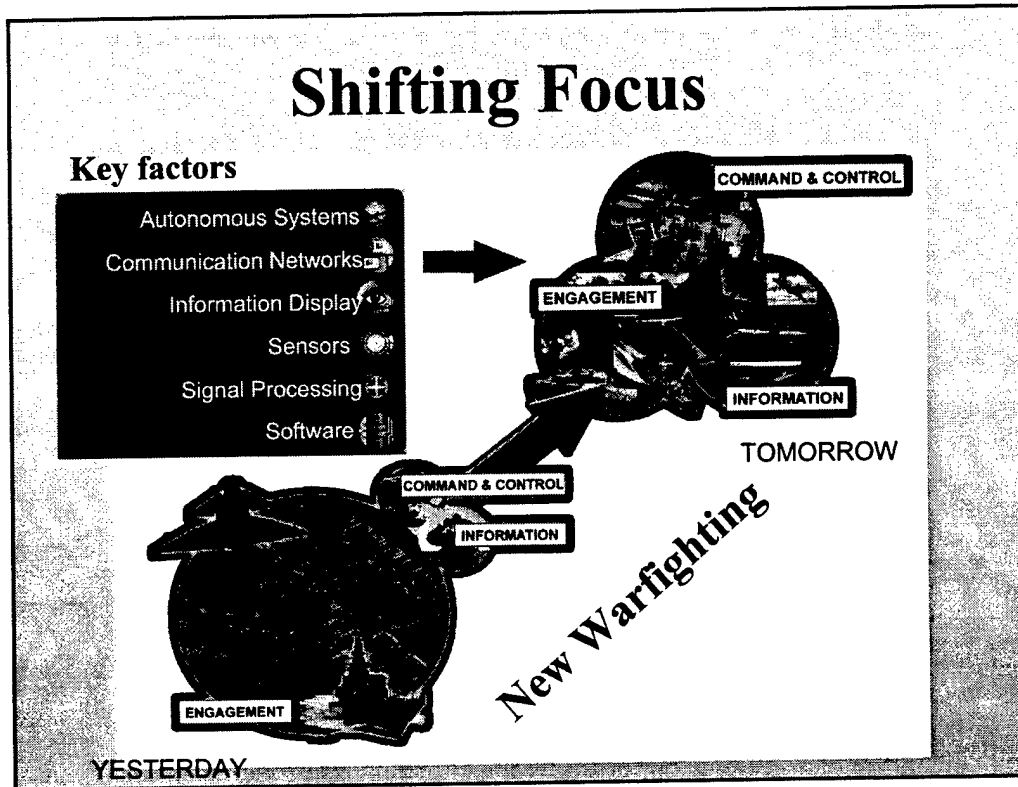


Sweden now has a “strategic opportunity” that will allow the time and resources necessary for a restructuring of the Swedish Armed Forces (SwAF) and a reorientation to new missions and new threats. Specifically, this strategic opportunity has enabled Sweden to undertake its own version of the revolution in military affairs (RMA).

This important conclusion and its consequences for Sweden's total defense posture were outlined in the government bill called *A Changing World—A Reformed Defence*, passed by the Swedish Parliament in Spring 1999.

Significantly, the Spring 1999 security policy review highlighted the threats posed by weapons of mass destruction (WMD) and information technology. In addition, the review determined that "the ability to contribute to international peace and security should be a high priority for the Armed Forces." In broad terms, Sweden has determined that it needs a defense system that is smaller overall but at the same time sophisticated, versatile, and capable of reacting to a wide variety of contingencies.

Adaptability to future requirements must be a hallmark of the SwAF. It is also a prerequisite for success in executing the RMA. In viewing Sweden's future choices in pursuing the RMA and its action component, Dynamic Engagement (DE), it is instructive to consider the meaning of, and experience of other nations with, previous RMAs and the information-based RMA that is now emerging. On this basis, Sweden can better plan and pursue its own RMA.

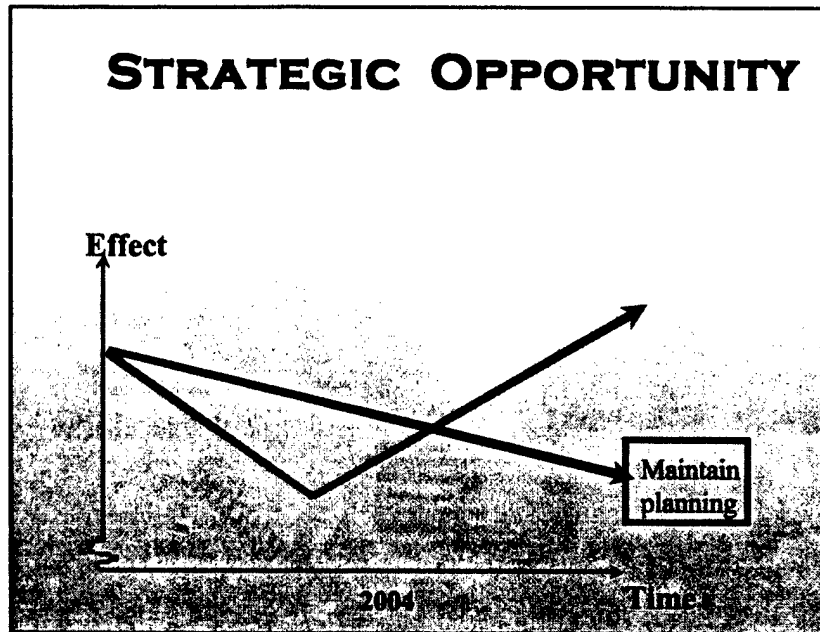


The Information Revolution and the Swedish RMA

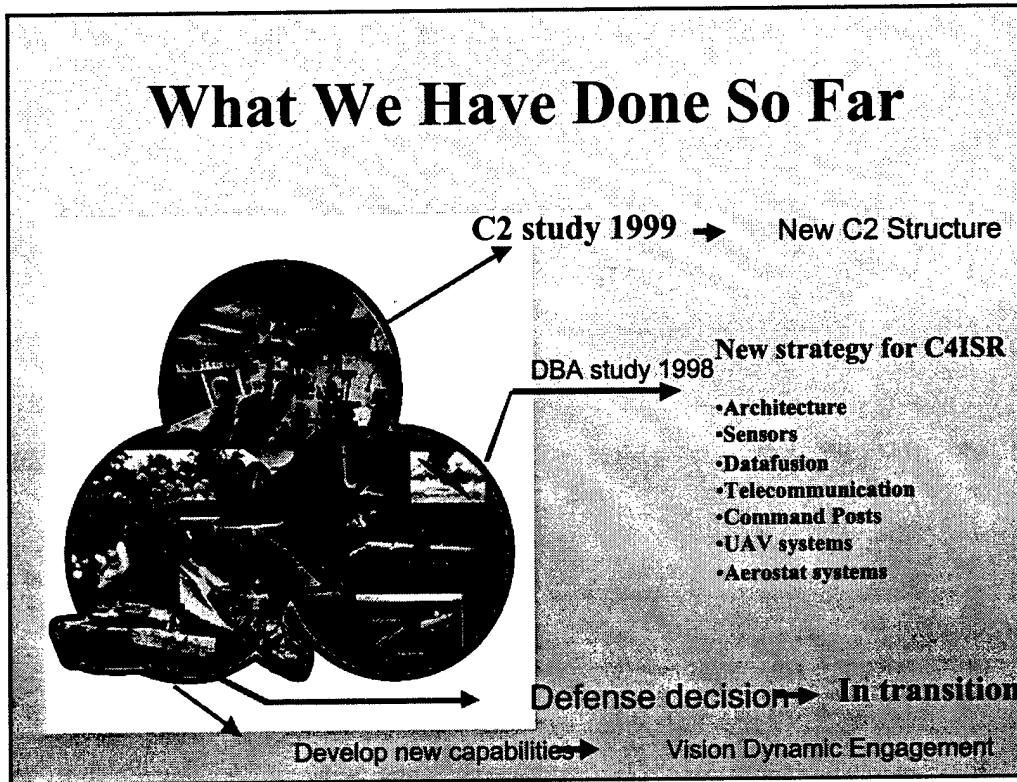
In view of the foregoing understanding of and experience with RMAs, it is vital that defense planners in a nation such as Sweden, contemplating major modernization and restructuring of its forces, identify and assess the essential characteristics of the emerging RMA. *The current RMA is driven by technology, primarily by information technologies.* The technologies in question—sensor systems, software development, signal processing, communications networks, autonomous systems, information display—are the key factors enabling the dramatic changes in conventional warfare.

These changes include the rapid transmission of real-time intelligence and the location of enemy targets, the deployment of a new generation of lethal and accurate precision-guided munitions, continuous 24-hour operations, the improved ability to engage in deep strikes, better control of information flows, and the ability to deny information to the adversary.

Sweden has some powerful natural advantages in the pursuit of an RMA, most notably in the overall quality of the personnel who fill the ranks of the SwAF, the technological prowess of its people, and the strength of the nation's defense industry. Indeed, Swedish industry is at the heart of this revolution, both in commercial and military applications of advanced information technologies.

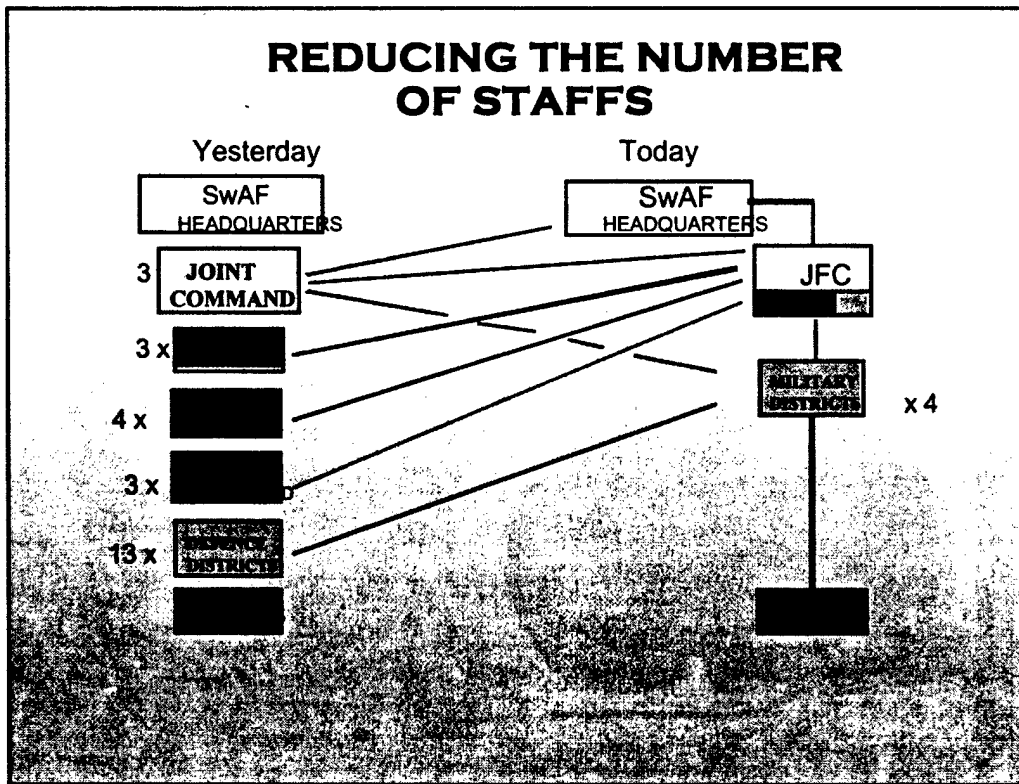


The perception of a strategic opportunity, the changing international security environment, and the growing requirement for the rapid delivery of accurate, timely information to commanders in the field on a continuous, around-the-clock basis led directly to the Swedish government's decision to undertake a revolution in military affairs (RMA).

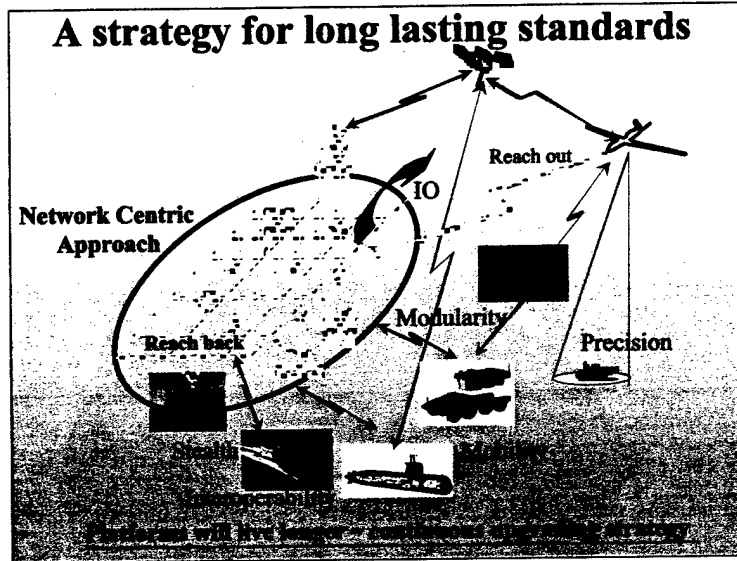


This RMA began with a focus on two of the three key components of the RMA: Information and Command and Control (C2).

The September 1998 *Perspective Study: Dominant Battlespace Awareness (DBA) 2020* by Science Applications International Corporation (SAIC) provided valuable findings that have been helpful to the SwAF in planning for and implementing the Information or DBA component.



In its RMA efforts thus far, the SwAF has already taken major steps in two of the three components: C2 and Information. Specifically, a number of actions have been taken to begin implementing the Information or DBA component in accordance with the recommendations of the 1998 DBA study. Similarly, the 1999 Command and Control study and related actions have had an important impact on planning for the SwAF's future C2 and Decision Superiority (DS) capabilities.





Dynamic Engagement: The Next Step in Sweden's RMA

For the SwAF to realize its full potential in the future, all three major components of the RMA must be thoroughly studied and carefully implemented in the years ahead.

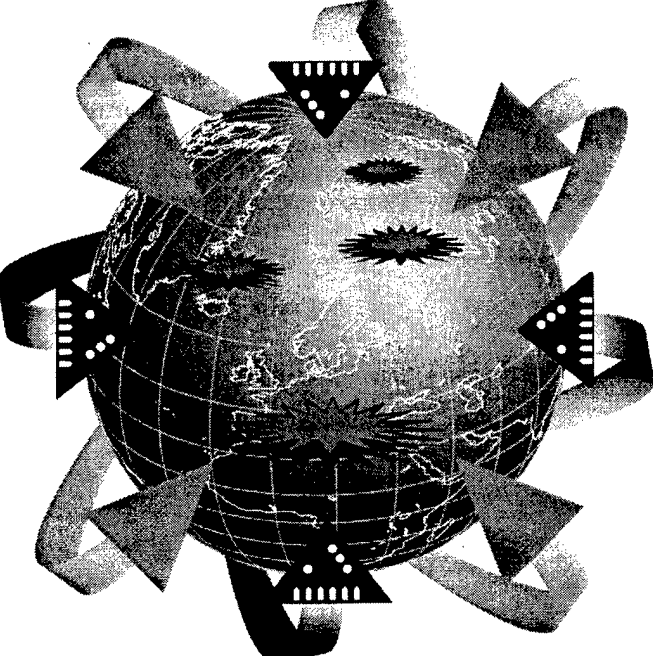
Building upon this foundation, the SwAF is ready to develop its Dynamic Engagement (DE) capabilities as the action component of the RMA. Gathering all of the available information for commanders at all levels and attaining mature DBA capabilities are vital steps in the process.

Clearly, DE, as the action component of the RMA, stands at the very center of RMA-based concepts and provides the operational rationale for realizing future engagement capabilities.

Future Security Environment

Threats are
more complex
more asymmetric
more frequent
less predictable

Demand
New thinking
New education
New training



Future Security Environment


Technology, especially information technology (IT) and nonlethal technologies, offers Sweden remarkable new opportunities to deal with this array of future threats.

IT is at the heart of the information revolution and the global economy, in which Sweden is a leading participant. Computer processing power and bandwidth for information transport are expected to grow at an accelerating rate over the next several decades. The utility, flexibility, and reliability of software also will increase dramatically. Wireless communications capabilities may be expected to spread very rapidly throughout the world and, together with the fiber-optic revolution, will facilitate broadband global connectivity for all users, whether fixed or mobile. Global connectivity will become ubiquitous, not only for the world's people but also for their appliances, sensors, and devices of all kinds. Based on IT performance improvements and the high costs of placing manned forces in harm's way, the future battle space will be populated with masses of mechanical surrogates—sensors, robots, and autonomous vehicles of all kinds—that will execute many of the most mundane and also most dangerous functions in conflict. Technical advances in planning and coordination, as well as weapons effects, will permit an increase in selectivity of effects across the spectrum of lethality, ranging from deterrence to soft kill to nonlethal to narrowly targeted lethal means. The challenge will be to focus the effects to obtain the desired outcomes.





To survive in future conflict, formations and objects in the battle space will necessarily be physically dispersed but connected closely through information networks. The object of conflict will be to move swiftly, directly, and decisively to achieve victory quickly rather than to grind through indirect courses of action with high attrition and ambiguous outcomes unsupportable by national and international public opinion.

Conflict in the future, as in the present, will have a strong physical component, but the temporal and information dimensions will grow markedly in importance. The emerging global infosphere of connection, information, and knowledge will become critical to the control of conflict at every level of intensity.



Global and Regional Trends for Technology



Information Technology

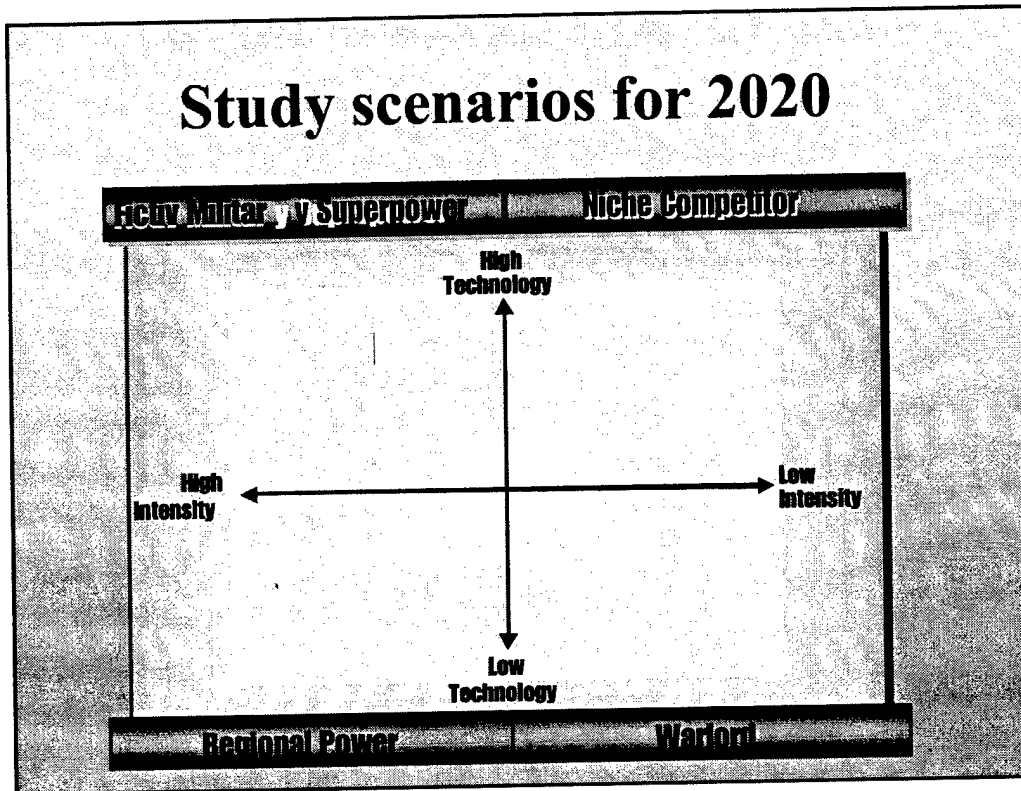
 Processing
 Software
 Bandwidth
 Mobility

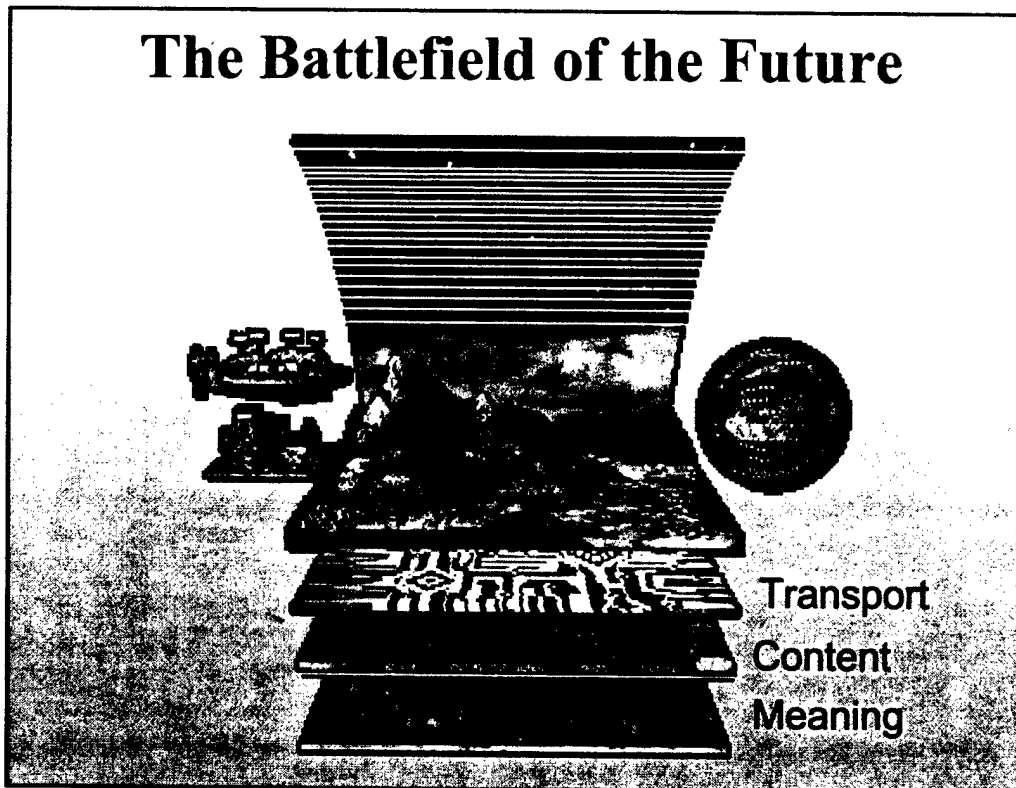
Predictable
Global Connectivity

 Integration
 Commercially Driven

Unpredictable
Exponential

Study scenarios for 2020

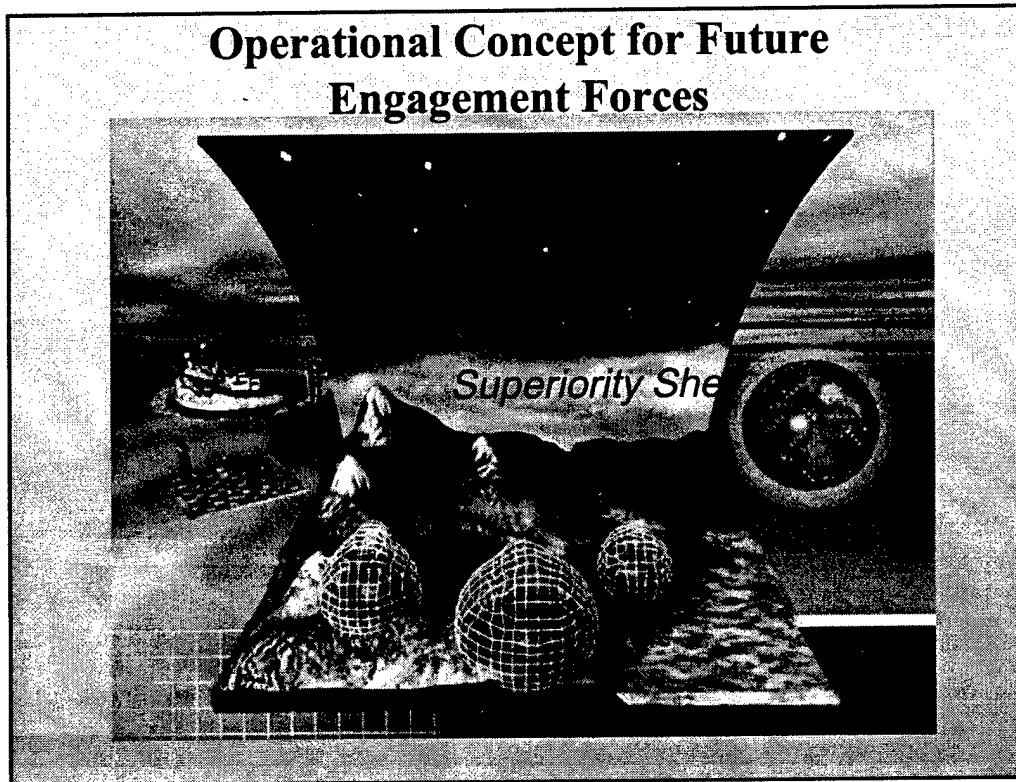




Future Battle Space

The future battle space takes into account the emergence of the global infosphere. The infosphere has a physical component for transport and virtual components that include content and meaning of information. The concept of an infosphere includes the processes of global collection and movement of data; data transport and transformation into information; and, ultimately, data fusion, filtering, synthesis, and exploitation as knowledge.

The future battle space assumes a depth and density not evident in the historic battlefield concept. It now includes not only the physical attributes of terrain and environment and the underlayers of organization, culture, and electromagnetic context but also the notions of data transport, information content, and, most critically, perception and knowledge. Advanced forces operating within the battle space are kept informed by DBA capabilities and enjoy decision superiority.

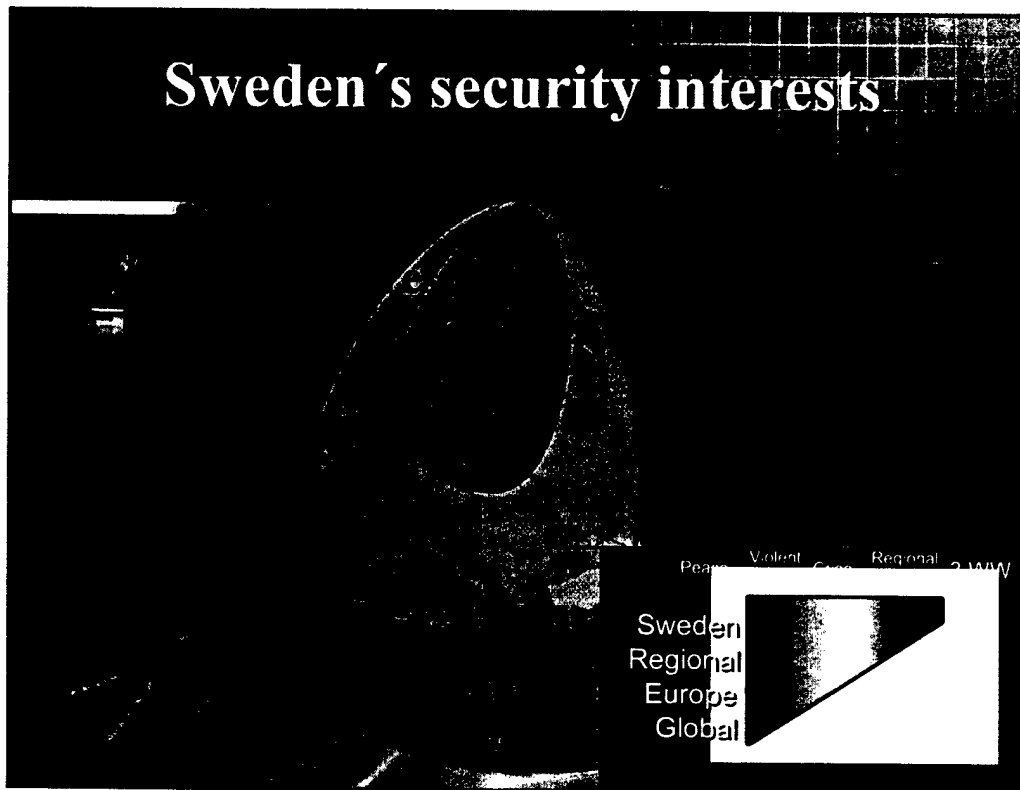


Dynamic Engagement Operations

The operational concept for DE requires precision in planning and execution and depends critically not only on timely access to information but also on knowledge to ensure decision superiority and the ability to deliver decisive effects before the adversary can decide and counter. Forces operating under the operational concept apply combinations of Physical and Information Operations for DE of the adversary.

While preparing for their missions, these forces are informed and protected with high confidence by means of Superiority Shells, the capabilities of which change to stay ahead of changes in adversary activity and the battle space environment.

When executing DE missions, forces are informed, protected, and supported by Superiority Shells, which reach wherever needed and for any necessary timeline in the battle space. DE forces get into and out of danger quickly, falling back to sanctuaries well protected by suitably configured Superiority Shells.



Swedish Security Policy

There are a number of important implications for Swedish security policy.

First is the notion that in the future and at variance with its past, Sweden's security interests will be tiered and layered. Sweden's first priority will remain the defense of Sweden itself.

Outside of the Swedish homeland, Sweden's security interests are, in order of priority,

- Sweden's northern European neighbors in the Nordic Baltic Region;
- Europe as a whole, including the security interests of the European Union, with special attention to areas of actual or potential armed conflict in Europe;
- the rest of the world, especially in those regions where Sweden has vital economic and/or political interests and where Swedish forces are deployed for peacekeeping, humanitarian, or other purposes.

This approach and order of prioritization enable Sweden to solve problems where they occur.

The Swedish RMA

Stated by Minister of Defense Björn von Sydow:

“There is an ongoing debate in Sweden about if or at which speed we should move into the RMA era. Some say, ‘Of course it’s OK for the United States to go for RMA, but is it possible for a small country like Sweden!?’ I believe that it is both possible and necessary for Sweden to take further steps into the new way of doing business—the RMA way!

“We are a modern democracy and a technologically well developed country. For me it is clear that RMA gives us the right way of developing our Armed Forces using high-level technology in the same way as all other parts of our Swedish society. RMA is a natural step for a democracy and a society leaving the era of Industrialism and going into the Information and Knowledge era.”

ARMS CONTROL OPTIONS IN AND FROM SPACE¹

Paul Meyer, Director-General, International Security Bureau, Department of Foreign Affairs and International Trade, Ottawa, Canada

The title of this session, "Additional Dilemmas and Opportunities," struck me as particularly apt, as the approach to the use of outer space for security and defense purposes is at a point where one can see both dilemmas (and dangers) as well as opportunities. As the Chinese like to point out, the character for "crisis" also contains the concept of "opportunity."

When one regards the current discussion, there appear to be two contending concepts of the use of outer space. One views outer space as the next battlefield, an arena for conflict where the goal will be to protect your space assets, while attempting to destroy those of your adversaries.

The other considers space as an increasingly vital realm for civilian and peaceful military purposes, in which space assets should enjoy immunity from attack as part of a cooperative international regime safeguarding its peaceful exploitation. These basic concepts are clearly in opposition to one another, and if the former prevails it will become increasingly difficult to sustain the latter.

Let us first consider the current situation regarding outer space. By some estimates, there are more than 500 active satellites currently in outer space, with the United States building about 75 percent of them. It is evident that the international community, and especially Western states, is dependent to an ever-increasing extent on the peaceful uses of outer space for crucial civilian and military functions. One need only consider the global communications, weather, navigation, and remote sensing functions performed by civilian satellites. Military applications include communication, navigation, search and rescue, and surveillance, including for purposes of verification of arms control and disarmament commitments. These civilian and military uses have been able to proceed largely without fear of hostile interference or attack, and although it is difficult to put a dollar figure to this activity, I think it would be fair to estimate that the value of these space assets and the functions they perform would be in the multibillion-dollar range.

This productive exploitation of space has developed without fear of molestation, on the basis of a broad international norm in favor of preserving space for peaceful purposes. The principal embodiment of this norm lies in the Outer Space Treaty of 1967 ("Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies," to cite its complete title). Article III states that parties to the Treaty "shall carry on activities in the exploration and use of outer space, in accordance with international law ... in the interests of maintaining international peace and security and promoting international cooperation and understanding." Article IV contains a direct prohibition against placing

¹The views expressed are the author's own, and do not necessarily reflect those of Canada's Department of Foreign Affairs and International Trade.

in orbit any nuclear or other weapon of mass destruction or installing them on celestial bodies, or stationing them in outer space in any other manner. Article IX has provisions for consultations in the event that a planned activity in outer space might "cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space." The guiding principle is clearly one of cooperation and the obligation of the parties to conduct their activities in space "with due regard to the corresponding interests of all other States Parties to the Treaty."

This presumption of cooperation and mutual respect in furtherance of the peaceful use of outer space is in sharp variance with the opposing view of space as just another arena for military competition and the pursuit of unilateral advantage over perceived or real adversaries. Notions of "space control" are premised on the deployment of a variety of assets into space, including actual weapons systems with the capacity to strike into space or from space down into the atmosphere or onto Earth. The policy direction of the U.S. military is clear in the doctrinal documentation that the Joint Chiefs of Staff (JCS) and the United States Space Command (USSPACECOM) in particular has produced. In the JCS's *Joint Vision 2020* (and associated *Long-Range Plan* enunciated by USSPACECOM), it is assumed that space systems will become targets and hence space superiority becomes an essential element of what is described as "battlefield success." Space control is defined as "ensuring freedom of operations in space, for your side, and the ability to deny others the use of space." The *Joint Vision* projects a future role for the United States "as guardians of space commerce—similar to the historical example of navies protecting sea commerce." Of course, exercising this "space control" would require what the *Joint Vision* somewhat euphemistically refers to as "robust negation systems." These will include space-based strike weapons and other systems whose "actions will range from temporarily disrupting or denying hostile space systems to degrading or destroying them. Our objectives must consider third-party use, plausible deniability, and how actions will add to debris or otherwise affect the environment." In a concluding section entitled "Out of Our Lane" (Policies, Treaties, and Agreements), USSPACECOM points to action in the international legal and regulatory environment that would complement the "space control" vision, including a call to "shape international community to accept space-based weapons to defend against threats in accordance with national policy."

Lest one discounts some of the above as reflecting the understandable enthusiasm of a military command for a new mission, it is necessary to bear in mind other expressions of policy intent. The report of the recently concluded congressionally mandated Commission to Assess United States National Security Space Management and Organization (better known as the Rumsfeld Commission, after its former chair, now Secretary of Defense) also seems to stress military over diplomatic options to preserve space for U.S. interests and to leave open the door to an eventual weaponization of space. While acknowledging the vulnerability of space-based assets, the Commission speaks of the need "to deter and defend against hostile acts" and assumes that space will necessarily become an arena for conflict. The possibility of

cooperative arrangements or a legally secured "sanctuary status" is ignored or dismissed. Instead, we are reminded that "[T]here is no blanket prohibition in international law, on placing or using weapons in space, applying force from space to Earth, or conducting military operations in and through space." The Commission report recommends that the United States should be cautious about any international agreements that could restrict future activities in space. The specter of a space "Pearl Harbor" is raised to evoke the need to defend, or even better to preempt, against an attack on U.S. assets. There is a dichotomy apparent in the Space Commission's aims of, on the one hand, "preserving the peaceful use of space" while, on the other hand, seeking a capacity "against the use of space hostile to U.S. interests." There is an inherent tension, some might say even a contradiction, between wanting to maintain unimpeded peaceful use (including military use) of space and pursuing the capacity to "negate" space use by others. To proceed down this path citing the potential capabilities of others is a tried and true means of eliciting the very responses one ostensibly is trying to avoid. Weaponization of outer space readily becomes a self-fulfilling prophecy.

This conference's title speaks of choices for small and middle powers, and in general the security interests of such states are best safeguarded through multilateral "rule of law" approaches, as opposed to great power unilateralism. International arms control and disarmament does provide an alternative route for securing the peaceful uses of outer space and avoiding an arms race in a new environment. Unlike the presumption that conflict and weapons will inevitably intrude into all realms, the international community can point to a series of accords that have excluded or restricted weapons use. The Outer Space Treaty reflects earlier efforts of self-restraint for the benefit of humanity, as the Antarctic, Seabed, Test Ban, and Environmental Modification Treaties are cases in point. To move via an international disarmament agreement to preclude the introduction of weapons into outer space, instead of struggling through arms control measures to "claw back" their numbers after the fact, is one course of action that Canada and others have long advocated. As noted earlier, the Outer Space Treaty of 1967 bans only one particular class of weapons from outer space: weapons of mass destruction (WMD). A new convention, or amendment of the existing Treaty, could extend that prohibition to all space-based weapons, regardless of whether they are WMD, conventional weapons, or exotic weapons. Space-based lasers, neutral particle beams, and directed energy weapons are examples of exotic weapons, while missile interceptors (either kinetic or armed with high explosive warheads) are examples of conventional weapons.

Such a convention would represent an initiative in preventive diplomacy, and build on both multilateral and bilateral precedents (e.g., the 1972 ABM Treaty and 1997 ABM Demarcation accords ban space-based weapons for purposes of ballistic missile defense). It would not interfere with current, and future, peaceful military uses of space, but would, at the same time, afford both civil and military assets protection from space attack. There would of course be challenges in negotiating such a ban. Definitional issues—such as "what is a weapon"—would figure prominently. One possible definition could be "Any device, specially designed or modified to inflict permanent physical damage on any other object through the projection of mass or energy." Under such a definition, the nonweapon components of a space-based mili-

tary system (e.g., navigation, communication, and observation components) would not be prohibited, but only the "sharp end" of such systems. Verification on a space weapons ban would be another crucial aspect. Here, ground- and space-based remote sensing technologies for verification of a space-based weapons ban have advanced substantially since the mid-1980s Canadian PAXSAT studies determined that such a ban would be verifiable even with the existing technology of the day. Advanced remote sensing techniques, supplemented as needed with on-site inspections and other transparency measures, could offer effective and efficient verification.

In our view, the negotiation of a space weapons ban would be the best short- to mid-term objective for protecting the peaceful uses of space. It is not an all-encompassing solution, however, as space-based assets can also be targeted from the ground. A ban on ground- (or air-) to-space antisatellite (ASAT) weapons would over time be a desirable adjunct to any accord prohibiting space-based weaponry. Earlier, bilateral efforts were made to conclude such an agreement during the Cold War, but did not result in success, although a reciprocal restraint in the development of such ASAT weapons has been observed up until now. Given that both ballistic missiles and antiballistic missile interceptors under development possess an inherent ASAT capability, the difficulty of arriving at a comprehensive ASAT ban is evident. A ban on space-based weapons would, however, encompass any orbiting ASAT, and could provide a basis of confidence for negotiating further arrangements to prohibit ASAT testing and use which would secure satellites from deliberate harm by Earth-based weapons deployed on land, at sea, or in the air. Moving in succession to negotiate both a space-weapons ban and an ASAT ban would provide a "sanctuary" for artificial satellites consistent with the principle of the nonaggressive peaceful uses of outer space.

Space has been called "the final frontier" of human exploration and activity, and it is largely up to us whether that frontier will be one where weapons abound, or a realm of "law and order" where possibilities for the peaceful, civil, and military use are maximized. History offers us examples of both scenarios; we should be careful in exercising our options.

DUAL-USE ASPECTS OF SPACE TECHNOLOGY AND THE IMPLICATIONS FOR THE MIDDLE EAST

Gerald M. Steinberg, Bar-Ilan University, Israel

For the most part, technological innovation is inherently neither virtuous nor malevolent. Its impact depends on the applications and the environment. Atomic science was both welcomed as the savior of mankind and the source of boundless energy and cursed for creating a nuclear Sword of Damocles threatening to destroy nations and mankind.

The same is true for the development and application of space-based systems. The United States, Soviet Union, and later China used the intercontinental ballistic missiles (ICBMs) originally made to carry nuclear warheads for launching space probes, and many of today's most active commercial launch vehicles are decommissioned ICBMs or their descendants. The most prolific satellite-based systems and technologies—for communications, navigation, and imaging—are dual-use systems, which can be and are applied in commercial and civilian applications, as well as in the service of security and defense (or for aggression). The components designed for commercial communications satellites are also used to direct military forces on the battlefield in the context of the "revolution in military affairs" (RMA), and commercial imaging can be used to verify arms control agreements and in other conflict resolution applications. In other words, the technology involved does not determine the application. Rather, applications are based on specific environmental factors—commercial, political, and military—strategic.

This paper examines the military and security applications of commercial and dual-use imaging satellites in regional contexts. As will be demonstrated, the impacts—in terms of security and stability—of the proliferation of this technology are likely to be particularly pronounced in the Middle East. In contrast to the mid-1990s, when there were some indications that the Arab-Israeli conflict was in the process of winding down, the situation that emerged toward the end of 2000 is increasingly dangerous. These dangers were compounded by the collapse of the Israeli-Syrian negotiations in 2000, followed by the outbreak of a major wave of Palestinian violence and low-level warfare at the end of September. Strong statements of support, accompanied by threatening language, were repeated in Iraq, Iran, Egypt, and Syria. And, in the case of Iraq, the rhetoric was accompanied by troop movements.

In this context, the role of strategic deterrence and careful assessments of the perceived military balance are also increasing in importance. In this environment, major strategic and tactical technologies, including the availability of real-time ultrahigh-resolution (UHR) images, could have important impacts on regional stability and on the vital security interests of Israel and other key actors.

From Classified Reconnaissance Satellites to Dual-Use Commercial Imaging

The dual-use dimensions of space applications are highlighted in the case of commercial UHR imaging. In September 1999, the U.S.-made IKONOS satellite was launched and began to return images with a resolution of 1 m. Fifteen months later, in December 2000, the first Israeli EROS satellite was placed into orbit, and in the next few years, the number and capabilities of such systems are slated to increase rapidly. As a result, formerly secret military facilities are becoming widely visible, not only to highly classified American and Russian reconnaissance satellites, as in the past, but to a much wider audience.

While some analysts view this development as positive, in terms of transparency and its applications to arms limitation agreements and prevention of surprise attack,² there are also potentially very significant negative impacts on security and stability, particularly in regions characterized by a high level of conflict, such as the Middle East. Instead of contributing to confidence building, high-resolution commercial imaging also has the potential for aggravating conflicts and international instability, changing the balance of power, sharpening existing asymmetries in military capabilities, and making regional and international conflicts harder to manage.

Military Applications of Imaging Satellites

The application of space-based imaging to military activities began during the early period of space exploration, shortly after the launch of Sputnik in 1957 and the American Explorer and Discovery satellites. The first operational imaging satellites were launched by the United States in 1960, but during the next three decades, this activity was confined to dedicated reconnaissance satellites operated by the two superpowers during the Cold War. Indeed, space-based military reconnaissance constituted the most important strategic development since thermonuclear weapons (with the possible exception of Multiple Independent Reentry Vehicles, or MIRVs).

Early U.S. satellite programs were developed in response to perceived Soviet threats, following the testing of an ICBM and the launch of Sputnik in 1957.³ U.S. reconnaissance satellites received hundreds of thousands of images, covering a wide variety of strategic and tactical targets, including Soviet and Chinese missile locations, the site of the detonation of the first Chinese atomic weapon, submarine ports, aircraft carriers, combat air bases, etc. Infrared and broad-spectrum imagery, space-based SAR, and other technologies were developed for all-weather, all-hours imaging. Other

²Ray Williamson was recently quoted as predicting that such UHR would "make the world a safer and more transparent place, even with high-resolution satellite photographs in the hands of potential adversaries." Vernon Loeb, "U.S. Is Relaxing Rules of Satellite Photos After a Year-Long Policy Review, Far Greater Detail Being Allowed," *Washington Post*, December 16, 2000, p. A3.

³See Dino A. Brugioni, "The Art and Science of Photoreconnaissance," *Scientific American* (March 1996) and Albert D. Wheelon, "Corona: The First Reconnaissance Satellites," *Physics Today* (February 1997); Gerald M. Steinberg, *Satellite Reconnaissance: The Role of Informal Bargaining* (New York: Praeger, 1983). See also John Lewis Gaddis, "The Evolution of a Reconnaissance Satellite Regime," in *U.S.-Soviet Security Cooperation*, George Farley Dallin, ed. (New York: Oxford University Press, 1988), pp. 353-363.

systems collected electronic information and monitored (or eavesdropped on) military and civil telephone communications.

During this period, civil and commercial satellite imaging systems were limited to resolutions of 30 m, in the case of the U.S. Landsat system, and to 10 m, for the French SPOT satellites, launched in 1986 (second-generation SPOT systems provide images of 5 m GSD, or ground separation distance). The American restrictions on commercial exploitation of high-resolution satellite imaging were imposed in order to avoid impinging on or interfering with operation and secrecy of the military systems.⁴

The military use of high-resolution satellite surveillance systems has expanded continuously, and after the end of the Cold War, this was extended to tactical warfare and regional conflicts. Satellite imaging was used extensively by the United States and allied forces in the 1991 Gulf War (referred to as "the first space war"),⁵ and by NATO in the Balkans conflict. In both cases, the U.S. government (and, somewhat reluctantly, the French government as well) restricted public access to images returned by the Landsat and SPOT systems, respectively, in order to prevent release of potentially useful military information to Iraq. The Gulf War also illustrated the significant technical challenges facing tactical, real-time application of satellite imaging on the battlefield, but the potential for these tactical applications is increasing.

Just as satellite reconnaissance played a major role in the strategic balance during the Cold War, the same technology can be applied in the post-Cold War era of regional conflict to provide targeting information and postattack damage assessments.⁶ The tactical importance of satellite imaging can also be seen in the large-scale European investment in such systems, including two high-resolution Helios-1 1.5-m optical-reconnaissance satellites (launched in 1995 and 1999 with French investment, and minor Italian and Spanish participation); the planned Helios-2 satellite (0.8-m GSD), to be launched in 2003-04; and the very high resolution radar-satellite constellation SARLupe being developed by Germany.⁷ In addition, the

⁴Brugioni, "The Art and Science of Photoreconnaissance," p. 78. The Corona orbiters lasted after the program had officially ended; some were known as Keyhole (KH)-1,2,3, and 4 and were followed by seven KH-5 satellites of the Lanyard program and one of the Argon program. According to Albert Wheelon, 145 satellites were placed into orbit in the 12 years of Corona's operation. From those launches, 167 film capsules were recovered, producing more than two million feet of film. See also Dwayne A. Day, "The KH-6 Reconnaissance Satellite," *Spaceflight Magazine* (May 1997), and Jeffrey Richelson, *America's Secret Eyes in Space* (New York: Harper, 1990).

⁵Quoted in Major Michael J. Muolo, ed., *Space Handbook: A Warfighter's Guide to Space (AU-18)*, Vol. 1 (Maxwell AFB, Ala.: Air University Press, December 1993), iv and cited by Peter L. Hays, "Space and the Military," in *Space Politics and Policy: An Evolutionary Perspective*, E. Sadeh, J. P. Lester, and P. Hays, eds. <http://ceiss.engr.colostate.edu/po371/textbook/space%20and%20the%20military.pdf>.

⁶See, for example, Vipin Gupta, "New Satellite Images for Sale: The Opportunities and Risks Ahead," *International Security*, Vol. 20 (Summer 1995); Ann M. Florini and Yahya Dehqanzada, "Commercial Satellite Imagery Comes of Age," *Issues in Science and Technology*, Fall 1999; Peter Hays, *Space Power and the Revolution in Military Affairs*, Institute for National Security Studies, www.airpower.maxwell.af.mil/airchronicles/apj/apj99/fal99/gray.html.

⁷"European military satellites: New tools for defence cooperation," *Strategic Comments*, Vol. 6, No. 10, International Institute for International Studies, London, December 2000.

Western European Union operates a satellite-imaging center in Torrejon, Spain, that has relied primarily on SPOT images.⁸

The Era of Commercialization

After the end of the Cold War, the U.S. government began to remove the licensing restrictions and restrictions on commercial high-resolution imaging technology. These changes were, in part, an American response to the commercial successes of the French SPOT, as well as growing competition from other suppliers, including Russia.⁹ The new American policy also reflected the optimism and changed security assumptions that accompanied the end of the Cold War and the proclamation of a "New World Order."¹⁰ Most importantly, this policy was based on very optimistic market forecasts that included annual sales estimates of billions of dollars in imagery, technology, and software.¹¹

The enthusiasm was tempered, to a limited degree, by warnings regarding the military applications that were likely to follow, and the implications, particularly for American security interests. For the first time, many countries as well as nongovernmental actors in areas such as the Middle East, North Asia, Central Europe, and South America are gaining access to very detailed and almost real-time images of neighboring states. Former U.S. government officials such as Henry Sokolski included satellites in a list of "non-apocalyptic weapons" and warned of the consequences had satellite imaging been available to Saddam Hussein in the Gulf War.¹² Vipin Gupta noted that unlimited sales of high-resolution imaging could disrupt "delicate balances of power," complicate the containment of international crises, and fuel developments in offensive weapons capability.¹³ Former CIA director James Woolsey counseled caution, noting that "this very comfortable world people have been living in where fixed target installations on land are safe" will vanish with the proliferation of high-resolution commercial imaging.¹⁴

⁸Ibid.

⁹Vernon Loeb, "U.S. Is Relaxing Rules of Satellite Photos After a Year-Long Policy Review, Far Greater Detail Being Allowed," *Washington Post*, December 16, 2000, p. A3.

¹⁰Although the text of PDD-23 is classified, the policy guidelines were made public. For a detailed analysis of the evolution of this policy, see Lt Col Peter L. Hays and Lt Col Roy F. Houchin, II, "Commercial Spysats And Shutter Control: The Military Implications of U.S. Policy on Selling and Restricting Commercial Remote Sensing Data," School of Advanced Airpower Studies, Maxwell AFB, Ala., prepared for the Institute for National Security Studies, USAF Academy, CO (1999 draft version).

¹¹Kevin O'Connell and Beth E. Lachman, "From Space Imagery to Information: Commercial Remote Sensing Market Factors and Trends," in John C. Baker, Kevin M. O'Connell, and Ray A. Williamson, eds., *Commercial Observation Satellites: At the Leading Edge of Global Transparency* (Santa Monica, Calif.: RAND and the American Society for Photogrammetry and Remote Sensing, MR-1229, 2001).

¹²Henry Sokolski, "Nonapocalyptic Proliferation: A New Strategic Threat?" *The Washington Quarterly*, Vol. 17, No. 2 (Spring 1994), p. 115; Ann M. Florini, "The Opening Skies: Third Party Imaging and U.S. Security," *International Security*, Vol. 13, No. 2 (Fall 1988), p. 10.

¹³Gupta, p. 117.

¹⁴R. James Woolsey, cited by Charles Lane, "The Satellite Revolution," *The New Republic*, August 12, 1996; Mary Graham, "High Resolution, Unresolved," *Atlantic Monthly* (July 1996), p. 26.

Other analysts and policymakers warned of the dangers linked to terrorist access to this data and capability.¹⁵ "Islamic Jihad could get its hands on a one-meter resolution picture of ... a U.S. Air Force General's headquarters in Turkey, convert the shot to a precise three-dimensional image, combine it with data from a GPS device ... and transmit it to Baghdad, where a primitive cruise missile, purchased secretly from China, could await its targeting coordinates."¹⁶

The impacts, both stabilizing and destabilizing, will depend on factors such as resolution, the form in which the data is sold (original digital data, or derivatives), the nature of the distribution system (direct real-time ground links to receivers, or delayed transmission via filtering stations), available software, shutter control, and similar factors.¹⁷ In addition, as UHR imaging becomes more widespread, countermeasures are likely to be developed in order to camouflage critical military installations and activities, and to limit the ability of overhead satellite imaging to degrade central military capabilities deemed vital for national security and survival.

The Initial Impact of IKONOS¹⁸

IKONOS was successfully placed into orbit on September 25, 1999 (after the first launch failed). Shortly after IKONOS became operational, a number of political advocacy groups and news organizations began to purchase and release images of military sites and facilities in areas of tension and conflict. The effect of these isolated and very public examples may be, to a limited degree, illustrative of the complex impacts of commercially available UHR satellite imaging.

In January 2000, a photo of the North Korean Tae Po Dong missile test site was obtained and made public by the "Public Eye" project of the Federation of American Scientists (FAS).¹⁹ This was an important event that focused attention on the threat posed by missiles from North Korea, and also from importers of this technology, such as Iran, Iraq, Syria, Libya, and Egypt.²⁰ The release of this image led to conflicting assessments, based on predetermined positions related to the debate over the U.S. National Missile Defense (NMD) program. While opponents of NMD claimed that it showed that the site and the North Korean capability are "much more crude than U.S. military leaders have portrayed it,"²¹ critics of this analysis, such as James Woolsey, took issue with this conclusion, noting that "the relative primitiveness of the site is not the main point.... In order to have a blackmail weapon, the North

¹⁵Eliot A. Cohen, "A Revolution in Warfare," *Foreign Affairs*, Vol. 75, No. 2, March/April 1996, pp. 37-54.

¹⁶Charles Lane, "The Satellite Revolution," *The New Republic*, August 12, 1996, p. 24.

¹⁷Hays and Houchin (1999 draft).

¹⁸This section is based on Gerald M. Steinberg, "Commercial Observation Satellites in the Middle East and the Persian Gulf" in *Commercial Observation Satellites*.

¹⁹<http://www.fas.org/nuke/guide/dprk/facility/nodong-2.htm>.

²⁰Aaron Karp, "The Middle East," in *International Perspectives on Missile Proliferation and Defenses*, Center for Nonproliferation Studies, Occasional Paper No. 5, 2001.

²¹http://www.fas.org/eye/000118_CL_satellites.htm.

Koreans really just need a missile that can hit a large area in Japan and [later] the United States."²²

Later, IKONOS images of Indian and Pakistani nuclear and missile sites were also made available on the Internet by the FAS. This new level of transparency highlighted the potentially destabilizing impact of the availability of this data, including those countries' mutual fear of a first strike.²³ As some analysts noted, "What's striking about this image is it shows the Pakistanis have all their eggs in one basket.... These Pakistani missiles are vulnerable to an Indian first strike."²⁴ The FAS has also purchased and posted IKONOS images of Chinese military air bases,²⁵ and perhaps following this lead, Taiwan was reported to have purchased 19 IKONOS images of seven military targets on the Chinese mainland.²⁶

From this preliminary assessment, based on the first year of IKONOS operations, it is clear that commercial UHR imaging had an immediate and significant strategic impact. Extrapolating from this limited experience, as well as from the history of strategic intelligence and regional conflict, these impacts are likely to grow as the availability of commercial space-based imaging systems continues to expand.

Dual-Use Impacts on Stability and Security in the Middle East

With the legacy of overlapping conflict zones (Arab-Israeli, Persian Gulf, Turkey-Syria, North Africa, etc.) and the resulting wars and terrorism, the Middle East continues to be characterized by a high level of instability. The failure of the peace process that began with the Oslo agreements in 1993 and the violence that erupted in September 2000 are indicative of the continuing potential for conflict. At the same time, the threats posed by Saddam Hussein and by the continuing Iranian efforts to acquire ballistic missiles and WMD contribute to and exacerbate the instability.

In this context, the potential military applications of commercial satellite imaging become particularly salient.²⁷ In the Middle East—and particularly the Arab-Israeli theater, the closed airspaces, and absence of overflights or regular reconnaissance missions along the borders—the level of transparency is quite low. (In 1990, highly unusual Iraqi Air Force reconnaissance flights along the Israeli-Jordanian border

²²Joseph C. Anselmo, "Commercial Images Detail North Korean Missile Site," *Aviation Week and Space Technology*, January 17, 2000; <http://www.fas.org/nuke/guide/dprk/facility/awst-korea.htm>; see also "Spy Photos of Korea Missile Site Bring Dispute," *New York Times*, January 11, 2000; Pat Eddington, "Orbital Snooping: Welcome to Amateur Hour," *Space News*, May 22, 2000, p. 14, <http://www.fas.org/eye/000522-sn.htm>.

²³<http://www.fas.org>.

²⁴Scientists warn of advancements in Pakistani nuclear program 15 March 2000, www.fas.org; see also <http://www.fas.org/nuke/guide/india/facility/pokharan-pir.htm>.

²⁵<http://www.fas.org/nuke/guide/china/facility/fuzhou-a.htm>.

²⁶Clarence Oxford, "Taiwan Taps into Private U.S. Spy Satellite," *SPACEDAILY*, April 30, 2000, <http://www.fas.org/eye/000430-taiwan.htm>.

²⁷Col. Charles P. Wilson, "Strategic and Tactical Aerial Reconnaissance in the Near East," *The Washington Institute for Near East Policy, Military Research Papers*, No. 1, Washington D.C., 1999.

were considered signs of preparation for a possible first strike.) The ability of space-based systems to overfly closed areas and return high-resolution images that will be widely and publicly available (in contrast to the closely held American and Soviet images during the Cold War) constitutes a major change in the strategic environment.

Among the states in the region, Israel appears to be the most sensitive to the military impacts and applications of high-resolution commercial imaging satellites. This sensitivity was expressed in the early 1990s, when the U.S. government's decision to remove the limitations on high-resolution commercial imaging led to concern among Israeli defense officials regarding the impact on national security. Israel's very small territorial extent, which allows for detailed and repeated coverage with a relatively limited number of images, makes it vulnerable to accurate counterforce attacks based on data accessible through commercial high-resolution imaging satellites. The Israeli deterrence posture and strategy is based on maintaining a high degree of uncertainty in the eyes of potential enemies.

Israeli policymakers are concerned that Arab states, Iran, and also the various terrorist groups operating in the region (such as the Bin Laden network) will be able to exploit these high-resolution images to obtain very detailed intelligence of Israeli capabilities and deployments. The ability to target Israeli sites with a high degree of precision would alter the balance of power fundamentally, particularly if these images were combined with GPS data to target cruise or ballistic missiles.²⁸

These concerns were raised in 1992, after the United Arab Emirates (UAE) submitted an application to purchase an imaging satellite from Litton/Itek. Israeli officials protested, charging that the United States was planning "to supply the Arab countries with binoculars that will enable them to see every military movement here."²⁹ The application was ultimately blocked by the U.S. State Department. Similarly, Israel objected to efforts by a Saudi company known as EIRAD, owned by Prince Fahd Bin Salman, to acquire a major interest in the Eyeglass and OrbImage system. EIRAD acquired a 20 percent interest in the company, and received a ground station in Riyadh and exclusive rights to receive and distribute OrbView satellite images in the Middle East. The main customer is expected to be the Saudi Defense Ministry.³⁰

In 1995, after considerable negotiations, the Israeli and American governments agreed to coordinate policies. The United States accepted the Israeli position on the need to prevent Arab countries such as Saudi Arabia from obtaining the ability to control the tracks of high-resolution imaging satellites from the ground, and also placed limits on the sale of state-of-the-art software for image enhancement. In addition, the details of shutter control were considered in greater detail for Middle East war scenarios.

²⁸Gerald M. Steinberg, "Middle East Space Race Gathers Pace," *International Defence Review*, October 1995; Gerald M. Steinberg, *Dual Use Aspects of Commercial High-Resolution Imaging Satellites*, Security and Policy Series Paper No. 17, BESA Center for Strategic Studies, Bar-Ilan University, 1998.

²⁹Michael Rotem, "Spy Satellite for Arab Emirates 'Serious Threat,'" *Jerusalem Post*, November 19, 1992; Sergey Koulik and Richard Kokoski, "Verification Lessons of the Persian Gulf War," *Conventional Arms Control* (New York: Oxford University Press, 1994), p. 199.

³⁰Lane, "The Satellite Revolution," p. 24.

In June 1996, the U.S. Senate passed an amendment to the 1997 Defense Authorization Act entitled "Prohibition on Collection and Release of Detailed Satellite Imagery Relating to Israel and Other Countries and Areas."³¹ The final version of the amendment prohibited the sale of imaging data over Israel with a resolution below that provided by other "commercially available" sources. The precise definition and implementation of this language was unclear, and the Israelis agreed to a 2-m limit, based on the availability of Russian KVR-1000 images (although there are questions regarding the degree to which these can be called "commercially available"). In 1998, the United States placed the limit at 1 m. Israel protested, and in July 1998, an agreement was reached blacking-out Israel at resolutions below 2 m.

The images of Israel released by IKONOS have complied with this limitation, but a reevaluation of U.S. policy is expected to reduce the limit to 1 m or less, and 0.5-m resolution systems are being planned for launching in 2004.³² While the impacts of these changes remain unclear, indications of these implications can be discerned by the activities and policies of the key states in the region, including Israel, Iran, Iraq, Egypt, and Saudi Arabia, with respect to high-resolution satellite imaging.

Israel. To offset major structural asymmetries and the Arab advantages in terms of territory, population, and other factors, Israel has generally sought to maintain a qualitative advantage through the use of advanced technology. This strategy has included intelligence-related systems such as manned aircraft and unmanned aerial vehicles (UAVs), as well as the development of a dedicated military reconnaissance satellite. In 1988, Israel joined the small number of states that have developed the capability to produce and place satellite systems into orbit. The Ofeq-1 (Horizon) satellite was launched using the three-stage Israeli-designed and -manufactured Shavit launcher. While details were classified, press reports referred to this system as a technical test bed. Ofeq-2 was launched in April 1990, similar in weight and technical characteristics to Ofeq-1, with an orbital lifetime of 3 months. Ofeq-3, launched on April 5, 1995, was apparently the first operational reconnaissance system, with a payload containing ultraviolet and high-resolution imaging sensors. On January 22, 1998, the attempted launch of Ofeq-4 (reportedly equipped with an advanced imaging system) ended in failure when the booster malfunctioned.

In parallel, Israeli defense industry officials were developing a multiuser commercial version of this system, known as EROS (Earth Remote Observation System). Following the lead of the United States, Israel sought to offset the high cost of the development of dedicated military reconnaissance systems and also gain a major share of the global market. EROS 1A was launched in December 2000, by a Russian START-1 launch vehicle from Siberia, and began transmitting images a few weeks later.³³ Images released for public distribution included Seoul, South Korea; Brest, France;

³¹Statement of Senator Bingman, *Congressional Record*, p. S6924-S6925.

³²Vernon Loeb, "U.S. Is Relaxing Rules of Satellite Photos After a Year-Long Policy Review, Far Greater Detail Being Allowed," *Washington Post*, December 16, 2000, p. A3.

³³Amnon Barzilai, "Israel to launch civilian satellite today, Israeli Defense Ministry expected to be customer," *Ha'aretz*, December 5, 2000.

and Izmir, Turkey.³⁴ The Israeli government (Ministry of Defense [MOD], Israeli Defense Forces [IDF], etc.) is the primary customer for this system. Press reports indicate that a number of potential customers have expressed interest in purchasing EROS imaging services, but no official information has been released. Thus, the success of the dual-use approach remains to be demonstrated. (On March 4, 1996, the Israeli Ministry of Defense issued the first formal public statement of Israeli policy, which included a ban on the use of Ofeq images for commercial purposes, and maintenance of the division between security-related technologies. "Any possible future commercial track" would require licensing from the MOD.³⁵ Israel also accepted this limit on the sale of EROS images, and the MOD agreed to license this program.³⁶)

Iran. After Israel, Iran is the most active country in the Middle East in the indigenous development of satellite and launch capabilities. The steady progress in the production of the Shahab 3 ballistic missile, based on North Korean and Russian technology,³⁷ has provided a technological foundation for space launchers. In 1999, Iranian Defense Minister Admiral Ali Shamkhani declared that the long-range Shahab 4 missile was in production for use as a space launcher.³⁸ Another source declared that the Shahab-4 would launch a telecommunications satellite in 2001. Although there have been no public announcements, press reports claim that Israeli intelligence officials believe that Iran is seeking to acquire a reconnaissance satellite.³⁹ Iran is also a participant in a \$20 million multinational project to develop and launch a satellite for use in telecommunications and monitoring. Other participants include China, Pakistan, Mongolia, Thailand, and South Korea, with the target launch date of 2001. (The official press release did not provide details on the potential monitoring activities of the satellite.⁴⁰)

Iraq. In December 1989, a few months before the invasion of Kuwait, Iraq launched a three-stage missile (the Al-Abid), and the Iraqi government declared that this was a test of an independent space launching capability.⁴¹ During the 1980s, Iraq was also involved in the CBERS satellite imaging development project, with Brazil and China.

After the Gulf War, and the imposition of United Nations sanctions, these projects were frozen. However, with the availability of commercial systems, the Iraqi regime will have the same access as other entities to the data and images that are produced. In late 1999, a Russian firm (NPO Mashinostroyenia) reportedly delivered the first 70

³⁴www.imagesatintl.com.

³⁵Lane argues that it is in America's interest to continue to lead the regulation in remote sensing, and claims that the loss of U.S. international leadership in launches has contributed to lower disincentives for missile proliferation (Lane, "The Satellite Revolution").

³⁶"U.S. bans some satellite images of Israel," AP, July 25, 1998; Ze'ev Schiff, "U.S. bans high-resolution satellite sales in bow to Israeli pressure," *Ha'aretz*, August 17, 1998.

³⁷Gerald M. Steinberg, *Arms Control and Non-Proliferation Developments in the Middle East: 1998/9*, Security and Policy Series Paper No. 44, BESA Center for Strategic Studies, Bar-Ilan University, 2000.

³⁸Clifford Beal, "Iran's Shehab 4 Is Soviet SS-4, Says US Intelligence," *Jane's Defence Weekly*, Special (Vol. 31, Issue 7), February 17, 1999.

³⁹"Israeli intelligence suspects developing spy satellite," AP, September 5, 1998.

⁴⁰"Iran to build \$20 million satellite with Asian states," Reuters, August 4, 1998.

⁴¹"Space Activities of the US, USSR and Other Launching Countries/Organizations: 1957-1993," p. 135.

(out of a total of 220) digital high- and medium-resolution satellite images of the Gulf region to Iraq. News reports noted, "[D]efense analysts believe the photographs will greatly improve the ability of the Iraqi armed forces to target neighboring countries."⁴²

Under sanctions, to the degree that these continue to be implemented, Iraq is barred from directly entering into contractual arrangements for receipt of data from American and perhaps European or Japanese firms. However, as in the case of other dual-use technologies, agents and contractors will be able to purchase the data via third-party transactions. Coupled with the missile and WMD capability that Saddam Hussein retains, and ability to launch terror operations throughout the world, the availability of the intelligence information provided by real-time commercial imaging systems will mark a major increase in the level of Iraqi capabilities.

Egypt. Israeli technological achievements have spurred similar efforts by the Arab states, and Egypt in particular. Egyptian Information Minister Sawfat Sherif declared that "Egypt cannot watch Israel launch a satellite ... and we adopt a bystander's attitude." According to reports in the government-controlled *Al-Ahram* newspaper, Egypt plans to set up a national space agency and build three satellites. This program, scheduled to be officially announced during a conference of Egypt's Space Science and Technology Council, is designed to develop space research centers that would enable Egypt "to effectively join the space industry."⁴³ Government officials have specifically announced plans to develop a reconnaissance satellite capability.⁴⁴

A ground station in Aswan is being constructed to download satellite images (including from the IKONOS system).⁴⁵ Egyptian analysts, both civil and military, have significant experience in processing and interpreting high-altitude aerial and satellite-based imaging data. As a result, Egyptian technicians and analysts are likely to be centrally involved in many of the application programs based on the use of commercial high-resolution satellite imaging in the Middle East.

Saudi Arabia. Saudi Arabia has invested considerable resources in creating a remote-sensing infrastructure, including an advanced center, located in Riyadh. As noted above, a Saudi company known as EIRAD, owned by Prince Fahd Bin Salman, acquired a 20 percent interest in Eyeglass (OrbImage), and received exclusive rights to receive and distribute OrbView satellite images in the Middle East. The main customer is expected to be the Saudi Defense Ministry.⁴⁶

In addition, the Saudi Center for Remote Sensing (SCRS), located in Riyadh, was established in 1983 and is developing an advanced capability for data analysis. In 1999, SDRS signed an agreement with RADARSAT International (Canada) for exclusive or-

⁴²Con Coughlin, "Russian Space Pictures Enable Saddam to Target Gulf States," *Sunday Telegraph*, October 10, 1999; Reuters, "Russia Sells Iraq Satellite Photos," October 12, 1999.

⁴³"Egypt to Build Satellite to Fix Muslim Calendar: Report," *Agence France Presse*, March 16, 2000.

⁴⁴Egypt has already launched a communications satellite for use in television broadcasts, "Egypt Wants to Follow Israeli Satellite," *MENL*, February 12, 2001.

⁴⁵*Ibid.*

⁴⁶Lane, "The Satellite Revolution," p. 24.

dering, scheduling, reception, and product generation of RADARSAT I (7-m resolution) data for the Middle East. This infrastructure is also likely to be used for receiving images from RADARSAT 2, scheduled for launch in 2002.

United Arab Emirates. As noted, in 1992, UAE sought to purchase an imaging satellite from an American manufacturer on a commercial basis. Although the rules had not yet been changed, this offer was seriously considered and favored by the Commerce Department before being rejected on political and military grounds.

In 1997, Dubai signed an agreement for the establishment of an imagery receiving station, operated by DSI-Dubai Space Imaging, a joint venture formed by Space Imaging EOSAT (U.S.) with a group of UAE investors. This station will provide customers with real-time (within 20 minutes of collection) access to detailed imagery in an area within a 2,300-km radius (including all of Iraq and Iran) from the receiving station.⁴⁷ In the first stage, the Dubai receiving station will use a ground imagery processing system leased from U.S. company Datron World Communications, and receive data from the 5-m Indian Remote Sensing (IRS) Earth imaging satellites IRS-1C and IRS-1D. After the launch of the IKONOS satellites, the Dubai station will be upgraded with Raytheon/E-Systems technology, to receive and distribute 1-m-resolution imagery. Company officials and sales material explicitly noted that this system "is easily capable of detecting and identifying individual vehicle movements, mobile missile launchers and other military activities under clear weather conditions."⁴⁸ DSI will sell information products and services as well as imagery, and will provide training in imagery analysis and geographic information systems tools and applications. The contract with DSI is not exclusive, and EOSAT officials have stated that "we are already talking to several other countries in this region who have an interest in establishing a national ground station to exploit our imagery."⁴⁹

Implications and Responses

Throughout history, developments in offensive military technology have led to offsetting advances in defensive systems and strategy, and the reverse. During the Cold War, space-based systems such as reconnaissance satellites were largely protected from this cause-and-effect process by agreements, both tacit and explicit, to avoid interference with these vital "national technical means of verification."⁵⁰ The rules of the game during this period were based on maintaining tight control on the circulation of satellite images, and unprecedented secrecy and lack of public comment on these capabilities. As a result, the military planners on both sides

⁴⁷"Space Imaging EOSAT Forms United Arab Emirates Partnership," *Florida Space Today Online*, November 18, 1999; <http://www.flatoday.com/space/explore/stories/1997b/111897c.htm>; "Middle East customers to obtain detailed space imagery," *Jane's International Defense Review*, January 1, 1998, Vol. 31, No. 1, p. 8.

⁴⁸"Middle East Customers to Obtain Detailed Space Imagery," *Jane's International Defense Review*, January 1, 1998, Vol. 31, No. 1, p. 8.

⁴⁹*Ibid.*

⁵⁰Gerald M. Steinberg, *Satellite Reconnaissance: The Role of Informal Bargaining* (New York: Praeger, 1983). See also John Lewis Gaddis, "The Evolution of a Reconnaissance Satellite Regime," in *U.S.-Soviet Security Cooperation*, George Farley Dallin, ed. (New York: Oxford University Press, 1988), pp. 353-363.

learned not only to live with the overhead imaging systems, but also relied on them for strategic stability based on timely detection of preparation for surprise attacks.

With the end of this arrangement, and the development of dual-use UHR commercial imaging systems, the action–reaction process of military innovation is likely to resume. To the degree that high-level satellite imaging is seen as playing a major role in altering the balance of power, and threatening national security or survival, countermeasures will be developed and implemented. Space control and “space denial” in various war scenarios has become a central factor in U.S. war planning and in technological development priorities. Some of these measures are likely to take the form of active antisatellite systems (whose development was essentially postponed by tacit mutual agreement during the Cold War). In addition, passive responses, including deception, are also being developed and implemented.⁵¹ In many countries in the Middle East, including Iran and Iraq, sensitive plants and storage facilities have been built underground in order to hide the activities from overhead imaging systems.

From these perspectives, there is little difference between commercial, dual-use, and dedicated military satellite reconnaissance systems. In situations in which overhead imaging constitutes a direct threat or is a central component of such a threat, countermeasures are likely to be developed and deployed. The proliferation of high-resolution imaging systems and the increasing commercial availability of such images marks the beginning of an important transformation in military technology, and the impacts of as well as the reactions to this process are still to be determined.

⁵¹Steven Livingston, “Transparency or Opacity? Information Technology and Deception Operations”; Bob Preston and John Baker, “Through a Glass Darkly: Deception in the Era of Commercial Imaging Satellites and Global Transparency”; and Peter Hays, “Transparency, Stability, and Deception: Military Implications of Commercial High Resolution Imaging Satellites in Theory and Practice,” presented at the 2001 International Studies Association Annual Convention, Chicago, February 2001.

CASE STUDIES IN USING COMMERCIAL SATELLITE IMAGERY FOR REGIONAL CONFLICT RESOLUTION

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One of the important developments in the space field in recent years has been the advent of commercial observation satellites that produce high-resolution satellite imagery data. Most importantly, the growing accessibility of commercial satellite imagery raises new opportunities for encouraging regional conflict resolution by providing higher resolution overhead images that can be broadly shared. Nonetheless, commercial and civilian observation satellites are intrinsically dual-use technologies that can be used for both military and civilian purposes. This raises the possibility that malicious states or nonstate actors could acquire satellite imagery to support their aggressive aims.

This paper highlights the potential implications of commercial satellite imagery, both potentially positive and negative, for regional security.⁵² It analyzes the contributions that commercial satellite imagery can make for supporting regional conflicts, and assesses the possible regional security risks that could arise from unprecedented international and domestic access to high-resolution commercial satellite imagery.

Advent of Commercial Satellite Imagery

The successful launch of the world's first true commercial observation satellite, Space Imaging's IKONOS, in September 1999 signaled the end of a long-standing (nearly three decades) distinction between imaging satellites intended for military and civilian applications. Although civilian, military, and commercial imaging satellites still can be distinguished by their ownership and purpose, the earlier distinction between military and civilian satellite imagery is increasingly blurred because commercial observation satellites produce imagery with characteristics that are relevant to both civilian and military applications.

- *Military imaging satellites*, such as the declassified U.S. CORONA satellite series, have traditionally emphasized high-resolution panchromatic (black-and-white) imagery. Military users generally place a premium on having assured access to satellite imagery to ensure a timely return of imagery data. These users often treat satellite imagery as a highly classified product with very restricted access.
- *Civilian observation satellites* have a different focus because they tend to place greater emphasis on lower-resolution, multispectral (or color) imagery data that is better suited for monitoring large-scale natural and human trends. Thus, civilian users, which are mostly scientists and government natural resource managers, emphasize the need for imaging sensors that have been carefully and reliably

⁵²This paper draws heavily on insights provided in relevant chapters contained in *Commercial Observation Satellites*.

calibrated. Civilian imagery is usually unclassified, thus increasing the propensity of civilian users to share imagery data with their counterparts in other countries.

- *Commercial observation satellites* possess some key characteristics of both civilian and military imaging satellites. For example, commercial imaging satellites are usually designed to collect both panchromatic and multispectral imagery data. Commercial imagery data providers are also placing growing emphasis on timeliness in imagery delivery for both military and commercial purposes. A wide range of domestic and international users potentially has access to commercial satellite imagery data that is available in the international marketplace.

The new commercial observation satellites are mostly financed, built, and operated by private firms with the aim of creating profitable businesses by selling satellite imagery data, information products, and services. Their top managers and investors are convinced that these nonmilitary imaging satellites can offer competitive data inputs for a broad range of geospatial information products. These commercial uses include supporting important civil government applications (e.g., land use and management, disaster planning and assessments) or commercial uses (e.g., energy exploration, insurance assessments, crop monitoring). The utility of satellite imagery for supporting decisionmaking is greatly enhanced by parallel advances in enabling technologies (e.g., computing power, user-friendly software, and data-storage systems) that have reduced the technical and cost barriers for a broad range of potential customers.⁵³

Commercial Satellite Imagery as a Dual-Use Technology

Although commercial observation satellites are mainly designed with commercial and civilian applications in mind, these imaging satellites are intrinsically a dual-use technology because they can also support military applications. The 1990–1991 Gulf War highlighted the growing importance of nonmilitary imaging satellites as the U.S. military took advantage of lower-resolution Landsat and SPOT civil observation satellites to support various military missions and to provide a way of sharing overhead imagery data among its coalition partners.⁵⁴ The new commercial observation satellites, which offer imagery data of higher resolution, possess greater potential for supporting military and intelligence missions. In fact, military organizations and intelligence agencies from around the world are expected to be among the leading customers for commercial satellite imagery for at least the near term.

The military utility of commercial satellite imagery could be enhanced by the projected growth of more than two dozen civilian and commercial observation satellites over the next 5–10 years. Despite likely technical failures and financial setbacks, a

⁵³See Ray Williamson, "Remote Sensing Policy and the Development of Commercial Remote Sensing," in *Commercial Observation Satellites*, pp. 47–48.

⁵⁴The Gulf War experience with the lower-resolution Landsat and SPOT imagery revealed that even lower-resolution civilian observation satellites could provide imagery data relevant to a wide range of military mission needs, including mapping, mission planning, and terrain analysis. See the discussion in John C. Baker and Dana J. Johnson, "Security Implications of Commercial Satellite Imagery," in *Commercial Observation Satellites*, pp. 102–104.

major increase is expected in the number of nonmilitary imaging satellites capable of producing relatively high-resolution imagery data (less than 5-m resolution) based on the number of governments and private companies with ongoing programs or announced plans for launching new imaging satellites.

Commercial observation satellites, such as IKONOS, provide overhead imagery for the international marketplace with better than 1-m resolution. Several other firms, including Imagesat International and DigitalGlobe, have plans for imaging satellites with equal or better resolutions. In addition, high-resolution imagery from government-owned satellites, such as SPOT and Russian satellite imagery, is expected to be increasingly available. This type of imagery data is sufficient for detecting vehicles and individual buildings. Finally, a new generation of mini-satellites (less than 1,000 kg) is being produced by enterprises such as Surrey Satellite Technology, Ltd. (SSTL) in the United Kingdom, with the capability to acquire higher-resolution satellite images.

Along with improved image resolution, the new commercial and civilian observation satellites feature other advances in timely acquisition and delivery of imagery data, as well as greater accuracy in geolocating an image to its precise location on the Earth's surface. Such advances enhance the potential utility of commercial and civilian satellite imagery data for supporting various security applications. These qualities enhance the utility of commercially available satellite imagery for supporting traditional national defense missions, and provide for innovative approaches to conflict prevention and resolution. Nonetheless, the dual-use nature of satellite imagery also poses some legitimate concerns over the potential security risks that could arise from satellite imagery use by aggressive states or violent nonstate actors.

Conflict-Resolution Potential

Commercial observation satellites also offer a new instrument that can help diplomats with negotiating an end to regional conflicts and border disputes. Unlike the classified imagery from military reconnaissance satellites, which has played a crucial role in monitoring the arms control treaties negotiated during the Cold War, the imagery data produced by commercial observation satellites has the major advantage of being unclassified and highly accessible by all sides in a negotiation. This characteristic greatly increases the utility of commercial satellite imagery data for use in mitigating regional conflicts by removing the barriers to sharing satellite imagery among various countries, including regional rivals.

Supporting the Dayton Peace Talks. The Proximity Peace Talks, which the United States hosted in Dayton, Ohio, in late 1995, is a good example of the novel ways that satellite imagery and related technologies have helped diplomats in resolving complex territorial disputes. Negotiating a peace agreement among the warring parties in the Bosnia-Herzegovina conflict required establishing precise boundaries that were mutually acceptable to the Bosnian, Croatian, and Serbian delegations. The peace negotiations were greatly complicated by the need to account for strategic considerations (i.e., providing for viable access routes through enemy-held territory); a political requirement that any territorial settlement result in a specific percentage alloca-

tion of territory between Bosnia and Serbia; and the need for quick-turnaround—but highly accurate—mapping products to support the intense negotiations. Civilian satellite imagery, such as SPOT imagery, automated mapping technologies, and sophisticated 3-D imagery visualization software such as PowerScene were all employed to assist U.S. negotiators in resolving repeated boundary disputes that were impeding the peace negotiations.⁵⁵ It is doubtful that the demanding Dayton negotiations would have succeeded in reaching a final agreement without the contribution made by these geospatial technologies.

Supporting the Ecuador–Peru Border Dispute Negotiations. A more recent example is U.S. technical assistance to Ecuador and Peru in settling a stubborn border dispute over the precise location of their boundary along the eastern slopes of the Andes and the headwaters of the Amazon. Along with facilitating the negotiations through quiet diplomacy as one of the “Guarantor Nations” supporting the peace talks, the United States made available civilian satellite imagery and mapping expertise from its National Imagery and Mapping Agency (NIMA) to support American diplomatic participation in the Ecuador–Peru negotiations.⁵⁶ RADARSAT and Landsat images were used to create complete and more accurate maps of the rugged and often cloud-covered border areas of this disputed region for the first time. Once again, PowerScene visualization software was used to help negotiators reach agreement on acceptable boundary locations. Once a final peace treaty was signed by Peru and Ecuador in October 1998, NIMA experts continued to provide detailed mapping support through the subsequent border demarcation process.⁵⁷

Potential Future Application: South China Sea Disputes. The historical cases offer some encouraging examples of how commercial and civilian observation satellites can be used to help reduce the risk of inadvertent military conflicts arising in other regional hot spots. One area that is probably ripe for using satellite imagery to enhance regional transparency is the South China Sea where a long-standing sovereignty dispute exists over who owns the Spratly Islands and their surrounding waters. The competing territorial and maritime claims of six littoral states (i.e., Brunei, China, Malaysia, the Philippines, Taiwan, and Vietnam) fuel persistent tensions among these claimant states that periodically erupt into confrontations and even low-level fighting on occasion. High-resolution commercial satellite imagery offers a means for broadly sharing data among the competing claimant states and other interested regional states (e.g., Singapore, Thailand, etc.) on what is occurring at particular Spratly Islands locations without the increasing the risks of military

⁵⁵The PowerScene software was originally used for mission planning by U.S. and NATO pilots in preparing for the precision air strikes on Bosnian Serb targets that helped to lead to the Dayton negotiations. Eric Schmitt, “High-Tech Maps Guided Bosnia Talks,” *New York Times* (November 24, 1995); and Joseph Anselmo, “Satellite Data Plays Key Role in Bosnia Peace Treaty,” *Aviation Week and Space Technology* (December 11, 1995). For greater detail, see Richard Johnson, “Supporting the Dayton Peace Talks,” in *Commercial Observation Satellites*, pp. 297–310.

⁵⁶The United States, along with Argentina, Brazil, and Chile, played a proactive diplomatic role in supporting the Ecuador–Peru peace negotiations following border fighting that occurred in 1995, which had produced several hundred casualties among the troops on both sides.

⁵⁷For in-depth case study of the role that satellite imagery and NIMA’s mapping expertise played in the peace talks, see John Gates and John Weikel, “Imagery and Mapping Support to the Ecuador–Peru Peace Process,” in *Commercial Observation Satellites*, pp. 311–325.

confrontation, which sometimes occurs with existing aerial reconnaissance and naval patrols. Thus, commercial observation satellites create the opportunity for countries to engage in a formal or informal cooperative monitoring regime concerning the disputed Spratly Islands that could help diminish the risk of inadvertent armed conflict.⁵⁸

These past diplomatic episodes and the future possible case concerning the South China Sea strongly suggest that commercial observation satellites and their resulting geospatial information products can play a potentially valuable role in supporting regional conflict resolution. By taking advantage of available expertise in satellite imagery, visualization, and mapping technologies, diplomats appear to have gained greater leverage in moving disputing parties toward the peaceful resolution of regional disputes. In principle, therefore, commercial satellite imagery is available as another useful information technology for helping diplomats resolve territorial disputes and create regional confidence-building measures that could be relevant to other regional hot spots, including the Middle East, Cyprus, and the Horn of Africa.⁵⁹

Potential Risks from Commercial Satellite Imagery

Although commercial and civilian observation satellites offer a means to enhance regional security through greater transparency, the dual-use nature of satellite imagery data can present new security concerns. Thus, it is important to consider under what conditions commercial satellite imagery could pose a significant threat, and what options are available to limit the risks that overhead imagery poses for states or even groups within states.⁶⁰

One potential risk is that aggressive states might exploit commercial and civilian observation satellites to gain an information edge over regional rivals. High-resolution imagery could provide such states with militarily useful information on neighboring countries, including up-to-date information on force deployments, which could be used to support offensive military operations.

Another potential risk is that some national governments will use commercial satellite imagery to support their internal operations against ethnic subgroups within their countries. Some governments are likely to use commercial imagery data to monitor the activities of organized opposition groups within their borders. Repressive governments might even take advantage of timely commercial images that are

⁵⁸The idea of using satellite imagery to support a cooperative monitoring regime is assessed by Vipin Gupta and Adam Bernstein in "Keeping an Eye on the Islands: Cooperative Remote Monitoring in the South China Sea," in *Commercial Observation Satellites*, pp. 327-360.

⁵⁹The use of commercial satellite imagery for fostering regional cooperation in the Middle East is thoughtfully examined in United Nations Institute for Disarmament Research (UNIDIR) and the Cooperative Monitoring Center of Sandia National Laboratories, *The Potential Uses of Commercial Satellite Imagery in the Middle East: Workshop Report* (Geneva, United Nations, UNIDIR/99/13, September 1999).

⁶⁰For a more in-depth discussion, see Baker and Johnson, "Security Implications of Commercial Satellite Imagery," in *Commercial Observation Satellites*, pp. 101-133. For a perspective on the increased security risks posed to the security of countries, such as Israel, by the growing availability of high-resolution commercial satellite imagery, see Gerald M. Steinberg, "Commercial Observation Satellites in the Middle East and Persian Gulf," in *Commercial Observation Satellites*, pp. 225-229.

made publicly available by the news media or humanitarian nongovernmental organizations (NGOs) as another information source to support "ethnic cleansing" operations against domestic opponents or to launch attacks on refugees.

However, it is important not to exaggerate the potential security risks presented by commercial and civilian satellite imagery. Several factors limit their utility for supporting military or intelligence missions. First, currently most of the high-resolution commercial and civilian observation satellites use optical sensors that are unable to collect imagery data at night or through cloud cover. This substantially reduces their ability to provide imagery data with the degree of assured delivery considered necessary for supporting intelligence-gathering or military missions, which often depend on having timely information available. Second, the operating characteristics of most nonmilitary imaging satellites are widely known. This fact increases the opportunities for knowledgeable countries or nonstate actors to avoid being detected or accurately identified by altering their operating practices or by employing various forms of concealment, camouflage, and deception.

Third, gaining a military or intelligence edge over another country requires much more than simply acquiring a high-resolution satellite image. Imagery is only one important input in a complex process that translates raw data into information or "actionable" intelligence for the user. Expertise in processing, interpreting, and analyzing the data is essential. Many military applications require information derived from satellite imagery to be generated in a timely manner. Furthermore, the user must possess the capabilities needed to take full advantage of the information for supporting various military operations, such as delivering precision-guided weapons. Besides the United States, few countries possess the technological capabilities and operational experience required for effectively translating satellite imagery into timely intelligence information needed to support military operations in wartime.

Nonetheless, whether for defensive or offensive purposes, a wide range of countries can presently take advantage of unprecedented access to high-resolution satellite imagery to support less-demanding military and intelligence missions. For now, these missions are likely to be focused on supporting the less time-urgent tasks of military mapping and identifying strategic targets in neighboring countries. Over the long term, however, the potential for threatening countries to make more effective military use of imagery data could substantially improve as their military and intelligence analysts gain more experience in handling high-resolution satellite images and as new weapons systems become available on the international marketplace that take advantage of the growing availability of commercial imagery for mission planning and targeting.

The security concerns of commercial and civilian observation satellites are not confined to governments. Certain nonstate actors, such as terrorist or narco-criminal groups, will have unprecedented access to overhead imagery. But the benefits of overhead imagery for these groups are questionable. Terrorists require more timely and detailed information than commercial satellite imagery can provide. Most terrorist attacks to date have focused on highly visible "soft" targets where satellite

imagery data was not necessary to accomplish the mission. Similarly, narcotics criminals can often purchase the information they need for frustrating government counter-operations from inside sources. The added benefit of satellite imagery data for these nonstate actors is likely to be relatively small given their access to a broad array of information sources better suited to supporting their illegal activities. The Internet and cell phone, not satellite imagery, are the information technologies of choice for these nonstate actors.

Although the security risks of growing access to high-resolution commercial and civilian satellite imagery are limited, at least for the near term, it is still prudent for policymakers to adopt measures to minimize such potential risks. One approach is to restrict the technological capabilities of new nonmilitary imaging satellites, such as limiting the resolution allowed for commercial or civilian imaging satellite systems to coarser levels to make them less useful for military users. However, the Gulf War experience has demonstrated that even lower-resolution satellite imagery, such as Landsat and SPOT, possessed some degree of military utility. Hence, restricting the development or operations of high-resolution imaging satellites is not adequate. Furthermore, it is uncertain that all governments and private companies that own and operate imaging satellites will agree to such restrictions.

An alternative approach is to rely on operational controls or "shutter controls" that place limits on the imaging operations of commercial and civilian observation satellites concerning a particular region during a crisis or military conflict. In such cases, governments could temporarily limit the collection and/or distribution of high-resolution satellite imagery of a particular territory if a conflict is imminent or ongoing. However, imposing timely shutter controls could be challenging—particularly for the United States, which is likely to face issues of constitutionality in implementing shutter controls on the operations of U.S. commercial remote sensing satellite firms.⁶¹ The efficacy of imposing shutter controls and their actual utility for restricting access to satellite imagery will remain uncertain until governments gain greater experience with operating under the conditions of growing global transparency.

In any case, the effectiveness of either technological or operational constraints is likely to be limited unless other countries are also willing to adopt certain restrictions on how high-resolution commercial and civilian imaging satellites will be operated in crisis or conflict situations. Absent some form of multinational collaboration among states with imaging satellites on a set of formal or informal "rules of the road," it seems unlikely that unilateral technical or operational constraints will be sufficient

⁶¹Media groups in the United States contend that the ability of Executive Branch officials to impose such shutter controls without judicial review is a form of prior restraint on the freedom of the press, and therefore a violation of the First Amendment rights provided in the Constitution. For a good discussion of the legal issues presented by U.S. shutter control policies for commercial remote sensing satellites, see Robert Preston, "Space Remote Sensing Regulatory Landscape," in *Commercial Observation Satellites*, pp. 501-531.

to prevent threatening actors from obtaining satellite imagery data.⁶² Nonetheless, achieving a broad agreement on conditions for restricting satellite imagery under particular circumstances, such as a regional crisis or armed conflict, is probably more feasible today while the number of countries that need to cooperate is relatively small.

Summary

Growth in the number and capabilities of commercial and civilian observation satellites is steadily occurring. These nonmilitary imaging satellites have demonstrated their usefulness in supporting diplomatic efforts to mitigate the risks of regional conflicts, particularly given that commercial satellite imagery data can be readily shared among all sides in a negotiation. However, satellite imagery is inherently a dual-use technology that can be employed by any government, or even nonstate actor with access to imagery data, for more harmful purposes. Through a combination of domestic policies and international collaboration, governments that control various commercial and civilian observation satellites can encourage the beneficial uses of high-resolution satellite imagery while limiting the potential risks that such imagery data will be effectively exploited by aggressive actors for harmful purposes. Time will tell whether these governments can successfully manage the growing global access to satellite imagery to the mutual benefit of all nations without significantly increasing the security risks for states (or nonstate groups within states) that do not harbor aggressive or malicious intentions.

⁶²The idea of pursuing a multilateral approach to regulating the operations of nonmilitary imaging satellites is thoughtfully analyzed in Gerald M. Steinberg, *Dual-Use Aspects of Commercial High-Resolution Imaging Satellites* (Ramat Gan, Israel: Bar-Ilan University, The Begin-Sadat Center for Strategic Studies, February 1998).

STRATEGIC CHOICES FOR SMALL AND MIDDLE POWERS

SPACE DEVELOPMENT IN KOREA

Hong-Yul Paik, Director, Satellite Operation Center, Korea Aerospace Research Institute, South Korea

Korea is a young country in the international air and space arena but has the ambition and energy to play its role.

In this paper, the current air and space development activities in Korea along with its future planning will be introduced: I hope that it can give some insights on the choices and strategies facing Korea in air and space as a small/medium power.

Air and Space Development Structure

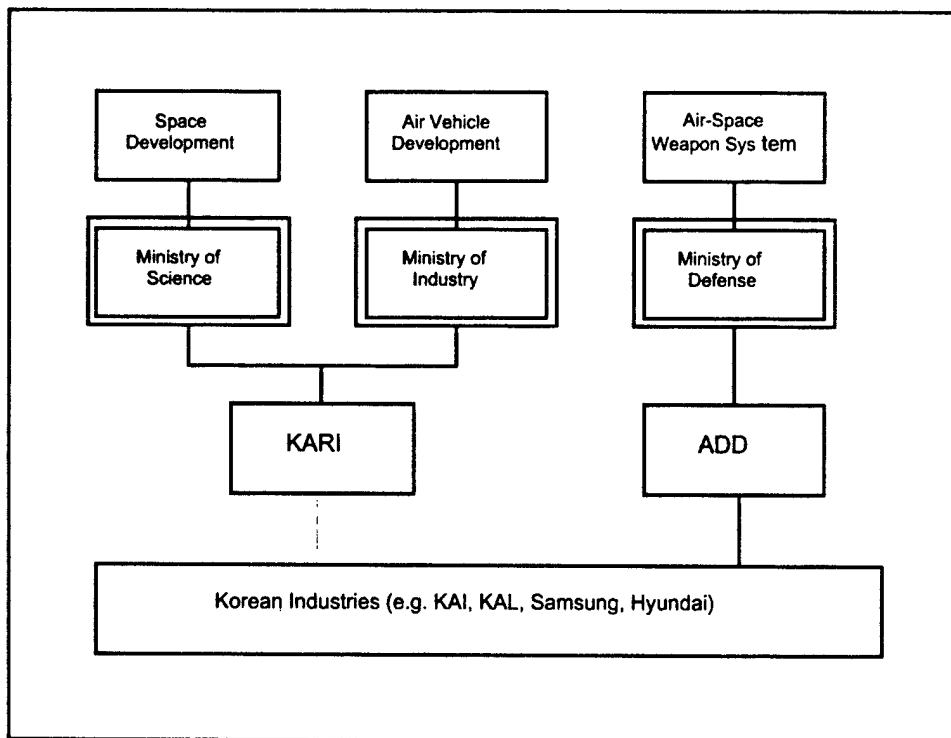
In Korea, air and space development is divided into three parts: space development, air development, and air and space defense system (as shown in the figure on page 110).

Space development in Korea is driven by the view of national needs and a technology development strategy. As the result, the Ministry of Science and Technology takes the leading role in the space development, while air development is mainly the responsibility of the Ministry of Industry in terms of industrialization and commercialization.

In the meantime, the development of air and space defense system is the sole and direct responsibility of the Ministry of Defense. The Agency for Defense Development of Korea (ADD) takes on the actual responsibilities in the weapon system developments.

Except for weapon systems, however, the Korea Aerospace Research Institute (KARI) takes the leading role in all air and space development activities in Korea, in cooperation with related research institutes as well as Korean industries such as KAI, Samsung, Hyundai, Daewoo, KAL, and other small and medium industries.

KARI is the government-funded research institute established in 1989 based on the special law to promote the development of air and space. With its 400 engineers and scientists, KARI plays the central role in the air and space development of Korea.



Air and Space Development Structure in Korea

Air Development

As already mentioned, air development in Korea is promoted through a commercial and industrial approach.

This means that Korean industries play the major role, while KARI provides technical support, R&D infrastructure, and government-level safety and quality control.

But despite our expectations, the Korean industry faces great difficulties competing commercially in the major worldwide airplane market. The development of a 100-passenger-class airplane, which was Korea's major air development project, is now canceled, mainly because of commercial reasons. Instead, a four-passenger small airplane is now under development for flight in 2003. The aim is to develop the commercially competitive private airplane, which is very lightweight, is low cost, and has smart and easy operation.

There is also the growing interest in the development of helicopters. It is quite natural considering the fact that Korea is one of the largest holders of helicopters in the world.

However, our main interest in air development is now focused on the leading-edge technology and smart vehicles such as RPV and stratospheric airship, which we think can compete in the world market.

The RPV program is now in the planning stage, while the stratospheric airship program was launched this year for operation in 2007.

Its main application is telecommunications (as well as remote sensing and surveillance). The length of the designed airship is about 170 m and powered by solar cells to hold the position at the operating altitude of 20 km for more than 2 months (see below).

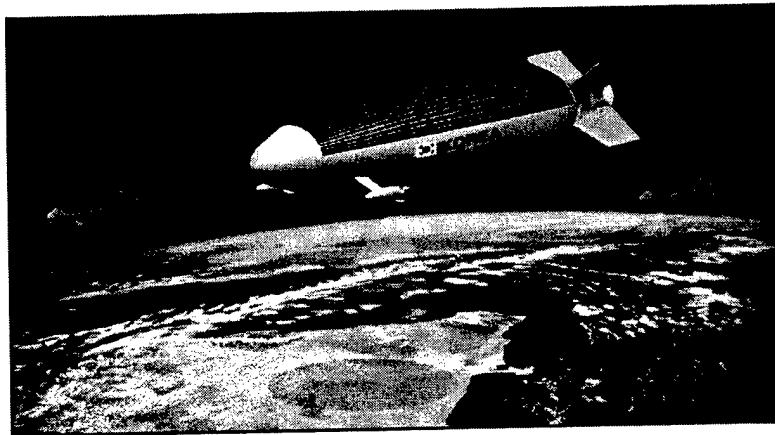
Space Development

Space developments in Korea proceed—based on the National Space Development Plan issued in 1995—until 2015.

This space development plan is composed of three areas: rocket development, satellite development, and space science and application. The final goal is for Korea to become one of the top ten space-faring countries by 2015.

To realize this goal, Korea plans to launch 500–1,000-kg-class satellite to LEO orbit using its own rocket by 2010.

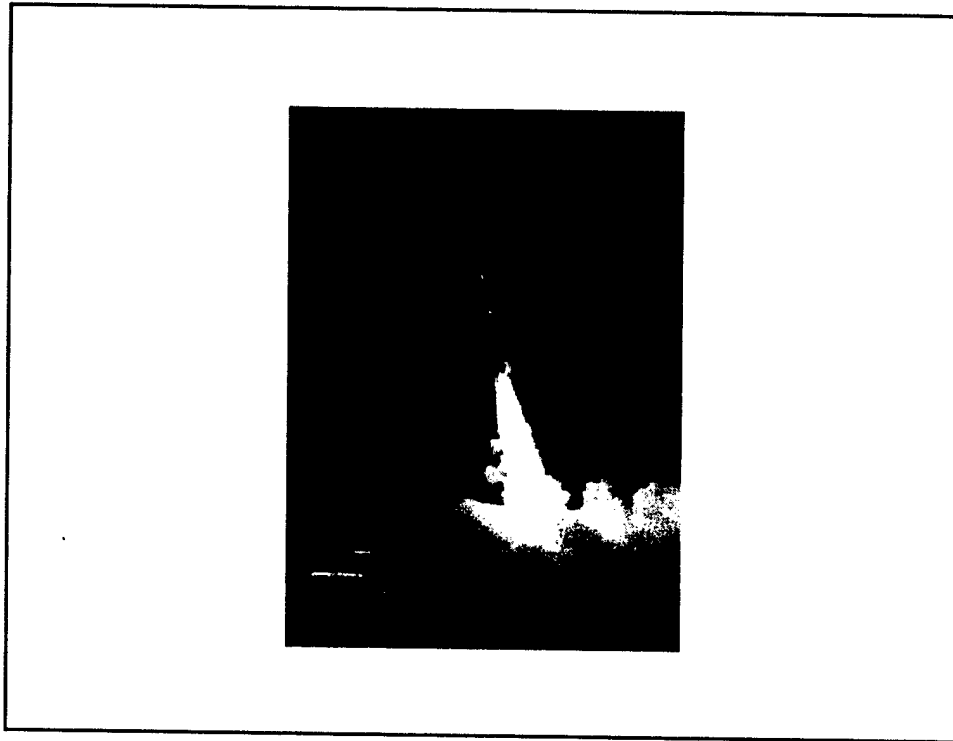
Korea also hopes to keep up with leading countries in the area of space science and application via international cooperation.



Stratospheric Airship

Rocket Programs. The Korean rocket program started when KARI launched its first single-state sounding rocket, KSR-1, in 1993.

In 1997 and 1998, the two-stage sounding rocket KSR-2 was also successfully launched for space science missions (see below). KSR-2 has the solid propellant motors for its main thrusters. The guidance and control system is also used to control the orbit and altitude of KSR-2. Its weight is 2 tons, length is 11 m, and maximum velocity is 1,550 m/sec.



Launch of KSR-2

KSR-3 is now under development; it is scheduled to launch in 2002.

Its weight is about 5 tons and length is 13 m. Unlike KSR-1 and KSR-2, the main motor of KSR-3 is the liquid propellant engine of 10-tons class.

The development of KSR-3 with its liquid propellant engine will be the basis for Korea Space Launch Vehicle 1 (KSLV-1).

KSLV-1 is the launch vehicle to put the small (100-kg-class) satellite into the LEO orbit. It is scheduled to launch in 2005.

The space center is the launching and control center for the Korean space launch vehicles. The construction of the space center starts this year in parallel to support the Korean rocket program. It has been decided that the location of space center will be Ko-Heung, which is located at the south coast of the Korean peninsula. The first phase of the construction of the space center will be completed in 2005, and the space center will be used for the launch of KSLV-1.

The final goal of Korea's rocket program is to have the launching capability for the 500–1,000-kg medium satellite to LEO orbit by 2010.

Satellite Programs. The satellite development of Korea is composed of three programs: the experimental satellite KITSAT, the communication satellite KOREASAT, and the multipurpose Earth observation satellite KOMPSAT.

According to the National Space Development plan revised in 2000, all 20 satellites will be developed by 2015: 7 KITSAT, 5 GEO communication satellites, and 8 KOMPSAT.

KITSAT: Launched in 1992, KITSAT-1 is Korea's first satellite. It was developed in cooperation with University of Surrey in the UK. Following KITSAT-1, KITSAT-2 was developed by SaTReC and launched in 1993.

KITSAT is the 100-kg-class, low-cost experimental satellite for space science, technology development, and educational purposes, and is conducted as a university research program.

SaTReC of KAIST is responsible for the KITSAT program under the supervision of KARI. The strategy is that through the KITSAT program, the necessary technologies and human resources are built and efficiently exploited for the main satellite program in close cooperation with KARI.

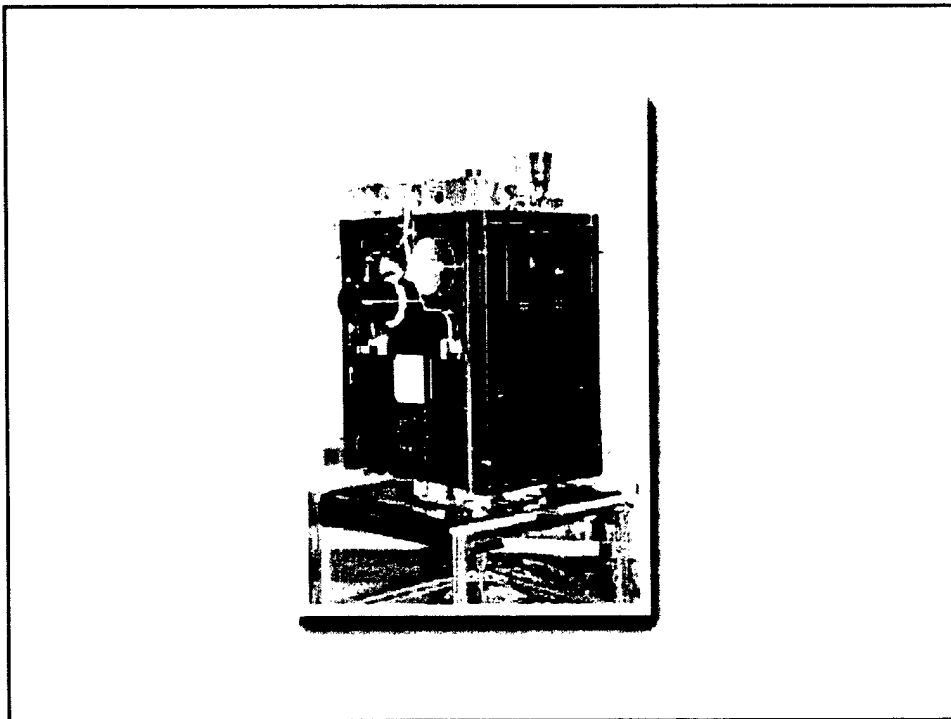
KITSAT-3 was also launched successfully in 1999, and its payloads have the 15-m GSD CCD camera and the space physics sensors composed of the high-energy particle detector, the cosmic ray sensor, and magnetometer (see below). The 110-kg KITSAT-3 has the 3-axis stabilization capability to support the 3-band CCD camera at the circular orbit of 720-km altitude.

KITSAT-4 is now under development; it is scheduled to launch in 2002. Its main mission is to make astrophysical observations via ultraviolet telescope, in addition to space science, data collection, and star sensor experiments.

KOREASAT: KOREASAT is the commercial broadcast/communication GEO satellite of Korea Telecom. KOREASAT-1 ('95), KOREASAT-2 ('96), and KOREASAT-3 ('99) are developed and successfully launched through overseas contract.

As an offset program, Korean industries as well as KARI participate in the development and manufacturing of KOREASAT. Now, KOREASAT-4 is under development for launch in 2005.

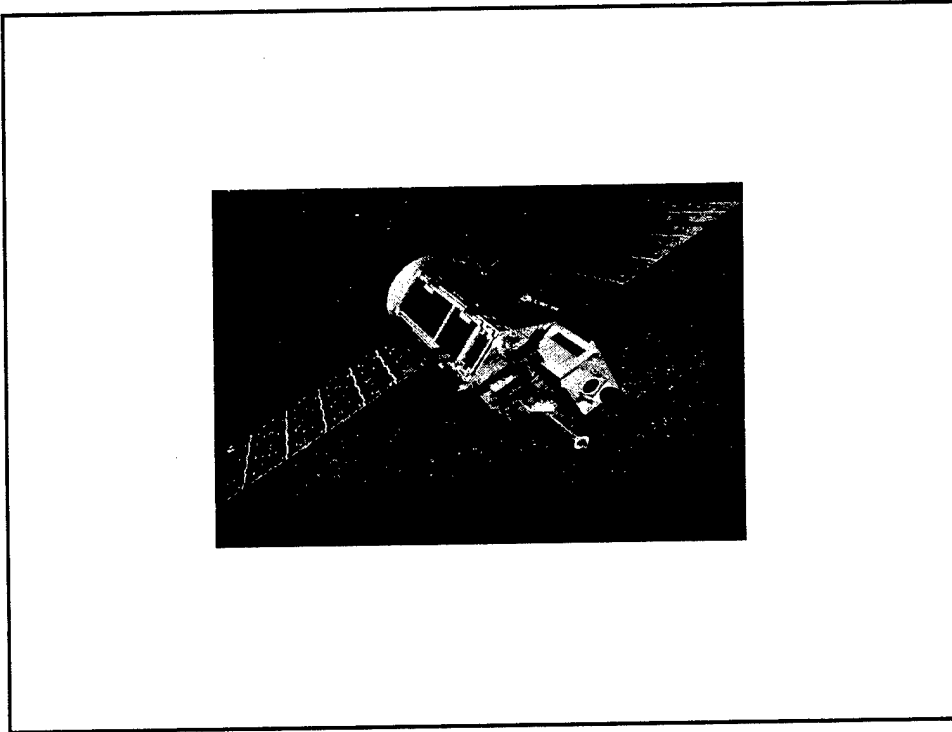
In parallel, in-country development of GEO telecommunication satellites with weather and ocean remote sensing capability is under planning for launch in 2008. This GEO satellite will be developed based on the KOMPSAT.



KITSAT-3

KOMPSAT: KOMPSAT is the key program in our space development plan and is intended to be the backbone of Korea's satellite technology development. Multi-purpose means the same bus can be utilized for many different applications—mainly for LEO Earth observations but also extended for GEO applications.

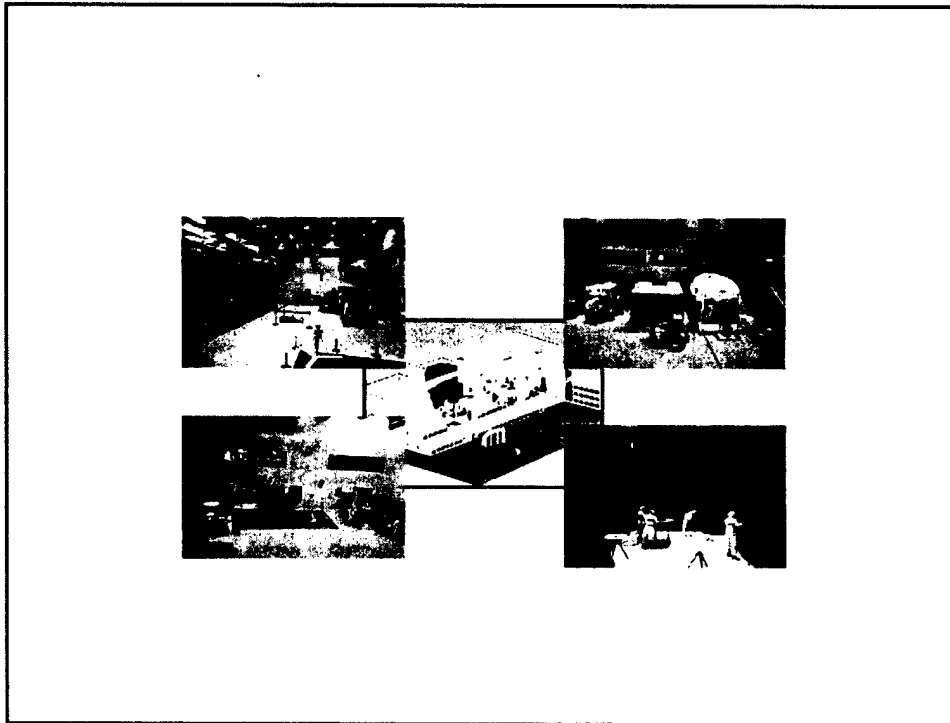
KOMPSAT-1 is the 500-kg-class Earth observation satellite with 10:50 AM sun-synchronous LEO orbit at 685-km altitude (see below).



KOMPSAT-1

The development of KOMPSAT-1 started in 1994 in cooperation with TRW. Through the joint development with TRW, KARI can set up enough infrastructure, manpower, and technology to develop the satellite systems for practical applications. The integration of KOMPSAT-1 Flight Model (FM) is performed at KARI AIT facilities by Korean engineers (see below). Seven Korean industries also participate in the manufacturing of KOMPSAT-1 at the sub-equipment level to accomplish 60 percent Koreanization.

KOMPSAT-1 has three payloads composed of EOC, OSMI, and SPS, as well an 8-Gb solid-state data storage unit. EOC is the high-resolution panchromatic camera of 6.6-m GSD and 17-km swath. OSMI is the ocean-scanning multispectral camera of 1-km GSD and 800-km swath. The six bands of OSMI can be selected by ground control using its internal hyperspherical capabilities. SPS is the science physics sensor for ion measurement and high-energy particle detection at the KOMPSAT orbit.

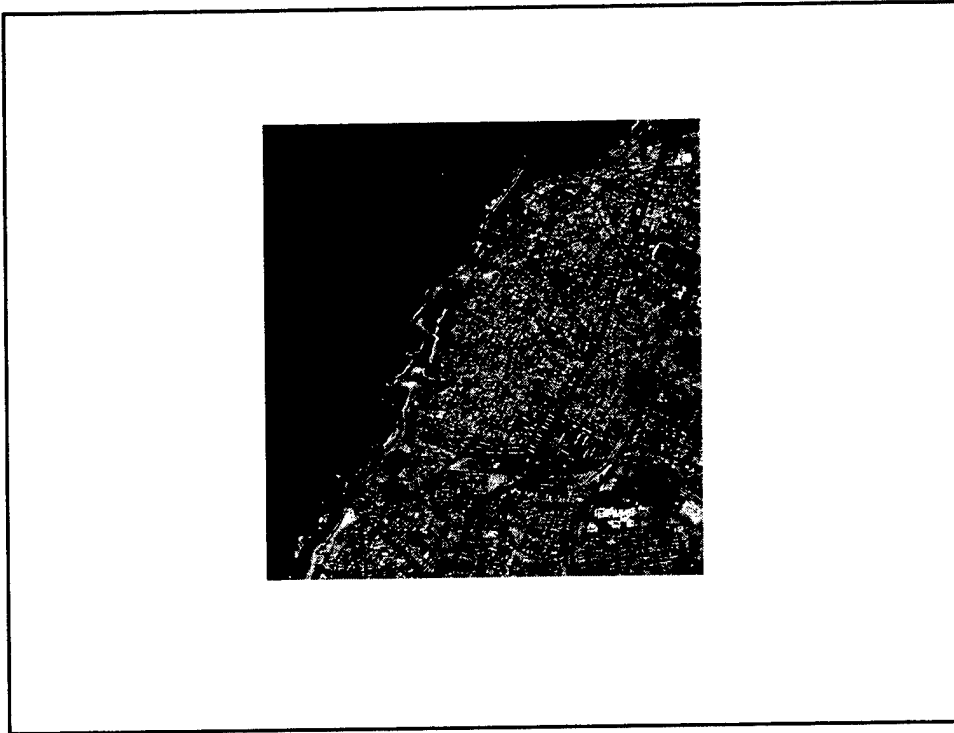


KARI Satellite AIT Facility

KOMPSAT-1 successfully launched in December 1999 and is now sending valuable Earth observation images to KARI ground station (see below).

KOMPSAT-2 is now under development.

The main payload of KOMPSAT-2 is its multispectral camera (MSC), which features a 1-m GSD panchromatic band and 4-m GSD 4-color band with 15-km swath.



KOMPSAT-1 EOC Image of Tel-Aviv



KOMPSAT-2

To support MSC as the main payload, KOMPSAT-2 is modified to have a total weight of 800 kg, 800-W power, and improved altitude and orbit control capabilities (see above).

ELOP is selected for the joint development of MSC with KARI. But the bus of KOMPSAT-2 will be developed by KARI. KOMPSAT-2 is scheduled to launch in 2004.

Space Science and Space Application. Korea expects that space application and space science will become more important in the coming years, and will be the basis for the industrialization of space. However, considering the huge amount of budget required, international cooperation is necessary for the development of space application and space science. Cooperation with leading international space organizations such as NASA, ESA, and NASDA is important, but cooperation with developing countries is equally important and has some advantages.

In that respect, the governments of the United States and Korea agree on the feasibility study for the ACCESS joint development in International Space Station (ISS) between NASA and KARI. ACCESS is the important space science mission of NASA in the ISS to study the origin of universe through the observation of very high energy comic rays.

Through joint study, basic design of ACCESS is reviewed by NASA and KARI. It was planned that Korea will be responsible for the development of Payload Support and Interface Module for ACCESS.

In February 2000, the NASA independent assess team visited Korea to review the joint development plan and drew very positive conclusions on the capabilities of Korea. ACCESS is scheduled to launch in 2007 on the space shuttle.

In the meantime, Korea also seeks international cooperation to utilize the KOMPSAT-1 PFM, which is now in storage at KARI. KOMPSAT PFM is the same as the Flight Model but was integrated and tested at TRW. Currently, EKOSAT—which combines KOMPSAT PFM and DAVID payload—is under consideration, in cooperation with ELOP and OHB.

DAVID is a 5-m-resolution, 30-km-swath, and 12-channel remote sensing camera of ELOP and OHB and is expected to be the ideal sensor for remote sensing applications. KARI, ELOP, and OHB are now promoting international partnership for the EKOSAT project.

Air-Space Defense System

ADD of Korea is solely responsible for the development of weapons system under the supervision of MND.

Since the first successful launch of the SS missile in 1978, improved SSM, ASM, and SAM are known to be developed. It is believed that Korea accumulated a certain level of technologies in missile development. However, Korea only intends to develop a few selected missile systems for practical purposes.

As for the fighter, F5 and F16 have been assembled in Korea, and the next generation FX Project is now under way. Currently, Korea has no immediate plan to develop a fighter, though we want to accumulate certain key technologies through an offset program for future development. As for the trainer, the turbo-prop KTX-1 was successfully developed and now the jet trainer KTX-2 is under development. The Korean trainer is expected to be exported to other countries on a commercial basis.

Another trend in defense development in Korea is the growing interest and investment in dual-purpose technologies. Some air- and space-related technologies are planned to be developed for dual purpose under the supervision of MND.

Strategy in Air-Space Development

In order to catch up with the front runners in air and space programs, Korea has adopted the mid-entry strategy in the development of air and space. This means that Korea has adopted the approach that enables us to directly jump into a certain technology level through technology transfer. The joint development of KOMPSAT is the typical result of this mid-entry strategy, which turns out to be very successful.

However, the mid-entry strategy always has some restriction and limit. The real development of Korea in air and space will start at the entry points into which we enter.

The other important strategy is the strategy of smart selection. Considering its limited national resources, Korea cannot develop and pursue all areas. A few key areas should be wisely selected to be competitive in the top level.

Another strategy might be to set the proper scale of air and space development which is appropriate for Korea as a small/medium power. Although it was a very difficult question, the consensus was that at least the minimum technical capability in air and space should be maintained to meet our national needs.

For space development, the guideline concerned Korea's capabilities to develop a 500–1,000-kg-class satellite and its launching capability to LEO orbit. For space science and applications, Korea just wants to keep up with the leading countries through international cooperation. For air development, Korea intends to maintain basic technology for commercial and industrial purposes and concentrate on the leading-edge technology.

For weapon systems, the selection of the system to be developed in Korea is very important. Systems should be either strategically important or cost-effective in view of life-cycle cost.

Though the national needs and strategic considerations have always been in the background, the eventual goal of air-space development is commercialization and industrialization of air and space in Korea.

DILEMMAS IN SPACE STRATEGY FOR REGIONAL POWERS: A BRAZILIAN PERSPECTIVE

**Demetrio Bastos-Netto, Chief, Combustion and Propulsion Laboratory,
INPE-CES, Brazil¹**

Introductory Remarks

An Historical Overview. Brazil was among the first countries to officially include space activities within its government program back in 1961 with the establishment of GOCNAE, the Organizing Group of the National Commission for Space Activities, placed under the National Research Council (CNPq). It is worth mentioning that, despite being a civilian organization, GOCNAE received staunch support from the Ministry of Aeronautics, which provided a site in São José dos Campos, São Paulo, and personnel to compose part of GOCNAE's initial staff.

In 1966, the Ministry of Aeronautics established the Executive Group for Space Projects Activities and Studies (GETEPE) which, in 1969, created the Institute of Space Activities (IAE). These activities were consolidated in 1971 under COBAE, the Brazilian Commission of Space Activities, a coordinating interministerial body under the head of the Joint Chiefs of Staff of the Armed Forces (EMFA).

In 1971, GOCNAE became INPE (the Institute of Space Research); and from 1985 on INPE (which since 1990 became the National Institute for Space Research) reported to the Ministry of Science and Technology.

INPE's activities, initially focused on aeronautics research, expanded in the '70s to include space applications such as remote sensing and meteorology. Actually, Brazil was among the first countries in the world to install a complete Landsat Satellite Ground Station in 1972, right after the United States and Canada.² From there it went into space technology (satellites and associated ground systems). Meanwhile, the IAE concentrated its efforts on the development of sounding rockets and, more recently, launch vehicles.

The Ministry of Aeronautics also set up the Launch Centers of Barreira do Inferno (CLBI) and Alcântara (CLA). The former has been in operation since 1965, providing facilities for launching and tracking Brazilian and foreign sounding rockets, aiming not only at the development of the country's capability in sounding rockets and

¹This paper is coauthored with M. N. Barbosa, former director of INPE, president of IAF, now adjoint general director of UNESCO. The authors are indebted to General of the Air Force Reginaldo dos Santos, chief of DEPED, the Brazilian Air Force Department of Research and Development; Dr. Luiz Gylvan Meira-Filho, president of AEB, the Brazilian Space Agency; Ambassador Carlos José Prazeres Campelo, chief of the Department of Space Cooperation, AEB; Dr. Lauro Tadeu Guimarães Fortes, chief of the Department of Planning and Coordination, AEB; and Rear-Admiral Hélcio Blacker Esposel of the Ministry of Defense, for their valuable counsel and suggestions.

²M. N. Barbosa and D. Bastos-Netto, "The Brazilian Satellite Remote Sensing Program," *Remote Sensing for Development, Part II*, Jörg Albertz and Rüdiger Tauch, eds. (Berlin, Germany: DSE, 1989), pp. 23-32.

launch vehicles but also for the research in space and atmospheric sciences. CLBI has successfully handled well over 2,000 launchings to date.³

In 1979, the government established the Complete Brazilian Space Mission (MECB), the first long-term space project which aimed at the development of small application satellites (environmental data collecting and remote sensing) and a launch vehicle to do the job properly, along with their ground infrastructure. This led to the building of the CLA in the state of Maranhão. The CLA is in use for suborbital launches. Its location, close to the equator, renders it an internationally competitive center for satellite launches.

Brazil pursued enhanced cooperation with other countries, in addition to maintaining the MECB project during late 1980s. Political changes plus the world scenario led Brazil to substitute COBAE with a new institution conceived to exert an ampler role in this country's space affairs, emphasizing not only its civilian role but its purely pacific nature during early 1990s. Hence, the Brazilian Space Agency (AEB) was created in 1994 as a civilian organization under the Presidency of the Republic (since last year, AEB has been put under the Ministry of Science and Technology). This has been kept this way, regardless of the statements and forecasts published in a RAND report back in 1993.⁴ It is also worth mentioning that Brazil signed the Missile Technology Control Regime (MTCR) agreement in 1998.

A Review of the Present Situation. Today, Brazil has nearly 300 Ph.D. scientists, 800 researchers and engineers, and 2,000 technical people from different fields engaged in space activities under the overall coordination of the AEB.

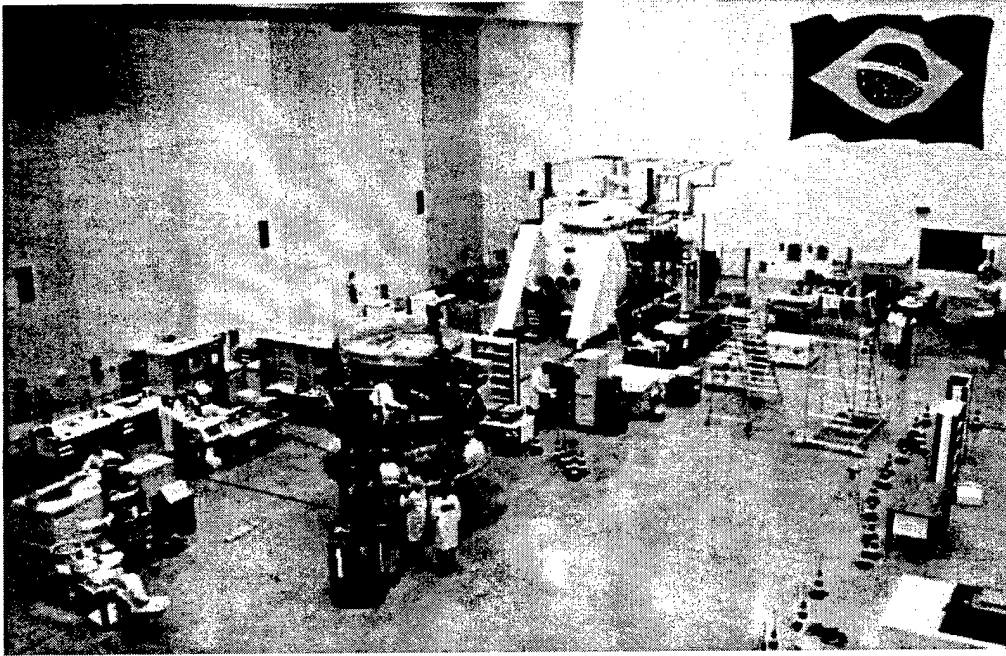
Infrastructure, space technology, and systems are the concentration areas of investment, for they are basically more expensive than scientific research and the application of proven technologies.

Brazil has matured in the fields of remote sensing and meteorology.

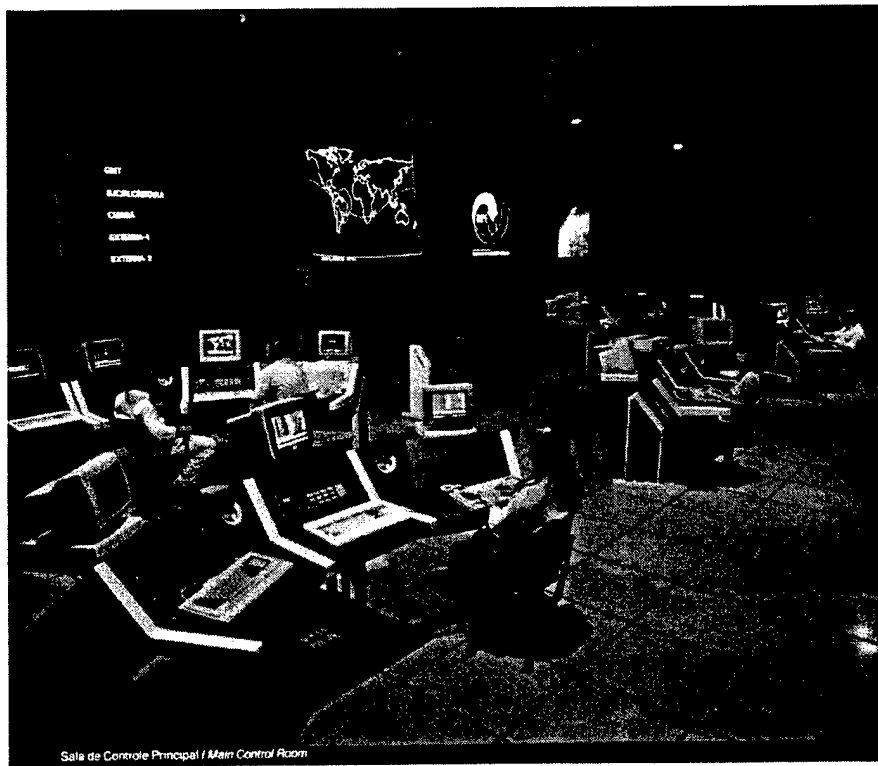
It also has a reasonable foundation in space technology and engineering. Besides the Alcântara (CLA) and Barreira do Inferno (CLBI) launch facilities, the space community in Brazil has succeeded in building other basic infrastructure items for space R&D such as the Integration and Test Laboratory (LIT), the Satellite Tracking and Control Center (CRC), the Colonel Abner Propellants Utility (UCA), and, more recently, the Satellite Thrusters Test Facility with Altitude Simulation (BTSA).

³A. G. Mota, "Esboço Histórico da Pesquisa Espacial no Brasil," Publ. INPE 3938 -RTR/088, INPE, São José dos Campos, SP, Brazil, 1986 (in Portuguese).

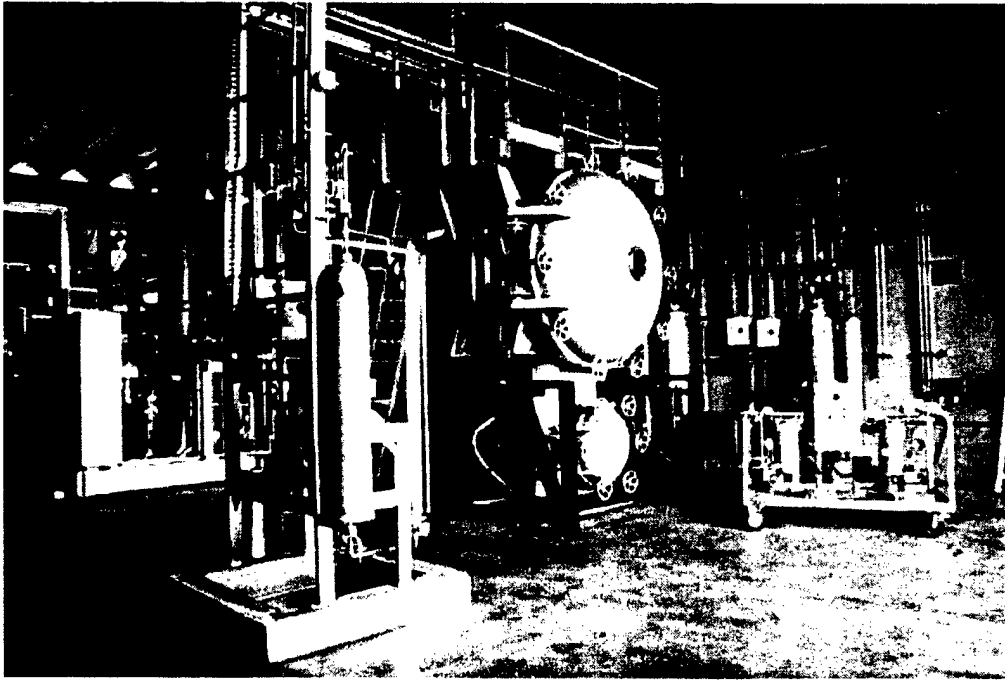
⁴B. G. Chow, *Emerging National Space Launch Programs: Economics and Safeguards* (Santa Monica, Calif.: RAND, R-4179-USDP, 1993).



Integration and Test Laboratory (LIT)



Satellite Tracking and Control Center (CRC)



Satellite Thrusters Test Facility with Altitude Simulation (BTSA)

Scientific Production: The Brazilian scientific body in space activities dwells in the fields of space sciences, meteorology, oceanography, earth sciences, thematic applications in remote sensing, global change, materials science, plasma, combustion and propulsion, orbital mechanics and control, mathematical modeling, and computation sciences.

This group presents a high level of productivity—with publication levels comparable with those found in other industrialized countries—and an active program of international collaboration.

Space Applications: A long-term program aimed at the establishment of proper infrastructure, human resources, and adequate methodologies and tools is under way and it has yielded significant dividends. Activities on remote sensing, for instance, have been incorporated into daily chores of social-economic weight and generated private enterprises that offer services to the general public. As far as meteorological activities are concerned, the Weather Forecasting and Climate Studies have been implemented at INPE to provide up to five-day lead time numerical weather predictions and climate forecasts on an operational basis. These services are freely available on the Internet.

Space Engineering and Technology: The first two satellites conceived, designed, developed, manufactured, and fully tested and qualified in Brazil were successfully placed into orbit. The SCD-1, the first data-collection satellite, was placed in orbit eight years ago and it is still operational, despite the initial planned lifetime of 18 months. The SCD-2 was launched in October 1998 and is also showing a good per-

formance. Both satellites receive and relay information from nearly 400 data-collection platforms scattered around Brazil, neighboring countries, and over the continental shelf.⁵

The Chinese–Brazilian cooperation for the development of remote sensing satellites has led to the successful October 1999 launching of CBERS-1 (now in operation). The launching of CBERS -2 is scheduled to take place early next year.

The country has developed (with an expressive contribution from the Brazilian industry) a series of sounding rockets (designed, integrated, tested, and qualified by IAE). The launching of Sonda Sounding Rockets II, III, and IV have enabled scientists from Brazil and abroad to carry out many suborbital scientific experiments. Well over 60 scientific technological payloads have been flown with success. Now the country is in the final phase of the development of its first launch vehicle, scheduled for late this year. This vehicle, VLS-1, was designed for the MECB program, i.e., for the launching of satellites up to 200 kg into 700–800-km orbits only.

Industry Contribution: Brazilian industry participation in space projects has been steadily growing. This can be evaluated using the ratio of the worth of industrial contracts to the overall system cost: It was 9 percent for the SCD-1 satellite, and increased to around 20 percent for the SCD-2 satellite. As for joint international ventures, it was 42 percent for the Brazilian segment of CBERS-1 satellite and it is expected to go up to 90 percent for the next ones in the CBERS series. It is estimated that the development of the VLS-1 vehicle will elicit around 70 percent of industrial participation.

The Brazilian Aerospace Industries Association (AIAB) has been created as a result of the importance of these recent activities in Brazil. It is well-known that EMBRAER, the largest Brazilian industry in this sector, has shown the highest net profit among all industries in the country last year. As the representative of the private sector, the AIAB is part of the National System for the Development of Space Activities (SINDAE).

International Scenarios

The changes following the end of the Cold War have altered the courses of space programs everywhere. Modernizing policies have led to frequent revisions of ongoing projects and changes for future plans. The end of the Cold War also allowed civilian space programs to benefit from technologies developed for military applications (such as, for example, the high-resolution and imaging techniques that opened new marketing opportunities for remote sensing applications).

These developments have fostered support for programs that lead to immediate returns for society, i. e., application programs. This suggests priority to Earth observation and telecommunication systems for which the space environment is used in developing new processes (such as microgravity experiments). Another trend easily

⁵AEB, *The National Space Activities Program, PNAE 1998–2007*, Brasília, DF, Brazil, 1998.

noticed is the worldwide tendency to replace long, expensive missions by large numbers of smaller and shorter ones, using off-the-shelf platforms, components, and even standardized design.

Therefore, it can be stated that most of the space programs today possess the following characteristics:

- They give priority to application areas, e.g., telecommunications, remote sensing (including microwave bandwidths), meteorology, and microgravity.
- They keep the schedule of the International Space Station (ISS) program and of those programs aimed at providing space infrastructure in support of scientific and technological payloads.
- They develop non- or partially reusable launch vehicles along with the development of reusable ones to reduce launch costs.
- They strive to increase the deployment of mini- and micro-satellites (recoverable or not) for scientific and technological experiments.

Dilemmas for the Country—

Space Development Priorities and the Brazilian Space Program: Its Reasons and Principles

It is known that, except for communication satellites, space programs do not offer a direct return to the investment made on them. On the other hand, as a developing country, one of Brazil's most important policies, regardless of other nations past experiences, is the high priority lent to its social chores and toward the protection of its environment.

This poses the following dilemma:

1. Should the government yield to the immediate political pressure and give up its space activities, reducing them to an absolute minimum? (Notice that this kind of pressure is not internal only, for Brazil is too big in surface and population to be fully welcomed among the developed space-oriented nations.)
2. Or should the country take the road of common sense and look beyond the horizon, believing that, as happens with any high-tech activity, it will pay off several times over (in the medium range) the investment made on it?

Brazil cannot ignore its position in the cadre of South America countries either, and thus it has to be prepared to share its knowledge and acquired expertise with its neighbor nations, for the common well-being. This is specially true within Mercosur community countries.

Therefore Brazil has chosen the second option:

Although the total investment in the sector is quite modest (this year around 0.025 percent of its gross national product), Brazilian space activities will follow within this

decade a well-defined program aimed at increasing of the return to society of the investment made in this area.

A comprehensive investigation of the reasons for the existence of space programs points out two major conclusions: (1) As mentioned above, these programs usually do not offer a complete and direct return of the overall investment (i. e., they do not cover the costs of design, development, construction, launch, and operations), with the exception of communications satellites. This is true even for the United States and the ESA countries. On the other hand, these programs still have a long way to go, as it is the case, for instance, with microgravity, which might turn out profitable in the future. This is the main impetus for a sizable part of the investment in the area. (2) The results of space programs, mainly those linked to Earth observation, are of government interest. This is so with systems for investigating large-scale phenomena covering large areas, such as environmental monitoring, data collections for weather forecast, geological and cartographic surveys, among others of direct benefit to society. Although these activities might even offer some financial returns, it is not expected that all necessary funds be provided by the private sector.

For Brazil, the lines of action follow these basic principles:

A. To find and to fill niches of interests for the country in the field of space activities. These niches may be a result of our own particularities, such as location and internal needs, which might not generate strong interest among the industrialized nations. For example:

1. Constellation of small, low-cost communications satellites in low equatorial orbit, to be used for the integration of remote regions and which may be of interest to other equatorial countries;
2. Small, low-cost, low-orbit remote sensing satellites capable of relaying images directly to small ground stations within each satellite-covering area for real-time monitoring of land use (i.e., for deforestation control or, if high resolution is available, frontier surveillance). It is important to note that, in the near future, SIVAM (Amazon Surveillance Integrated System) activities will rely heavily on space technology.
3. Broadcasting satellites that run educational TV systems to assist remote regions.
4. Other niches for Brazil are, for example, in the area of scientific research: the Equatorial Electrojet and the South Atlantic Magnetic Anomaly. In addition, the ocean-atmosphere interaction in the South Atlantic and the climate of the Amazon are scientific themes of regional and global importance.

B. To enhance integration with international programs through scientific and technological cooperation. As space activities and its by-products have been shown to have a significant impact on society (or to possess potential, not yet fully exploited benefits), the main target of a national space policy for Brazil should cover a wide range of interests that engages, whenever possible or acceptable, private organizations. This way, progress can be foreseen in space applications (remote sensing, meteorology,

oceanography, geodesy, and navigation), in space systems and its technologies (satellites and launch vehicles), and in space sciences.

Objectives of the National Policy for the Development of Space Activities (PNDAE)

The main aim of the PNDAE is “to advance the capacity of the country according to appropriate criteria, to utilize space techniques and resources in the solutions of national problems and in benefit to Brazilian society.”⁶

For this aim to be achieved, the following specific objectives have been identified:

A. The establishment in the country of a technical/scientific competence in the area of space, which would permit a genuine autonomy of action in

- the selection of alternative technologies for the solution of Brazilian problems;
- the development of in-house solutions for problems specific to our territory or society, wherever more economical alternatives are either unavailable or cannot be guaranteed;
- the effective use of information of interest to Brazilian society, provided by space techniques; and
- international negotiations, accords, and treaties, involving material pertinent to space activities or capable of benefiting from knowledge based on such activities.

B. Advancement of the development of space systems, together with the corresponding means, techniques, and ground-based infrastructure, making necessary or desirable services and information available to Brazil.

C. Qualification of the Brazilian industrial sector to participate and become competitive in the supply of products and services related to space.

To achieve the above-mentioned objectives, the PNDAE also establishes the following guidelines to be observed, most of them self-explanatory:⁷

1. Priority for the solution of national problems
2. Concentration of efforts in high-profile projects
3. Scope defined by final results
4. Critical analysis of the investment⁸

⁶AEB, *The National Space Activities Program, PNAE 1998–2007*, Brasilia, DF, Brazil, 1998.

⁷Ibid.

⁸That is, prioritizing initiatives involving a balanced temporal distribution of results with guaranteed returns in short and medium terms and submitting program investment proposals to cost-benefit analysis.

5. International cooperation of consequence⁹
6. Incentives for industrial participation
7. Optimized use of resources
8. Development of capability in strategic technologies¹⁰
9. Pragmatism in the conception of new space systems
10. Importance of scientific activities
11. Emphasis on space applications¹¹
12. Coherence between autonomous programs
13. Matching technological objectives with scientific aims and application goals¹²
14. Dual-use technologies¹³
15. Other guidelines. In addition to the items mentioned above, one should also include activities promoting (a) the generation and training of highly qualified human resources; (b) international cooperation at all levels; (c) greater integration between the university and the industry; (d) with priority, the development of space systems; and (e) the development and dissemination of space applications. It should promote and encourage commercial participation in sponsoring of space systems for commercial services; it should also encourage the commercial exploitation of space activities-generated services and products, giving priority to the private sector.

It should complete and maintain adequately the needed infrastructure for space missions of national importance including development, integration and tests of space systems, laboratories, tracking and control centers, and launch facilities. Finally, it should also promote the dissemination and the effective use of space-related information with emphasis on that of normative nature.

⁹In the context that information sharing is limited to that strictly necessary to achieve the common objective and due to the fact that in the technical area international cooperation is not usually characterized by a free interchange of valuable information, the following items should be observed: Benefits should be stated clearly and pragmatically; cooperative scientific projects should be encouraged that seek to establish favorable conditions for personnel, equipment, and data exchange, and to ensure beneficial participation in major international scientific programs; opportunities for cooperation in space engineering, technology, and systems should be taken whenever possible within the interests of the country; cooperative initiatives with countries with similar problems should merit special attention; the establishment and adoption of international standards should be adopted.

¹⁰Given the importance in dominating techniques considered strategic for the country, this guideline should consider the following criteria: their importance for space systems or services of major interest; difficulties with their importing; their potential commercial value for Brazilian concerns; and the competence and facilities available in the country to make state-of-the-art contributions.

¹¹For a country with the geopolitical characteristics of Brazil, the application of space technology to the solution of national problems constitutes the main justification for government investments in the area.

¹²This should be taken as fundamental in programming the development of space activities; the scientific and application objectives, respectively, should be directed toward the advancement of universal knowledge and to the solution of problems of national scope or of interest to the country.

¹³A significant part of the technologies used in space applications can be termed as such. Therefore, the national space activities program should take into account the government policies and legislation on export controls on dual-use material and related services, seeking, where applicable, proper coordination.

Strategy to Fulfill the Objectives of the PNDAE

Given the directives of the PNAE through its objectives and guidelines, PNAE has established a ten-year plan, organized in major programs, which, in harmony with those directives, also took into account the peculiarities of the various sectors and were consistent with the policies of the ministries responsible for the country's position in the international arena. These major programs, fully taken from AEB's *National Space Activities Program, PNAE 1998–2007*, are listed next along with some of their major specific objectives and some considerations:

1. *Space Applications*—To create the tools for society to best use the data generated by application satellites, mostly in the fields of remote sensing, meteorology, oceanography, telecommunications, geodesy, and navigation.
2. *Satellites and Payloads*—To generate the capability for the conception, design, development, construction, and use of satellites and their subsystems. These activities include
 - data-collection satellites (SCDs);
 - Earth observation satellites (the SSRs [Small-Scale Remote Sensing Satellites] and CBERS series);
 - scientific and demonstration satellites (small, low-cost satellites for short missions, such as the SACI series and the SFB, the French Brazilian Scientific micro-satellite under development by CNES and INPE);
 - telecommunication satellites (aimed at establishing, in the long range, autonomy in the conception and design of systems to exploit alternatives of specific interest to the country as well as to enable national enterprises to increase the share in the telecommunications satellite subsystems market)
 - Payloads and Complementary Initiatives (experiments with foreign space agencies, e.g., CIMEX and HSB with NASA and the PSO [Sub-Orbital Stabilized Platform]; and, last but not least,
 - the International Space Station (ISS).
3. *Launch Vehicles*—To give the country the capability to design, develop, and build launch vehicles for suborbital payloads and satellites. It includes three subprograms: sounding rockets, launch vehicles for small satellites, and launch vehicles for medium satellites.
4. *Space-Related Infrastructure* —To expand and keep up the existing facilities that constitute the mainstay of the space activities in Brazil and to set up new units deemed necessary. This consists of four subprograms:
 - (a) Support infrastructure for satellite development (with the integration and tests Laboratory, LIT [see page 123], the Satellite Tracking and Control Center, CRC [see page 123], and the Satellite Propulsion Laboratory, BTSA [see page 124]).

(b) Support infrastructure for the development and launching of space vehicles, with the following facilities in operation: the Alcântara Launch Center (CLA), the Barreira do Inferno Launch Center (CLBI), and the Colonel Abner Propellants Utility (UCA), as well as the following planned facilities: a satellite launch vehicle tracking and control network, a rocket motor propulsion laboratory, an acoustic tests laboratory, a carbon-carbon research and production unit, and a transonic wind tunnel.

(c) Support infrastructure for research in space and atmospheric sciences (including facilities such as the Itapetinga Radio Observatory, the São Luiz Equatorial Space Observatory, the Balloon Launch Unit, and the southern regional Space Research Center).

(d) Support infrastructure for space applications (with satellite data receiving, processing, and distributing systems for remote sensing satellites such as the Landsat, SPOT, and CBERS series and for meteorological satellites such as Meteosat and Geostationary Operational Environmental Satellites (GOES), as well as for polar orbit NOAA series and the Weather Forecasting and Climate Studies Center [CPTEC], which generates and disseminates numerical weather and climate forecasts for Brazil with lead times and reliability similar to those of other first-rate centers). An Integrated Space Data Center (CIDE) will be installed in the near future, to allow access to all space data archives.

5. *Research and Development*—To foster, coordinate, and support projects on basic and applied research in space science and technology. It consists of six sub-programs: (a) space and atmospheric sciences; (b) meteorological sciences; (c) global change; (d) microgravity; (e) space technology; and (f) related areas, including R&D in fields associated with space activities such as material physics, mathematical modeling, scientific computation, and plasma physics.
6. *Human Resources*—To establish in the relevant fields the trained human resources needed for carrying out the PNAE.
7. *Development of National Industrial Capability*—To establish industrial competence among the Brazilian companies to participate in the supply of space-related services and products within the country and abroad.

Concluding Remarks

The Brazilian policy in space activities has been always transparent and keeps it that way, even in the quite sensitive area of launch vehicles development. This was detailed in a RAND report back in 1993,¹⁴ which offered the primary reason for selecting Brazil as a case study to be extrapolated to other countries: “economic data on emerging national space launch programs are generally closely held, but Brazil’s data are available.”

¹⁴B. G. Chow, *Emerging National Space Launch Programs: Economics and Safeguards* (RAND R-4179-USDP, 1993).

Brazil has been collaborating with its neighbors in South America and countries abroad: It has started the development with Argentina (and lately with Spain) of a remote sensing satellite, the SABIA, for applications in water resources, agriculture, and the environment. Its presence in the ISS will bring to the country the opportunity to hold experimental activities in earth observation, biotechnology, material sciences, and combustion microgravity, and the ability for its industry to improve its competitive level in the international high-technology market. A platform for scientific micro-satellites is under joint development with CNES. The association with China has led to the successful launching of CBERS-1, the first of a series of remote sensing satellites; CBERS-2 is scheduled for early next year.

As for the dual-use technology implications, everybody knows it is nearly impossible to split them clearly for this or that utilization. Just recall the many items which, within our life span, drifted from the ultrasecret realm into everybody's house.

The Brazilian company EMBRAER, the largest aerospace private enterprise in the country, presented in 2000 the stock market's largest investment return, so space development (launchers included) is not only a matter of national pride but also one of sheer economic common sense.

MEETING AUSTRALIA'S SPACE REQUIREMENTS THROUGH COLLABORATIVE AND COALITION ARRANGEMENTS

Roy Sach, Director, Defence Space Engagement, Department of Defence,
Australia

It is a pleasure to be here and in particular to address such a prestigious audience. This conference comes at an interesting point in the development of Australian space engagement and I welcome the opportunity to share some thoughts with you today.

Some Basics

I would begin with a positioning statement. In the Australian Defence Organisation we recognize that space-based capabilities in military operations will be fundamental to the achievement of objectives. We understand that no country, other than perhaps the United States, will have the ability in the short term to successfully develop and implement the full range of space-based capabilities required to support military operations. It follows that for our space engagement we will generally seek to build upon our long-term and highly successful alliance relationship with the United States.

Thus, space offers us opportunities to further enrich the United States–Australia relationship and to support the interoperability of our defense forces. This does not imply 100 percent reliance upon the United States for space access either now or in the future.

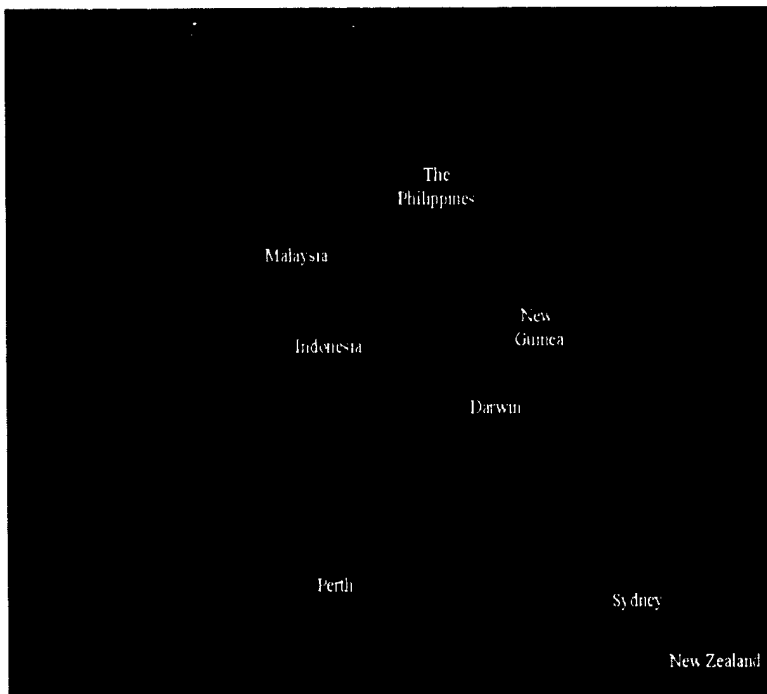
For the most part, Australia relies, militarily, on collaborative and coalition space arrangements. Where we do have exclusive space resources, they tend to be acquired by leasing or perhaps buying components of more extensive systems. Australia does not yet have a space launch capability.

Much of our space-relevant military expertise is concentrated on acquiring, analyzing, and distributing space-sourced data. We also conduct quality research and development through our Defence Science and Technology Organisation—a center of scientific excellence that we are fortunate to have.

I would expect much of this architecture to remain in place during the foreseeable future although our indigenous space commitment and capability will increase.

Australia in Context

Putting Australia into context, we have a population of fewer than 20 million people and a landmass of 7.7 million square kilometers. Australia is about the same size as the continental United States and 370 times the size of Israel. The following figure shows our immediate geographic neighborhood.



Australia's Immediate Geographic Neighborhood

Our northernmost city of Darwin is nearer to Singapore than to Sydney and you can fly from Sydney to New Zealand in less time than from Sydney to the city of Perth on our west coast.

Most Australians live in the southeast and southwest of the continent. However, key areas from a defense perspective are primarily in the sparsely populated northern regions of Australia and in the littoral zone.

This means that air and space assets are ideally suited to support our defense and related operations.

The Australian Defence Force comprises approximately 71,400 personnel in a Navy of 12,400; an Army of 24,600; and an Air Force of 13,400, all supported by an effective Reserve Force of 21,000. As the figures imply, we do not have compulsory military service.

The Australian Defence budget for FY 2000–01 of approximately \$A12b represents 1.8 percent of Australia's gross domestic product.

Space Engagement Origins

If you will permit me a brief but relevant walk along memory lane, I should mention that Australia started in the long-range rocket launch business in 1949. At that time, we began working cooperatively with the British in the development of a new missile. The British eventually discontinued this and related projects. They joined the Euro-

pean Launcher Development Organisation, which also operated in Australia. That initiative was discontinued in 1970.

We did however build and launch a satellite from Australia as early as 1967 on a U.S.-owned Redstone rocket.

I should add that Australia has since endorsed the Missile Technology Control Regime (MTCR). We neither have, nor intend to import, technologies contrary to those arrangements.

Today

Meanwhile, other Australian space-related activities have continued. For example, our University of Queensland is well advanced with research into hypersonic scramjet engines. Australians can build small satellites. One organization, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), has designed a space sensor that employs spectroscopic principles and is supported by significantly advanced processing algorithms.

International participants in the launch market have rediscovered Australia. With our low population, benign climate, quiet electronic environment, high-technology support, educated workforce, and political stability, we are an attractive proposition. In one region alone—Woomera—Defence has a test and evaluation range about the size of England. The Woomera range has a permanent population of some 70 people.

The full range of commercially available, space-sourced products is used extensively by Australia's corporate world for applications as diverse as minerals surveys, land management, geolocation, and financial transactions, as well as communications.

Five organizations are at present considering space launches from Australia. Of these, four intend using either Russian-originated launch vehicles or rocket motors.

By passing the Space Activities Act (1998), Australia established a legislative regime to manage commercial launch activity. Australia has also ratified the five major space-related treaties: Outer Space, Rescue of Astronauts, Registration of Space Objects, Liability for Damage Caused by Space Objects, and the Moon and Other Celestial Bodies Agreement.

Australia is about to sign a space cooperation agreement with Russia, this as a precursor to Russian rockets being launched from Australia. We will of course remain conscious of our obligations under the MTCR.

Military Aspects

Australia's earliest efforts in the military use of space were focused on intelligence gathering and communications. They have remained dominant themes.

During the 1990s, the Australian Defence Organisation increasingly used commercial satellite communications services to support the tactical environment through a Defence Mobile Communications Network, Transportable Earth Stations, and

Mobile OffShore Terminals. We also increased our use of satellite-based navigation systems.

Defence utilizes NAVSTAR GPS extensively. Receivers are currently fitted on major naval vessels; in helicopters; and in strike, reconnaissance, and maritime patrol aircraft. Differential GPS that provides down to 4-m accuracy has been procured for selected applications. Standard Positioning Service portable GPS equipment with accuracy in the order of 100 m has been procured for use throughout the Australian Defence Force. The Precise Positioning System, a handheld GPS with much improved accuracy, is currently being fielded.

In addition, Defence is developing navigation warfare capabilities as part of its efforts to protect its navigation equipment from electronic attacks and to prevent the use of navigation signals by hostile forces.

Defence has leased a dedicated ultrahigh frequency (UHF) satellite and decided to buy a military payload on the Cable and Wireless Optus C1 satellite. We expect that satellite to become operational in August 2002.

We use commercial remote sensing data for mapping.

Defence is also introducing into service a new personal locator beacon complemented by GPS. It will use the Russian COSPAS and the United States' SARSAT search and rescue satellites.

The Defence Theatre Broadcast System is a good example of an indigenous capability developed to meet Australian requirements. This system was deployed in East Timor with excellent results. It can support Web-based command systems and deliver high-bandwidth products, such as imagery, to multiple users concurrently.

Importantly, it is intended to be interoperable with the United States Global Broadcast and the United Kingdom Direct Broadcast.

Our Navy, Army, and Air Force use the data from meteorological satellites.

As indicated earlier, Australia's alliance with the United States will help us to pursue our strategic objectives. As part of our ongoing arrangements, Australia hosts components of U.S. technologies through which we cooperate in a number of missions.

Australia is also the location of choice for ground stations such as those of the National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA).

Space Policy Considerations

With this diversity of Defence activity in particular, you will be pleased to learn that we have, finally, appointed a director of Defence Space Engagement—*me*. My responsibilities include overview of Defence space activity, writing a Defence space policy (and later a space doctrine), and liaising with and supporting other officials involved with the establishment of the corporate space-launch industry.

A New Approach to Defense Organization

Output	Owner Support	Enabler
Australian Theatre	Knowledge	Intelligence
Army	Finance	Acquisition
Navy	Personnel	Science and Technology
Air Force	Public Affairs	Corporate Services
Strategy	Inspector General	

These are interesting challenges, but the burden will be eased by our new Defence organization and related arrangements. In broad terms, Defence organizations now fall into one of three categories: advice to government (which we term “owner support”), operations (our “output”), and support functions (our “enabling” organizations). They are shown in the table above. This arrangement is overlaid by a committee structure to provide governance. The top echelon comprises the Chief of the Defence Force and the Secretary of our department. They are in turn responsible to our Minister for Defence.

Planning and related processes translate grand strategy into strategic objectives and so on, down to capabilities supported by projects. Once a requirement is formally recognized within that system, it gets the resources necessary to produce the endorsed outcome.

These arrangements are still evolving but I am pleased to report that in general the system works well.

Returning to Defence space policy, space-based capabilities are growing in importance for both the military and the economic elements of our national power. Moreover, those two categories of activity are interrelated. As commercial space-related developments proliferate, our capacity to adapt them for military operations also increases.

In some respects, Australia, and other nations, are acquiring a national space estate—and this is an important concept given that a Defence force is responsible for defending its national estate. But the space element of a national estate cannot of course be defended by conventional means.

We would not necessarily know which corporate space assets the Australian commercial sector is employing at any given moment. Additionally, most commercial space assets are owned by multinational corporations that have a confusing tendency to own each other.

At the same time, there has been a trend away from space as a government-dominated function to space as a corporate enterprise. Past mergers of the bigger space enterprises, with possibly more to come, have resulted in fewer but more influential major corporate participants.

Because space assets have potentially dual-use features, corporate ownership has given multinational organizations control over a segment of international military capability. This begs the question of who can control the multinationals.

From Australia's perspective, these developments—together with the weakening of the bipolar politics that dominated the 1950s through to the early '90s—have woven an intricate tapestry.

On the one hand, there are benefits in dealing with organizations less likely to be swayed by regional tensions or political issues. On the other hand, it is disconcerting to realize, for example, that the imagery one might purchase from a commercial operator could, in theory, also be sold to less-friendly nations who might use it to build a potent intelligence library.

As a result of the actual and potential capabilities of space-based sensors, the term "countersurveillance" has gained a new emphasis. At the most basic level there might not be much point in an Army conscientiously parking trucks or armor under netting if space sensors can "see" through the camouflage, and not only see through it but identify the assets involved with a fair degree of confidence. We need effective policies, doctrines, and technologies to counter this sort of challenge.

Even partial space denial by jamming or other intentional intervention could be a serious problem for us. Responses would be necessary to restore or reroute the traffic and could go further than that. Some rules of space-related engagement may be necessary. In this context, the first problem will be determining whether the origin of incidents lies in nature or humankind and, if the latter, whether it was intentional or not.

Hardening, encryption, and other technologies can to an extent protect space assets that were designed for military applications. But the commercial operators who carry military traffic, not to mention financial and related business data that may be critical to the national infrastructure, have not in the past placed a high priority on such insurance.

If any single feature of space stands out at present, it is the vulnerability of critical aspects of the infrastructure. The prerequisite capital, both financial and human, is vast. The potential to disrupt is enormous.

Such concerns gain weight when we note the increasing life spans of commercial satellites, particularly those in geosynchronous orbits. We are keenly aware that, for all practical purposes, it is not possible to retrofit satellites. Data encryption and other transmission management techniques can of course be subsequently introduced at some cost to available bandwidth.

At least the ground segment of space operations is more readily identifiable and manageable, certainly at the downlink point, and those facilities are rapidly becoming significant strategic assets.

We are examining all of these issues carefully and attempting to formulate appropriate and practical approaches to them. If anyone here has ideas to contribute, I would welcome an informal dialogue.

Within the Australian military community, it is fair to say that the Air Force occupies the high ground in space engagement. They have invested in space-related training for a cadre of personnel and are considering an identifiable space career stream. This will provide the nucleus for a space education and awareness program throughout our three armed services and in the Defence organization more widely.

The Future

Given the avalanche of data now arriving from space and other sources, one of the challenges that has emerged is the need for Defence to manage data efficiently. This sounds prosaic until one has to confront the intellectual, cultural, and technological challenges involved in managing a defense information environment.

We are taking this seriously and we have appointed a two-star chief knowledge officer to head a team of innovative people. The results to date have been highly promising.

We will keep under review the potential to migrate systems to space, but our reviews will be tempered by the appreciation that terrestrial technology is also advancing and might remain the better option for some applications. Five years ago, who, for example, would have predicted the flexibility now inherent in terrestrial mobile telephones (if is still appropriate to refer to them as *telephones* given the Internet connectivity and other features available)?

I would expect that our planned space education and awareness program will whet Defence appetites for a range of space-related capabilities and products. It is, however, too early to conceive of the form that they might take.

My point here, and hopefully throughout this presentation, is that we in Australian Defence have come to appreciate the need to consider space in a holistic and systemic framework. We are therefore attentive to both the strengths and the vulnerabilities offered by space. We have a focus on both space-borne assets and the supporting ground stations. We comprehend the significance of data processing, management, analysis, and distribution.

Looking further into the future, technologies such as nano-satellites, laser linking, developments in electronic and other forms of warfare, and expanded ownership of space assets by the multinationals will all create both challenges and opportunities. We hope to meet them in nationally and regionally appropriate and constructive ways.

At the policy and strategic level, it seems reasonable to suspect that for the small and medium powers some unique alliances, accommodations, and other international arrangements may emerge as the need to cooperate to achieve national objectives becomes more apparent. I anticipate that an increased satellite population may lead

to space control that will be comparable in some respects with air traffic control. It is also difficult to see the longer-term future without some international effort to clean up the increasingly dangerous assortment of orbiting space junk, once the necessary technologies have been developed. This will of course raise the delicate question of who pays the bill.

Closure

Given a modest level of good will, we in Defence hope that space will provide new opportunities for beneficial cooperation; interdependence; and other prerequisites for prosperity, stability, and peace. But these benefits are unlikely to flow spontaneously. Space is very much an international environment and it seems to us that a concerted and continuing effort will be necessary so that all might enjoy the benefits available from space exploitation.

I do, however, believe that Australia will seek to play a constructive role in its space engagement initiatives.

JAPANESE AEROSPACE AND NATIONAL SECURITY

Tetsuo Tamama, Senior Researcher, Defense Research Center, Japan

Is Japan a Small/Middle Power?

The title of this conference is very interesting: "Toward Fusion of Air and Space: Surveying Developments and Assessing Choices for Small and Middle Powers." I have been asked to present a Japanese perspective on this issue. Let me begin by asking the question, "Is Japan a small/middle power?"

First: the simple physical facts of area and population. In terms of *area*, in comparison to the G8 and China, Japan is somewhat larger in area than Germany, Italy, and the UK, but France is nearly 1.5 times larger than Japan; Canada, China, and the United States are some 25 times larger; and Russia is 45 times larger.

In terms of *population*, China is nearly ten times larger and the United States is more than twice the size of Japan. Japan is only 16 percent less populous than Russia, but its population is nearly 1.5 times that of Germany; more than twice that of France, the UK, and Italy; and more than four times that of Canada.

Second: gross national product (GNP). Japan is the leader in per capita GNP: Its per capita GNP is more than 1.1 times that of the United States, more than 14 times that of Russia, and more than 43 times that of China.

Area and Population of G8 Plus China

	Japan	U.S.	Ger	Fr	UK	Italy	Can	Russ	China
Area (k km ²)	378	9,364	357	552	243	301	9,971	17,075	9,597
Area Ratio	1	24.8	0.94	1.46	0.64	0.80	26.4	45.2	25.4
Pop. (M)	126.4	270.56	82.02	58.85	58.65	57.37	30.30	146.54	1255.7
Pop. Ratio (M)	1	2.14	1/1.54	1/1.34	1/2.15	1/2.20	1/4.17	1.159	9.93

GNP and per Capita GNP of G8 Plus China

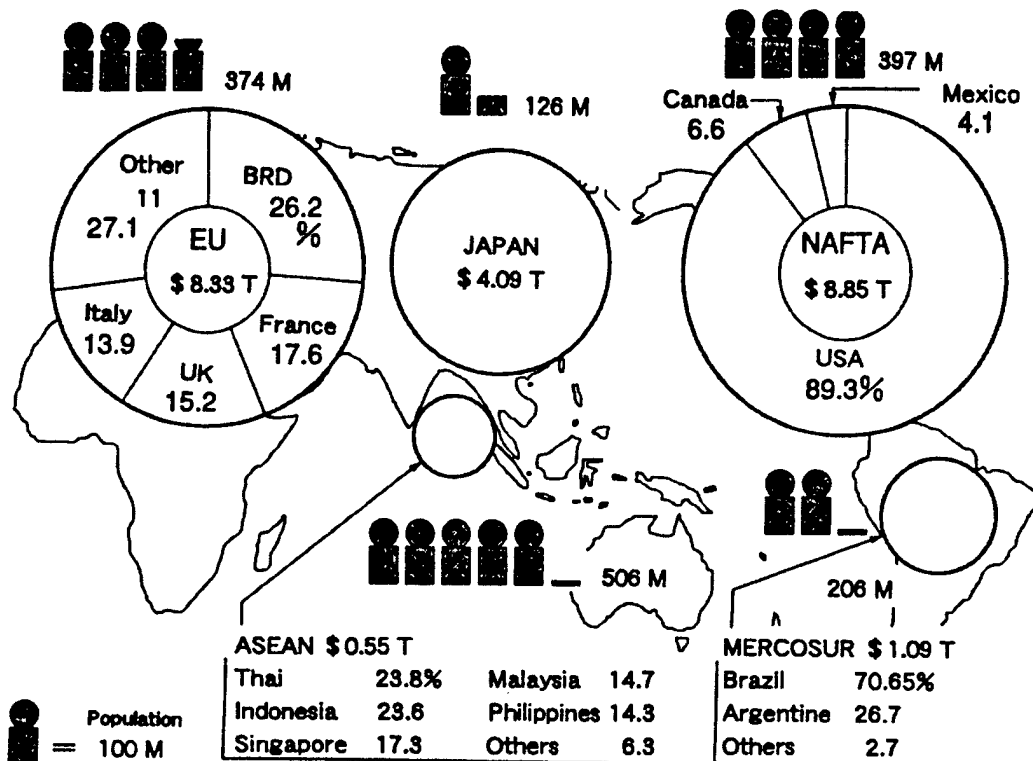
	Japan	U.S.	Ger	Fr	UK	Italy	Can	Russ	China
GNP (G\$)	4,089	7,903	2,180	1,465	1,264	1,157	581	332	923
Per Capita (\$)	32,350	29,240	26,830	24,210	21,410	20,090	19,170	2,260	750
Per Capita Ratio	1	1/1.11	1/1.21	1/1.34	1/1.51	1/1.61	1/1.69	1/14.3	1/43.1

SOURCE (for both tables): Sekai Kokusei Zue (*World National Statistics Illustrated*), 2000/2001.

Let us take a look at GNP as such. The figure shows the GNP of main economic blocs. Japan, with its population of 126 million, produces nearly half of what NAFTA (population 397 M) and the EU (374 M) produce, nearly four times what MERCOSUR (206 M) produces, and more than seven times what ASEAN (506M) produces.

So we can conclude from these simple figures that Japan is a curious mixture of big and small: Small in area but fairly populous. And in terms of economy, she's not just big—she's huge.

GNP of Main Economic Blocs (1998)

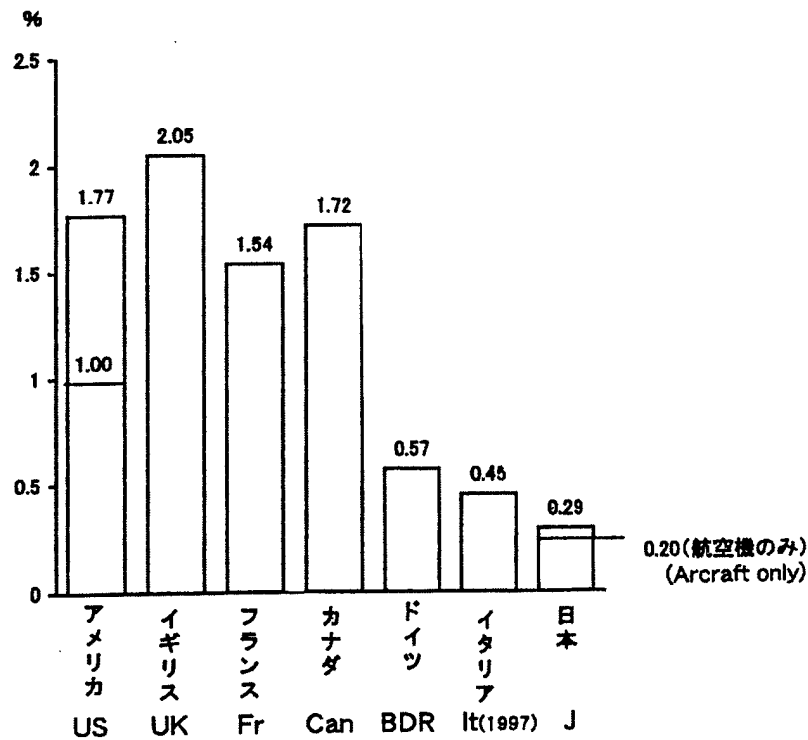


SOURCE Sekai Kokusei Zue (World National Statistics Illustrated), 2000/2001

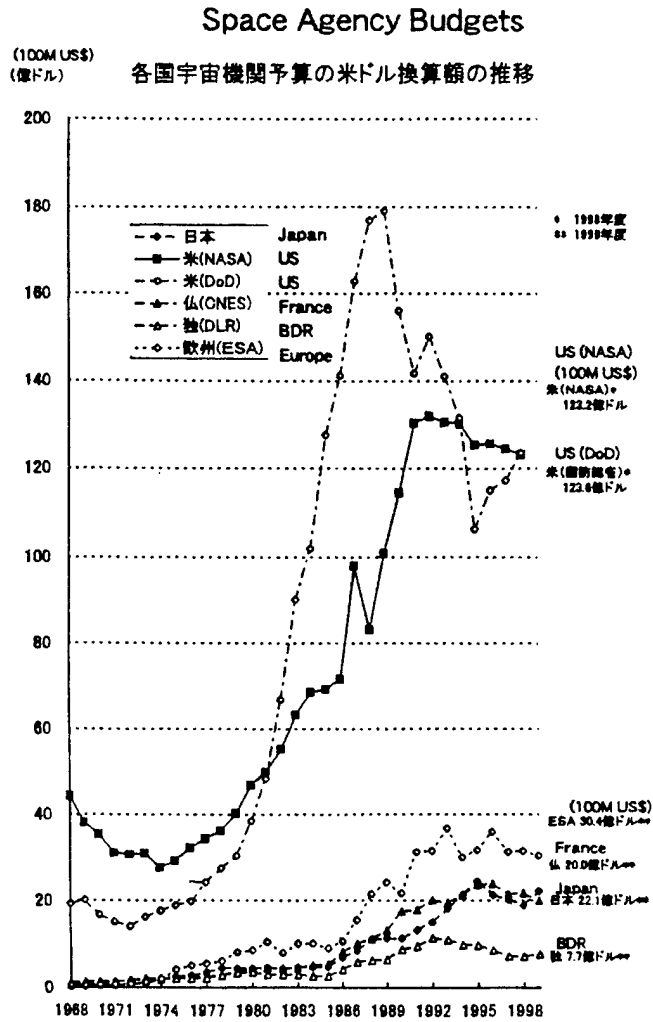
Japanese Aerospace Outputs and Budgets

One convenient measure of assessing the place of aerospace in Japan is, again, the simple figure of budgets and industry outputs. The figure below compares the aerospace industry outputs of several nations in their ratio to the national gross domestic product (GDP). In contrast to the UK, the United States, Canada, and France with 1.5–2 percent figures, Japan is well below with 0.29 percent, and especially for space (only 0.09 percent). Even with this low ratio, her huge economy puts the absolute value at a respectable level, as demonstrated in the figure on page 144, which shows the space agency budgets. The United States is by far the largest, of course, but Japan ranks third and fourth, a little behind the ESA and about on a par with France.

Aerospace Industry Output/GDP (1998)



SOURCE Nippon Koku-Uchu Kogyokai (The Society of Japanese Aerospace Companies), 2000



SOURCE Ministry of Educ, Culture, Sports, Sci & Tech (formerly Science & Technology Agency), 2001

Several brief comments are offered here to supplement the figures.

a. The indigenous/worldwide tender issue: Stemming from the 1989 Japan-U.S. trade talks, the Japanese commercial satellite procurements are required to be tendered worldwide (unlike developmental satellites that may be indigenously tendered), which means not all Japanese space budget turns to Japanese output.

b. Aircraft customers: By far the largest Japanese aircraft customer is the Defense Agency. The defense dependence of Japanese aircraft industry is high: 55 percent in

1998, compared with the UK (51 percent), the United States (41 percent), France (31 percent), etc.¹

c. On the contrary, Japanese space and defense are almost completely unrelated, quite unlike most of other developed nations. Why?

Japanese Sensitivity on Defense and National Security²

The post-WWII Japan is a contrite nation. A peculiar sensitivity on defense and national security pervades the whole fabric of Japanese society. The source that made the spirit (and vice versa) is the 1947 Constitution, especially its Article 9 (the No-War Clause). And there are numerous restrictions to safeguard it. Let me quote, without much comment, the original Japanese official statements.

a. The Constitution of Japan, Chapter II, Renunciation of War, Article 9

“Aspiring sincerely to an international peace based on justice and order, the Japanese people forever renounce war as a sovereign right of the nation and the threat or use of force as means of settling international disputes.

“In order to accomplish the aim of the preceding paragraph, land, sea, and air forces, as well as other war potential, will never be maintained. The right of belligerency of the state will not be recognized.”

b. Basic Policy of National Defense^{3, 4} (abridged)

- A. Exclusively Defense-Oriented Policy
- B. Not Becoming a Military Power
- C. Adherence to Three Nonnuclear Principles (see below)
- D. Securing Civilian Control

c. Limitations on Self-Defense Force Operations⁵

- A. Negation of Preemptive Attack
- B. Negation of Right of Collective Self-Defense
- C. Negation of Overseas Deployments
- D. Negation of Possession of Strategic Weapons
- E. Negation of Possession of Nuclear Weapons

¹Japanese Aerospace Industry, Nippon Koku-Uchu Kogyokai (The Society of Japanese Aerospace Companies), 2000.

²TAMAMA: Debate vs. No Talk: Cultural Side of Japan-U.S. Technological Exchange, in *Through Asian Eyes: U.S. Policy in the Asian Century*, Sanders, ed., University Press of America, 2001.

³*Defense of Japan 1999*, Defense Agency, Chapter II, Section 3, the Basis of Defense Policy (pp. 55-56).

⁴Defense Agency Homepage in English: Boueichou Jieitai: www.jda.go.jp/e/policy.htm.

⁵Defense Agency Homepage in Japanese, quoted by this author's translation: www.jda.go.jp/j/defense/index.html.

- F. Negation of Possession of Space Weapons
- G. Suspension of Possession of Anti-People Landmines

d. **Budgetary Limitations:** The Japanese defense budget has long been under the symbolic (not legal) limitation of 1 percent of GNP. Despite her huge economy, one statistic⁶ has her per capita defense expenditure at world's No. 23—and in terms of ratio to the GDP, world's No. 77!

e. **Special Limitations:** There are three especially delicate limitations, one from above, two other additional—one of which has a special bearing on the nature of Japanese space.

- A. **Three Nonnuclear Principles:** Japan will not possess, produce, nor permit the introduction into Japan of nuclear weapons.
- B. **Principles on Arms Export⁷:** Arms export is not permitted, including the equipment related to arms production. (This means that the aircraft industry is heavily dependent on domestic defense market only.)
- C. **"Peaceful Use of Space" Resolution:** In 1969, the House of Representatives of the Diet passed the "Peaceful Use of Space" Resolution.

"Peaceful Use of Space" and Nature of Japanese Space

The peculiar Japanese sensitivity for national security and defense has placed a distinctive barrier between the civil and national security communities (the latter being a very small minority); in few other places is the barrier more visible than in space.

It is the above "Peaceful Use of Space" Diet Resolution of 9 May 1969 that has, and still is, setting the basic tone of Japanese space activities in relation to defense. The Resolution states, in essence, that the launching of objects beyond the atmosphere, and their launchers, should be limited to "peaceful purposes." What this "peaceful" means, in the context of sensitivity on national security, is actually "non-defense," thereby practically excluding the Defense Agency and the Self-Defense Forces from use of space.

This peculiar limitation has, since then, been slightly alleviated by the "Government View on the Use of Satellites by the Self-Defense Forces" of 6 February 1985, which stated, in essence, that the satellites in "common use," or those equivalent to them, may also be used by the Self-Defense Forces (SDFs), without violating the Resolution. This opened the way for the SDFs to use the U.S. military, and to rent transponder channels on Japanese commercial communication satellites, as well as to purchase commercial satellite images. Even in the recent move to introduce the "information

⁶Nippon Bouei Sobi Kogyokai (Japan Association of Defense Industry), 1997.

⁷*Defense of Japan 1999*, pp. 288–289.

gathering satellites”⁸ in response to the August 1998 North Korean Taepo-Dong missile launch over Japan, the responsibility for development rests with other ministries and agencies; the status of the Defense Agency, only one of the users, is believed to be based on this “common use” principle.

Conclusion

The status of Japanese aerospace and national security may be summarized as below.

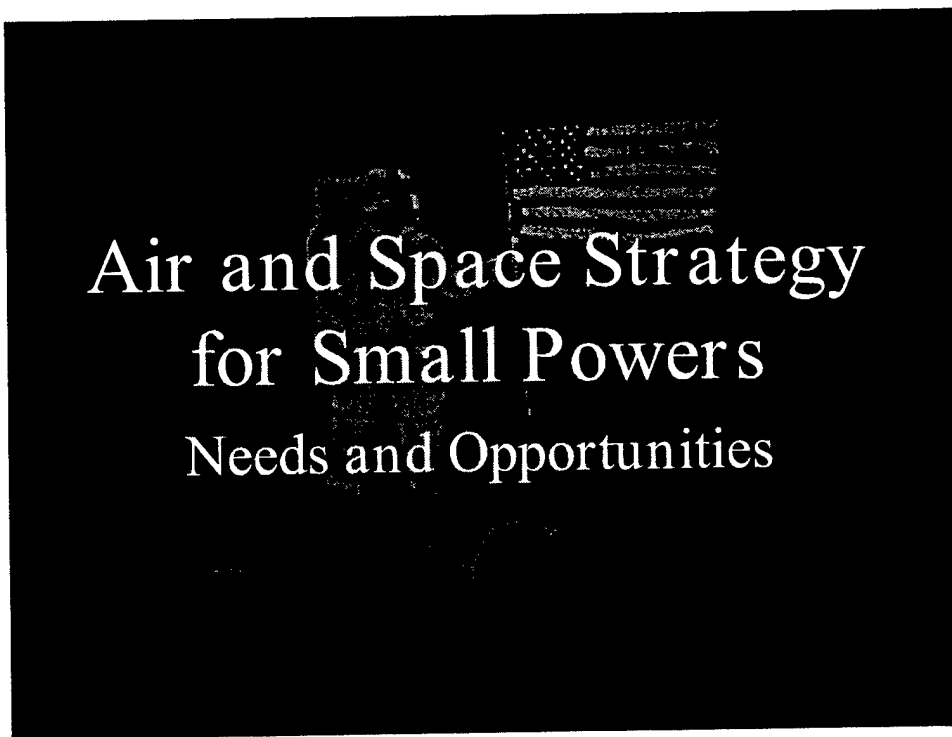
1. Japan is big in economy, but small among the developed nations in aerospace ratio in the gross domestic product, especially in space. Because of her huge economy, her aerospace is still respectable, but remains at that level.
2. The Japanese aircraft industry is heavily dependent on the domestic defense market; on the contrary, the space industry and the defense are almost unrelated.
3. Stemming from the post-WWII contrition of the Japanese people, peculiar sensitivity exists on the defense and national security issues, from the “No War Clause” of Article 9 of the Constitution to the multiple limitations of the Self-Defense Force operations.
4. Distinctive barriers exist between the civil and the national security communities as a result of the sensitivity; in the case of space, the “Peaceful Use of Space” Diet Resolution of 1969 still governs the basic tone of space and defense, limiting the national security use of space to those areas already “in common use.”

⁸*Defense of Japan 1999*, Chapter VI, Section 2, “Response of the Defense Agency to the Missile Launch by North Korea,” pp. 202–208.

**SPACE VISION AND POLICY OPTIONS:
ISRAELI PERSPECTIVES**

**AIR AND SPACE STRATEGY FOR SMALL POWERS:
NEEDS AND OPPORTUNITIES**

Major General Dani Haloutz, Commander of the Israeli Air Force



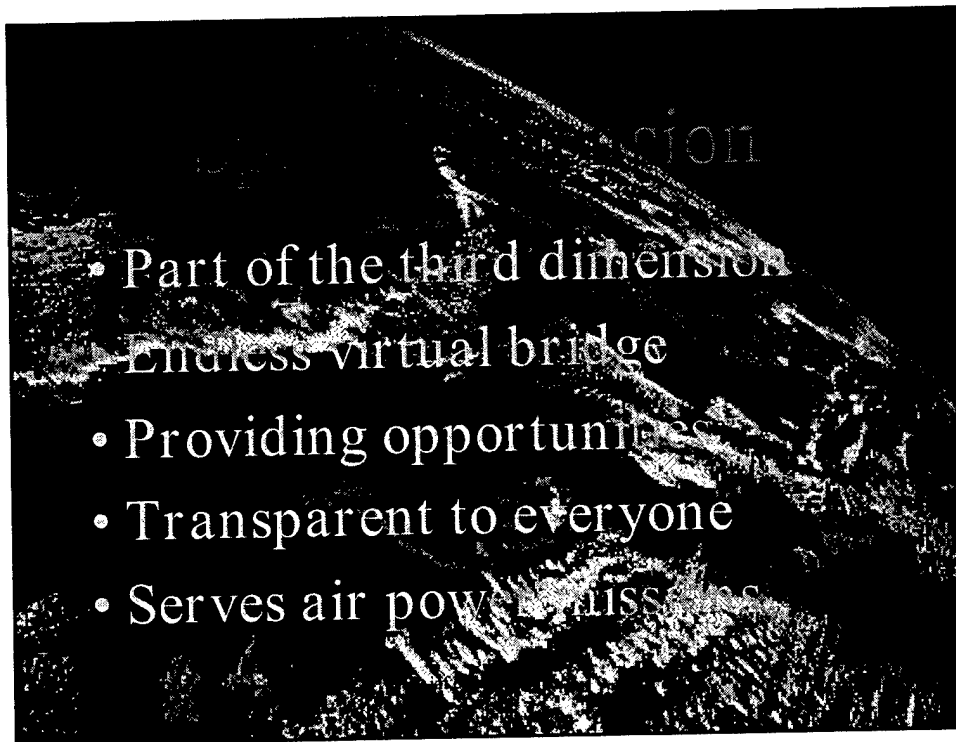
At this conference we have been discussing the challenges, needs, and opportunities facing small and medium powers in making strategic choices about their air and space capabilities. My talk today will focus on an Israeli perspective of the complementary nature of air and space capabilities and the elements of a strategy linking the two.

Like other nations, Israel's needs for air and space power are based on its particular national security objectives and requirements. But the opportunities offered by expanded access to commercial space technologies and systems are enhancing how Israel achieves its objectives. While as Commander of the Israeli Air Force I must be concerned with keeping the skies over Israel clear from aerial threats, I have to also consider the environment of space, a new medium from which new threats are emerging.

In a modern-day military context, air and space are complementary components. When addressing space issues, I primarily think in terms of defensive measures, but thinking "defense" does not mean that "offense" goes unconsidered. Ideally, the use of space capabilities should compensate for inefficiencies inherent in traditional air power capabilities. However, "how" space power is integrated with air power in support of national security objectives is shaped by certain considerations:

1. Space power was formerly considered available only to high-technology states. However, today commercial space technologies and capabilities are enabling small powers to have greater access to space.
2. National needs for a presence in space are derived from the need to complement a nation's aerial abilities, i.e., air power.
3. A space presence lowers risks in all supporting military missions by offering certain operational advantages to military forces.
4. Space activities create a new operational culture, pulling the whole air force to a higher, and enhanced, operational level.

I will discuss these points as I go through this presentation.

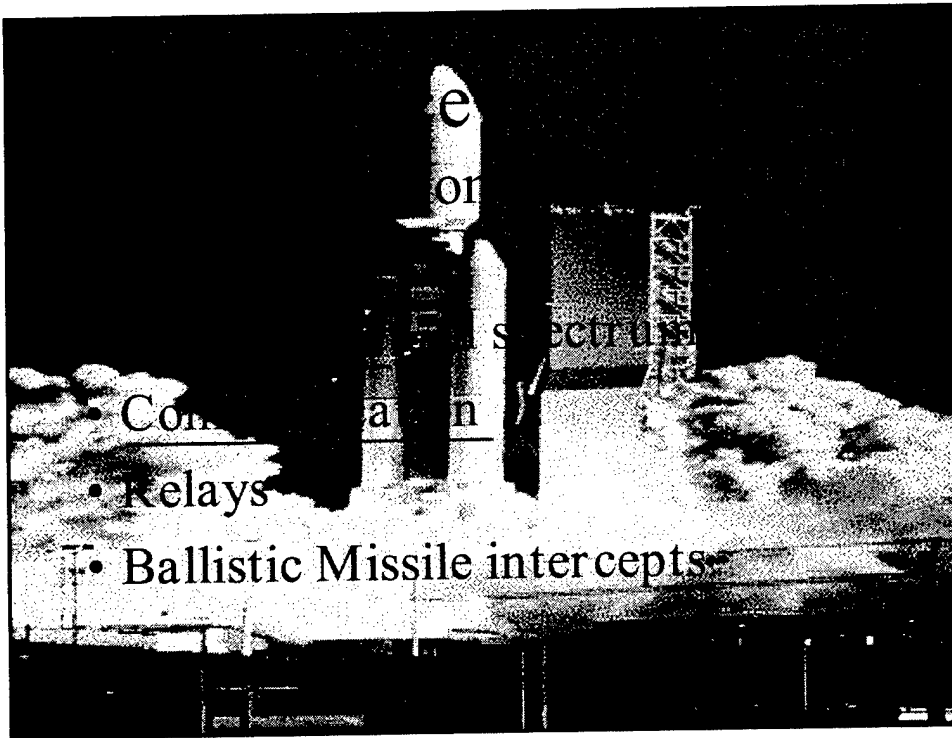


Air power, unlike other military forces, can operate in and over all four mediums: space, air, land, and sea. Air power is a component of all missions of military forces, and, in some of them, air power is the exclusive component. Space provides an additional critical dimension to air power by enabling a “virtual bridge” to other capabilities, i.e., integrated operational synergy among intelligence, communications, surveillance, and ballistic missile defense. It provides opportunities to overcome geographic distances by enabling a nation to look beyond its boundaries, while simultaneously creating new operational challenges. As many of the earlier speakers have discussed at length, a space presence makes a nation’s activities transparent to everyone, including its adversaries. These are factors that military commanders and national leaders need to consider. We believe that space serves air power missions, that space cannot be considered separate from air. Thus, air and space power are integrated and mutually supportive.



The remainder of my presentation will consider the key elements of a presence in space:

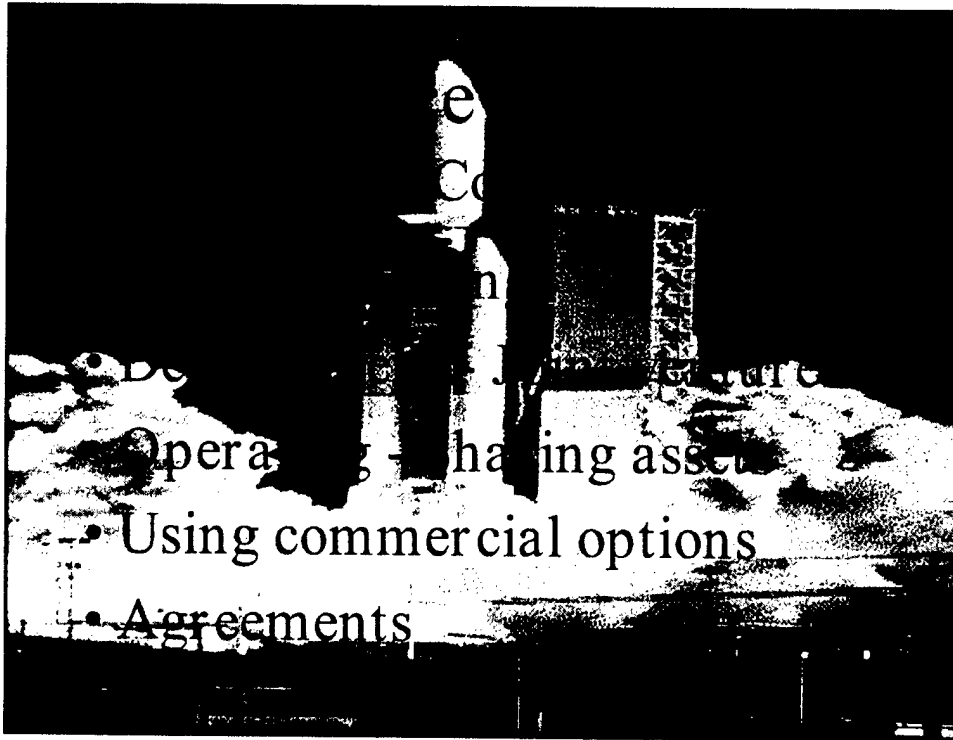
1. Operational needs; i.e., the kinds of capabilities needed to enhance air power
2. Budget constraints, which shape our choice of space capabilities to meet our national needs
3. High technology, which enhances the capability of the Israeli military to carry out traditional operational missions while potentially enabling new missions
4. Launching capabilities, which are central to our developing and exploiting a space presence
5. Concerns; i.e., emerging issues of organizational responsibility for space activities, and the effects of transparency on operational decisions



Examining the presence in space through the framework of operational needs, a number of points can be made.

First, the operational area of interest is getting larger in light of technology developments that increase weapon systems capabilities. Theater distances are longer, an outcome of the expanded operational capability of the threat. What is the impact of such development on air power? Air power, in concert with space power, must react against targets arriving through space, and to deter or prevent the use of such weapons and the need to retaliate against them should an adversary choose to use those capabilities. Space both enables the use of such weapons, and enables deterrence of such use.

Intelligence is the basic element needed to utilize air power properly. In concert with intelligence, communications also enables military operations, particularly at minimum, one's command and control capability. Other sensors needed include optics, radar, weather, infrared (IR), laser, ELINT, and COMMINT. These capabilities provide an aerial picture for air controllers and mission planners.

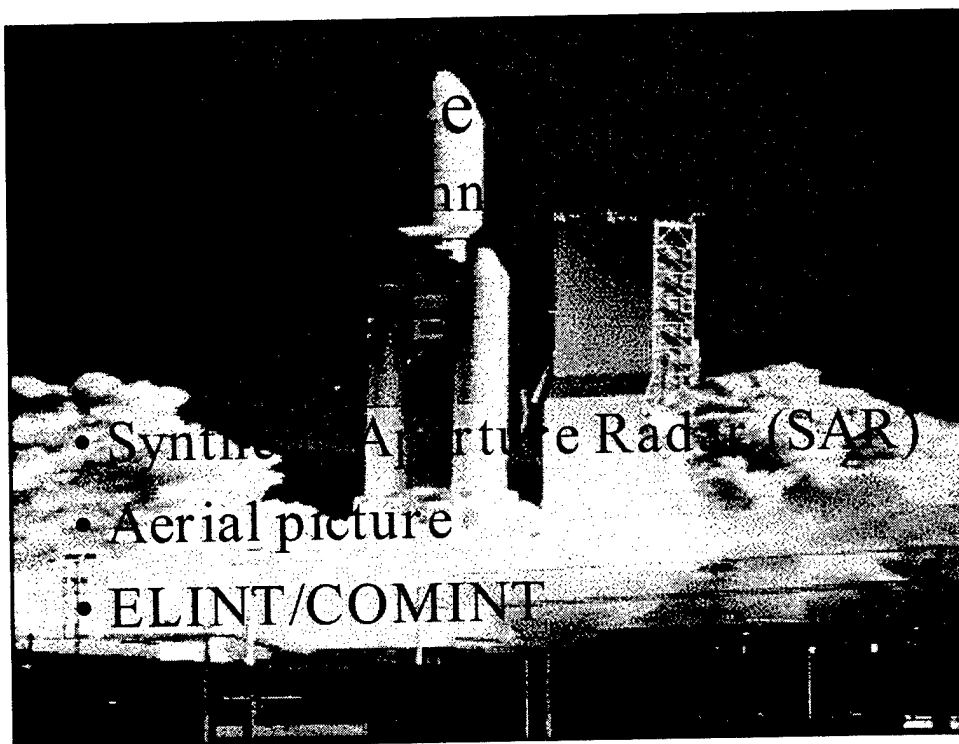


Developing and maintaining a presence in space are very demanding in terms of budget. Budgets are subject to unique developments and programs are ultimately tailored to meeting operational needs.

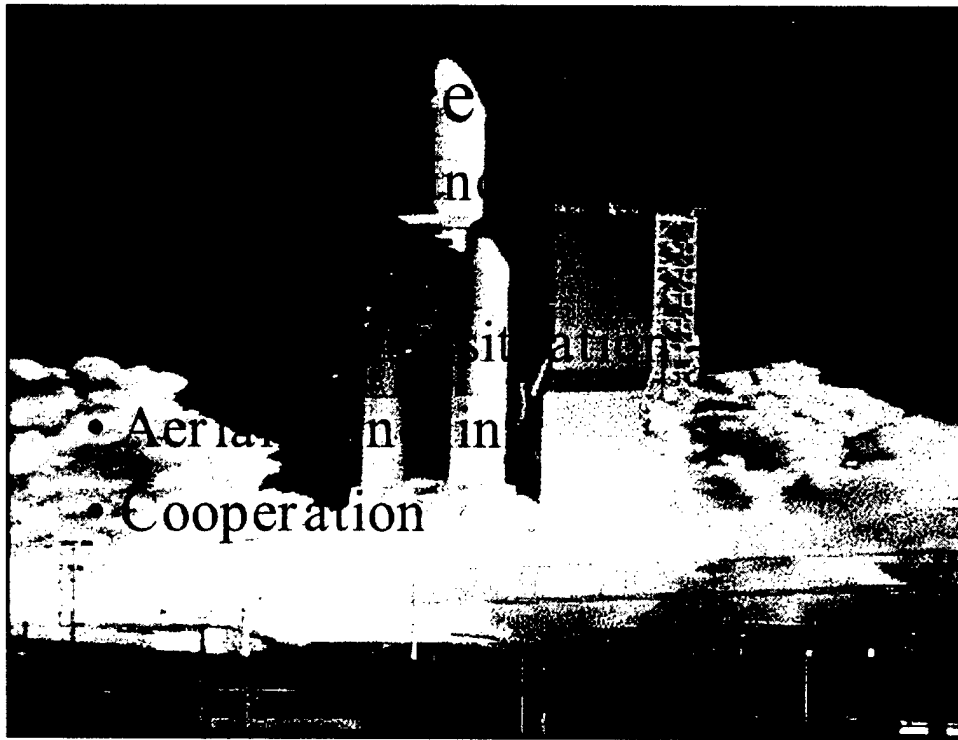
The problems that Israel faces are those of a superpower even though Israel only has the resources of a small power. This means that we will have to bridge the gap between national interests and resources by creating innovative solutions to our space needs. Examples include

1. Conducting joint ventures in space capabilities, such as sharing space assets or developing one satellite with multiple users. However, this option must consider potential concerns of allies.
2. Compromising on the operational need, i.e., perhaps developing and deploying less-capable systems to meet our operational requirements.
3. Buying commercially available space capabilities to meet our operational needs
4. Using bilateral or multilateral agreements to selectively exchange or share capabilities with other nations.

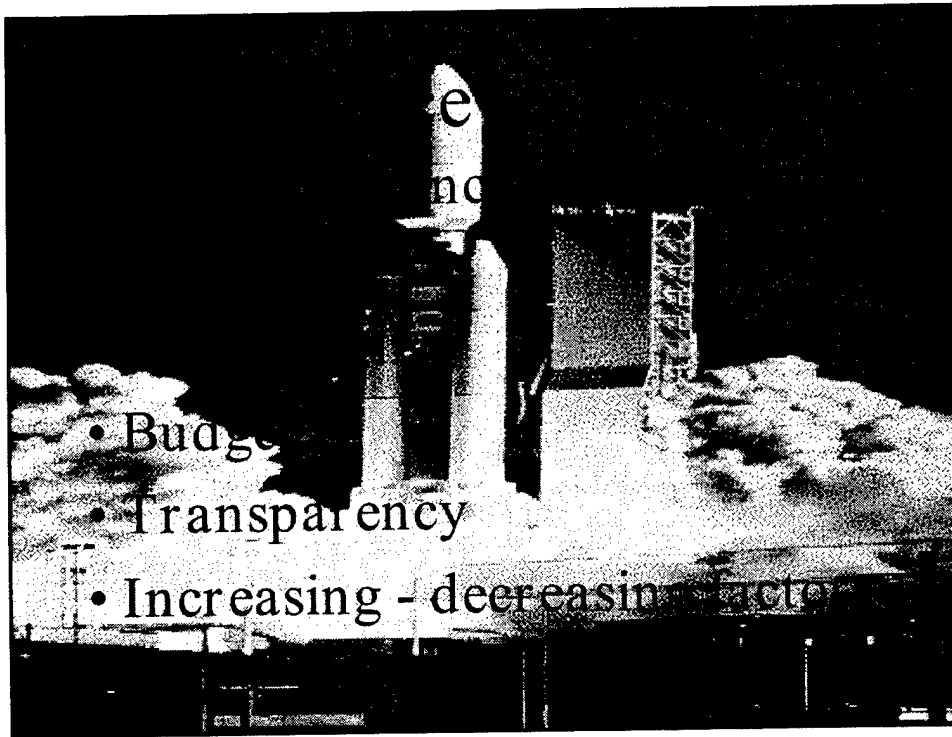
These are but some of the potential choices to address gaining needed capabilities within limited resources.



From a technology standpoint, a number of developments can be considered that enhance the ability of the Israeli military to use space for operational requirements. Mini-satellites can be used to develop specific capabilities at reduced cost, thereby achieving a certain amount of needed operational capability. Synthetic aperture radar (SAR) technology can be used to provide an over-the-horizon aerial picture of the theater. Furthermore, real-time remote intelligence can be exploited for a range of military needs.

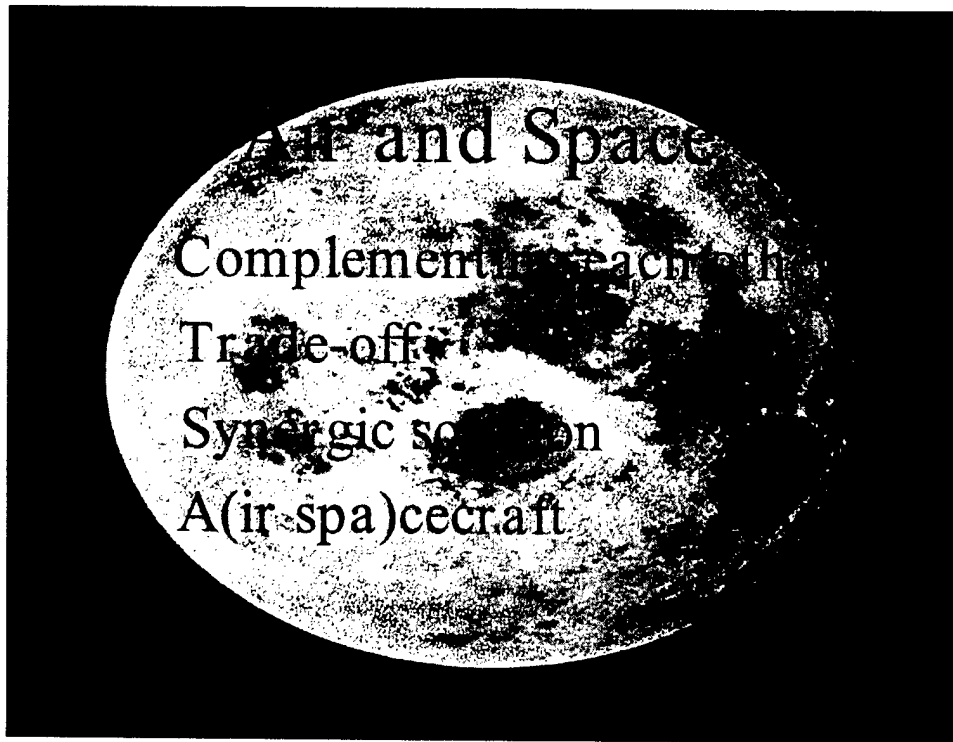


From a space launch perspective, launching payloads into space carries a number of issues and concerns that help shape the kinds of capabilities needed. Reducing the costs of launching payloads into space is a factor, but Israel's special national security situation requires other considerations, such as launch safety and launch trajectories. Real-need launching leads to a dependence on developing mini-satellites, as well as conducting cooperative efforts with others to achieve Israeli national security objectives.



A number of concerns are raised by an expanded presence in space. For example:

1. In manpower, those who use and operate space systems need to be of high quality—that is, highly trained and technologically proficient—to be able to exploit space capabilities efficiently and effectively. We are a nation of limited resources, which also includes our manpower resources, and we do not have the luxury of being able to explore a wide range of space systems and technologies. Rather, we must make hard choices about resources and not spreading or diluting our efforts in areas that do not meet our national security needs.
2. Given our limited resources, we must ask, Who shall assume responsibility for space power—the air force or intelligence agencies?
3. Being organizationally responsible also means having fiscal responsibility—budgeting for space capabilities. This responsibility can both enhance and detract from traditional organizational responsibilities and may influence organizational culture.
4. Again, as was pointed out by many speakers at this conference, space systems are now becoming available to many, not just those nations with high-technology resources. This means that space is becoming transparent, that more information and knowledge about others are increasingly available to not only allies and friends but also to adversaries. Military commanders must take transparency into account in their planning.



In summary, air and space power complement each other operationally through command and control of air missions, targeting, intercepting ballistic missiles, providing weather information over long-distance areas, and intelligence mission escorting. Building up of military forces should be based on exploring and understanding the trade-offs between air and space requirements—each can be operationally integrated to provide greater capabilities than perhaps might be available separately. Thus, a synergistic solution to operational problems can be implemented (for example, an integrated space command and control capability replacing separate air and ground capabilities). Finally, our vision is one of a combined air and spacecraft—multi-role *and* multi-use.



In conclusion, we view air and space as one domain, integrated, and mutually supportive. A space presence enables long-distance operations that previously were not possible for small and medium powers, and enhances the security of those nations in ways not considered earlier. Consequently, small countries such as Israel need what I call great imagination—imagination to consider the possibilities now available to meet national security needs, and the will to pursue those possibilities through an integrated air and space strategy. That strategy includes national development of space capabilities, exploitation of advanced air and space technologies, and the acquisition of commercially available space systems and services. We welcome that opportunity, and look forward to further discussing these topics with others.

Thank you.