

# SPACE, SECURITY AND THE ECONOMY

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## PREFACE

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**Michael D. Intriligator**, Professor of Economics, Political Science, and Policy Studies, UCLA and Senior Fellow, The Milken Institute and The Gorbachev Foundation of North America

Richard Kaufman, together with his co-authors Jeffrey Lewis and Henry Hertzfeld, has produced this highly significant and timely report on “Space, Security and the Economy.” Few people outside a small number of specialists are even aware of the issues this Space Report discusses, but these issues are of great and growing importance to the nation and the planet. This Space Report should play a significant role in opening up these issues to a wider audience, including especially relevant decision makers in nations with assets in space or with plans to launch such assets. These nations include the US, Russia, the EU, individual European nations, China, Japan, India, Israel, Pakistan, North Korea, South Korea, Iran, Australia, and possibly others.

Space presents both opportunities and dangers. The opportunities stem from the actual or potential use of space for communications, weather forecasting, remote sensing, global positioning, navigation, and many other commercial applications as well as science. The dangers stem from the possible weaponization of space, leading to a potential arms race in space and even the accidental or intentional launching of weapons from space, which would be highly destabilizing.

There were decades of quiet on this front following the 1967 Outer Space Treaty, the 1972 ABM Treaty, and an implicit agreement not to conduct anti-satellite tests. Several recent developments, however, have suggested a potential for the militarization of space with its accompanying dangers. These recent developments include the military and space practices and policies of the administration of President George W. Bush since he took office in 2001, as well as the recent shoot-down of their own satellites by both China in January 2007 and the US in February 2008. The potential for developing anti-satellite weapons in several nations could be stimulated by these shoot-downs, which would be destabilizing in these areas.

The practices and policies of the Bush Administration have revived the possibility of the weaponization of space and even a future arms race in space. The US withdrawal under President Bush from the ABM Treaty was a fundamental break from the past and a signal of possible interest in the weaponization of space. There has also been the development of weapons that could be used in space, indicating the dangers that exist. Several policy statements of the Administration have also pointed to this possibility. One was the adoption of the *National Security Strategy of the United States of America* that was issued by the Office of the National Security Advisor to the President, which was then directed by Condoleezza Rice, in September 2002. According to it, there are plans to ensure that no nation could rival US military strength. It proclaimed the doctrine of US preemption, as took place in the invasion of Iraq in March 2003. It stated, “For

centuries, international law recognized that nations need not suffer an attack before they can lawfully take action to defend themselves against forces that present an imminent danger of attack.” It further stated, “The US has long maintained the option of preemptive actions to counter a sufficient threat to our national security.” It should be noted, however, that the US did not preempt in most of the recent wars it has fought, including the two World Wars, Korea, Vietnam, and the Gulf War, while its attempt at preemption in the Bay of Pigs invasion of Cuba was a total failure. Far from there being historical precedents, this new policy represents a fundamental shift from a US policy of reaction to a new policy of war initiation, including possibly the initiation of a war from space.

A second such document is the *National Strategy to Combat Weapons of Mass Destruction (WMD)* that was issued by the White House in December 2002. It noted that WMD, including nuclear, biological, and chemical weapons in the possession of states hostile to the US or terrorists represents one of the greatest security challenges facing the US, and it stated that an effective strategy for countering WMD, including their use and further proliferation, is an integral component of the US national security strategy. It stated that, as in the war on terrorism, the strategy for homeland security, and a new concept of deterrence, this new approach to WMD represents a fundamental change from the past. It affirmed that the highest priority is accorded to protection of the US and its allies from the threat of WMD. It discussed such policies as interdiction of WMD, new methods of deterrence with threats of overwhelming force, and defense mitigation, including the destruction of an adversary’s WMD before their use, on a first-strike attack as in the US preemptive policy. It did not exclude the use of nuclear weapons to destroy facilities that could produce WMD, nor did it exclude a preemptive strike from space.

The third such development and the one that is most relevant to this Space Report is the *US National Space Policy Directive of 2006*, calling for the deployment of space capabilities to sustain the US advantage in space and in effect allow the US to decide which nations should have access to space as well as allow the US to deploy weapons in space. This directive called for permanent US dominance in space, including the right to deny any nation access to space if its actions are seen as hostile.

Taken together these stated policies and actions constitute a new doctrine, the Bush Space Doctrine, ending the space policies of the Cold War period. They represent a discontinuous sea change in the international security system that calls for discussion, debate, and analysis, none of which have occurred. This new doctrine could lead to the weaponization of space, with serious consequences for the US and the world, as discussed in detail in this report.

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## PREFACE (continued)

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The report discusses these issues and the dangers they imply in detail and should play a significant role in opening them to wider discussion and potential changes in policy in the US and worldwide. Changes in policy could stem from multinational negotiations including the new US Administration on this issue among nations with space capabilities. Such negotiations would ideally lead to a new treaty on outer space to prevent the world from backing into a possible weaponization of space, a space arms race, and possible space wars that could involve WMDs with all the accompanying instabilities. Since it would take many years to negotiate such a new space treaty, in the interim there might be an informal agreement on the "rules of the road" in space to prevent weaponization.

An important part of this report is its discussion of highly relevant transparency and economic issues. The steps it proposes in this respect are especially important as they provide a basis for quantifying and keeping track of the rapidly expanding peaceful space applications and how much can be lost if space is weaponized.

## EXECUTIVE SUMMARY

The recent launchings of anti-satellite weapons by China and the US have implications for both the military and commercial uses of space. China's destruction of its own satellite in January 2007 together with the US destruction of its own satellite in February 2008 suggests the beginning of a low-level arms race in space. Anti-satellite tests had previously been suspended during the Cold War for more than two decades.

China bears responsibility for its ill-considered action. The explosion produced thousands of large pieces of debris which will remain in orbit for many years, endangering any satellite that may be struck by one of them. The US shares responsibility for what could become a full-fledged arms race because of the policy of space dominance adopted by the Bush Administration, and other steps that have caused international concern over America's role in space.

The steps taken by the administration include:

- US withdrawal from the ABM treaty, which removed the long-standing prohibition of deploying space-based missiles;
- Adoption of a new *US National Space Policy* in 2006 that states that capabilities be maintained to execute space control and force application missions, and that asserts the right to deny any nation access to space if its actions are "perceived" to be hostile;
- Development by the US (and other space-faring nations) of weapons intended to attack targets in space;
- Development of technologies that have dual capabilities of protecting and attacking satellites.

A favorable outcome could result from this dangerous dynamic if it induces world leaders to come to a new understanding that balances the uses of space among the major interests – military, civilian and commercial – and prevents the weaponization of space. The next American President could begin the process. For that to occur, the US needs to change its aggressive policy of space dominance, and all nations including the US, China and Russia need to be more transparent about their military space programs and policies.

The reason no one can prevail (and that all stand to lose) in an arms race in space concerns the unique nature of space and the vulnerability of objects placed in orbit. Certain defensive measures can be taken with systems in space, but they are easier to attack and disable or destroy than to successfully defend. Satellites are vulnerable to high altitude nuclear detonations, electronic warfare, blinding of sensors with directed energy, and hit-to-kill anti-satellite missiles, among other things. They travel in fixed, repeated orbits that are observable from the ground. This enables a determined adversary to target an object such as a satellite and make multiple efforts, if necessary, to disable or destroy it.

The international community considers that the uses of space systems are peaceful if they are not aggressive – that is, if they are not intended to attack other objects in space or targets on earth. From this reasoning it is said to be acceptable to "militarize" space with systems that can aid terrestrial warfighting. However, it is not acceptable to "weaponize" space with systems that can attack other systems in space or on Earth. Thus, a line has been drawn between systems

deployed in space that can be used to assist military operations on Earth, and systems deployed in space that can be used to attack targets in space or on Earth.

The US is dominant in military space systems but others are gaining. Russia has the second largest number of systems in space and, after a lull following the break-up of the USSR, has substantially increased spending for its military space program in recent years. Following the US lead, Russia, China, Europe, and India are in the process of acquiring space-based capabilities for attacking targets. Some and possibly all of these countries are also developing precision position maneuverability, missile homing sensors, and large deployable optics, all useful technologies for space weapons.

It is unwise and counterproductive to assume that others will not respond independently or collectively to US attempts to establish space dominance, as it challenges their access to and/or use of space.

It is not possible to fully track the amount of resources allocated for the space program. The Department of Defense does not maintain a single, consistent figure that describes space spending. There is no line item for space in the defense budget. Spending on military space systems and technologies is spread across the Department of Defense and the services, reflecting diverse organizational priorities and distinct views of the role that space plays. In addition, a substantial amount of space funds is classified. The limited transparency into space spending makes it difficult to understand precisely how much is spent and which programs are being funded.

The amount of spending in this area is large and growing. We estimate that spending for missile defense and military space programs was about \$30 billion in FY08. Of that amount \$10 billion was for missile defense, \$12 billion was for the major space programs, and about \$8 billion was for classified programs. The overall levels of spending have increased substantially since the year 2000. These figures do not include the NASA FY08 budget of \$17.3 billion for science, aeronautics, exploration and space flight programs.

The Department of Defense has missions directly relevant to weaponizing and conducting a war in space. Among them, the "space control" mission refers to capabilities that would allow the US to impose its will in space and decide who should have access to space. The "force application" mission refers to capabilities of using weapons in space to strike targets anywhere on Earth.

Programs designated for space control and force application have received relatively modest amounts of funding, in part because of the technical difficulties of development and cost overruns. In addition, many members of Congress are concerned that going forward with these programs will antagonize other countries. However, the Bush Administration was determined to look for opportunities as they arose in space, such as the February 2008 event in which it destroyed the failed military satellite that was in an uncontrolled deorbit.

There has been rapid growth over the past few decades in commercial activities in space and in the economic applications of space technology. Continued growth and dynamism, especially in the commercial space sector, is dependent on a space environment that is free of military

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## EXECUTIVE SUMMARY

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threat or conflict. The policy of space dominance threatens that precondition. If there are more anti-satellite tests, or if space-based missile defenses are deployed, it will be difficult to prevent the proliferation of weapons in space, or terrestrial weapons that can target space assets. One possible scenario could be the transformation of space into a battleground.

Once the process of weaponization gets under way, the ability to use the space environment for peaceful purposes is threatened. At some point commercial investors in space will have to consider the security of their investments. It is unlikely that they would place additional resources at risk in a vulnerable area of military conflict.

Space policy and economic policy are not normally connected in Washington. Often overlooked is the fact that space capabilities and applications have greatly expanded and have become integral to our security, our economy and our society. Industry is a major user of satellite services. Consumers benefit from applications ranging from weather forecasts, to cell phones, to search and rescue activities. Satellite applications are now essential to electronic transfers of money, credit card purchases, and banking communications. The value of space equipment and ground-based facilities combined with the revenues from those services only begins to gauge the influence of the space economy.

Space-based remote sensing has become an important tool for land-use mapping, crop inventories, water resources, and forestry and environmental assessments. Remote sensing is also being used to assess the effects of the use of fertilizers and pesticides, to assess coastal and marine resources, for urban planning, mineral prospecting, and meteorology. Space-based communications are used for tele-education and tele-medicine in remote areas, and for disaster management.

There are now multiple uses of the global positioning system. In addition to its extensive use by vehicle operators and for emergencies and rescues, it is used in air and rail transport, inland waterways and fisheries navigation. Earth observation data have applications in human health and epidemiology, energy management, water management, weather forecasting, inventorying landslides, preparing fire danger maps, and measuring droughts.

The lack of reliable economic indicators represents an important gap in our knowledge of the space economy and is a major impediment in the making of rational space policy. This gap restricts the information about space available to interested citizens. As a consequence elected representatives, other policymakers and taxpayers do not fully understand where the public interest lies in space policy, and therefore cannot make informed judgments or know how policy might be modified to serve the public interest. And this makes it possible for others – including those committed to the goal of space dominance – to tailor policy to their preferences, which may severely limit future investment in private commercial space projects.

The US government does not presently report in a quantitative, systematic and comprehensive way the basic facts about commercial space activities, the space based services and benefits, or the space activities of the non-military agen-

cies of the government such as the National Aeronautics and Space Administration and the National Oceanic and Atmospheric Administration. This report contains specific recommendations and the steps needed to fulfill this requirement.

# 1. MILITARY AND COMMERCIAL USES OF SPACE

## Introduction

There is a balance that needs to be maintained between military and commercial uses of outer space. For many years, the nations with large investments in space (principally the US and Russia) avoided placing weapons in space or taking other actions that increase the vulnerability of satellites and other assets. However, there are signs of a growing expansion of the military role in space in line with the assertion by the Bush Administration of the right to exercise space control. Among the more disturbing recent developments are indications of the start of an arms race in space.

There should be little doubt that the world is witnessing a low-level and high-stakes arms race in space that no one can win. In January 2007 China fired a missile that destroyed one of its satellites. In February 2008 the US fired a missile that destroyed one of its satellites. These actions followed a train of US initiatives that raised international concerns about what is seen as Washington's policy of space dominance.

Although all the facts about the decisions to launch the missiles are not yet known, it is widely believed that China attacked its orbiting satellite as a demonstration of its capabilities, and as a response to the US assertion of the preemptive right to control access to space. It is also believed, among other possible explanations, that the US attacked its out-of-control satellite as a demonstration of its capabilities and as a response to China's action. There were sharp responses by many nations, including the US, to what China did, and equally pointed responses by many nations, including China, to what the US did. The two shoot downs are evidence to many observers that after more than 20 years in which anti-satellite (ASAT) tests had been suspended we have entered a new period of space weapons development, anti-satellite testing, and possible deployment of weapons in space.

A favorable outcome could result from this dangerous dynamic if it induces world leaders to work out a new understanding that balances the uses of space among the major interests – military, civilian and commercial, and prevents the weaponization of space. The next American President could begin the process. For that to occur the US needs to change its present policy of space dominance, and all nations including the US, China and Russia need to be more transparent about their space programs and policies. As a first step, the US could initiate discussions with other space-faring nations about global space policies.

## Military Uses of Space

The modern race to use and control space began with the Soviet Union's 1957 launch of Sputnik, the first artificial satellite. The Superpowers used satellites during the Cold War primarily to spy on one another and to verify compliance with arms agreements. Both sides developed anti-satellite weapons and conducted a limited number of tests to destroy satellites. Also, early high-altitude nuclear weapons tests revealed how much damage could be done to satellites from the electromagnetic pulse caused by nuclear explosions. Those tests were then suspended. Research, development and testing continued with directed energy such as lasers and

other means of disabling or destroying satellites.

In the late 1960s Washington and Moscow realized that the continued non-aggressive use of space was to their mutual advantage and they signed the *Outer Space Treaty of 1967*, the terms of which were worked out by the United Nations Committee on the Peaceful Uses of Outer Space. Among the principles embodied in the treaty are that outer space shall be free for exploration and use by all nations, and shall be used for peaceful purposes for the benefit of all nations and for mankind. Nuclear weapons or other weapons of mass destruction were prohibited from being placed in outer space. One hundred twenty-four nations have signed or ratified the agreement.

ASAT testing slowed with the signing of the *Anti-ballistic Missile (ABM) Treaty* in 1972. Aside from prohibiting work on ABM systems, that agreement barred interference with "national technical means" of verifying compliance – in other words, interference with satellites. In the late 1970s the US and the USSR began discussing an ASAT arms agreement while both nations kept working on anti-satellite technology.<sup>1</sup> However, the talks ended without an agreement.

Ronald Reagan's *Strategic Defense Initiative (SDI)*, announced in 1983, signaled a shift from cooperative towards coercive diplomacy in space. President Reagan may not have seen it that way initially. His stated goal was to provide the technology to the Soviets and end the threat of nuclear war for all. The program included multiple systems of ground-based, sea-based, air-based and space-based weapons intended to destroy offensive weapons directed against the US. But they could be adapted for offensive uses such as the destruction of satellites.

In 1988 the Reagan administration adopted a National Space Policy containing a clear statement of the policy of space dominance. According to it, the Defense Department's missions included space control and force application in addition to space support and force enhancement. Eventually, technological problems and budgetary limits, together with the end of the Cold War sense of urgency, placed restraints on the implementation of the policy. During the presidency of George H. W. Bush, SDI was given the more restricted mandate of defending against a limited rather than a massive nuclear attack.<sup>2</sup>

The administration of Bill Clinton tried to sidestep the issues of ASATs and SDI by not actively pushing those programs forward and suspending some projects such as the Kinetic Energy (KE) ASAT. But there was continued funding of research and development for anti-satellite and missile defense weapons. During this period missile defense was at first shifted from a strategic to a theater program. Clinton later advocated a national missile defense program employing land-based missiles and a theater defense.<sup>3</sup>

Throughout the 1990s and in the early years of the 21st century there was significant expansion of the use of space systems to aid military operations on earth. In fact, most space systems were initially developed for this purpose, as was the case with the first generation of US and Soviet spy satellites. Since the end of the Cold War there have been continuing improvements in the use of space systems for

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tactical war-fighting: intelligence, communications, surveillance, reconnaissance, early warning of missile launches, navigation, and the targeting of weapons.

The US made extensive use of these systems in the wars in Serbia and in the Middle East, and makes extensive use of them for military operations generally. This does not contravene the “peaceful purposes” principle of the *Outer Space Treaty* as the international community considers that the uses of space systems are peaceful if they are not aggressive – that is, if they are not intended to attack other objects in space or targets on earth.

From this reasoning it is said that it is acceptable to “militarize” space with systems that can aid military conflict on Earth so long as space is not “weaponized” with systems that can attack other systems in space or on Earth. Thus, a line has been drawn between systems deployed in space that can be used to assist military operations on Earth, and systems deployed in space that can be used to attack targets in space or on Earth.

Because the line has been maintained for so long, it came as a shock to the relative equilibrium of the global space community when the administration of George W. Bush indicated an explicit return to the policy of space dominance of the Reagan era. The new Secretary of Defense, Donald Rumsfeld, had chaired a government commission on space policy just prior to his appointment. The Rumsfeld commission suggested in its report that military conflict in space was inevitable and that in order to protect its assets in space the US needed to have weapons systems that operate in space.<sup>4</sup>

The Bush administration adopted the core recommendations of the Rumsfeld commission and took several steps towards implementation of the updated policy of space dominance. First was US withdrawal from the anti-ballistic missile (ABM) treaty. This action removed the long-standing prohibition of space-based missiles. Second was the promulgation of a new US national space policy directive in 2006. The tone of the space dominance aspects of the policy directive was especially disturbing as it came on the heels of the actions cited above, and in the context of other problematic defense and foreign policy initiatives such as assertion of the right to initiate preemptive war in Iraq. Although the policy directive does not expressly call for placing weapons in space, it does contain language strongly suggesting such action. Third, was the decision to continue developing weapons intended to attack space targets.

In addition, various technologies were developed to protect space systems against attacks. However, some of these technologies can also be used offensively. For example, microsatellites can be used for inspection of satellites or to attack them. The significance of this is that other nations would not necessarily know, once such a system is deployed, whether it is for defense or for offense and therefore they could view such deployments as threatening.

The 2006 space policy directive and its interpretation by administration officials have added to the concerns about US intentions. Included in the directive is the statement that the Secretary of Defense and the Director of National Intelligence shall “develop and deploy space capabilities that sustain US

advantage....” Another provision states that the Secretary of Defense shall “maintain the capabilities to execute the space support, force enhancement, space control and force application missions.” The “space control” mission refers to capabilities that would allow the US to impose its will in space and decide who should have access to space. The “force application” mission refers to capabilities to use weapons in space to strike targets anywhere on Earth.

According to the directive, among the fundamental goals is to ensure that space capabilities are available to further US security and foreign policy objectives, and to “enable unhindered US operations in and through space to defend our interests there.” Another section of the directive warns others against impeding US rights “or developing capabilities intended to do so....” In addition, the directive states that the US will oppose the development of legal regimes or other restrictions that seek to prohibit or limit US access to or use of space, or the rights of the US to conduct research, development, testing and operations or other activities in space.<sup>5</sup>

It is fair to conclude from these statements that the US intends to unilaterally control what others can and cannot do in space, and is reluctant to discuss the need to develop new legal measures or “rules of the road” for space. As one foreign expert and close observer of the US recently stated, “the US policy of ‘negation,’ which advocates active denial of the use of space to any other nation if its actions are perceived as hostile to US national interests threatens to demolish the basic legal fabric of space security itself.”<sup>6</sup> Others in the US and in the international community have noted the decline in trust in rule-based approaches to space security.<sup>7</sup>

The decline in trust was exacerbated by the anti-satellite exercises mentioned at the beginning of this section. China’s ASAT exercise, which took place just a few months after the US National Space Policy was made public, has not been adequately explained. According to Beijing, it was a scientific experiment not directed at any country. It is also possible that the Chinese program is driven by a desire to match US hit-to-kill technology. Regardless of China’s intent, the effect is to demonstrate that it too has the ability to destroy satellites.

It is known that the satellite that China destroyed was failing and would have been destroyed of its own accord when it entered earth’s atmosphere. Its destruction by a missile is a matter of great concern because of what it suggests about space policy and because of the problem of space debris. The impact created thousands of large pieces of debris that will remain in orbit in the most densely utilized portion of space for decades. Given the speed that space debris travels, any satellite in its path is endangered.<sup>8</sup> It is estimated that a piece of debris in low earth orbit would strike a satellite with the force of a one-ton object that fell off a five-story building.<sup>9</sup>

At some point the buildup of debris from such events could threaten the safety of space operations. In 2007 there were about 13,000 pieces of debris in orbit large enough to damage or destroy spacecraft. This includes objects of various sizes. If other nations conduct their own ASAT tests causing the weapons or the satellites to break up, the debris problem will become much worse. This issue is contributing to the increasingly serious issue of space traffic management because of

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the growing number of space launches by government and non-government organizations and the positioning of satellite constellations, among other factors.<sup>10</sup>

The 2008 US anti-satellite exercise is even more troublesome despite the fact that the destruction occurred at an altitude too low to cause debris to remain in orbit. As the world's only superpower and leader in space technology and space operations, the US might be expected to be an example in a positive sense for others to follow by pursuing a non-threatening and cooperative space policy. It is now possible and perhaps likely that others will follow the US lead in developing or acquiring their own anti-satellite capability.

Certain defensive measures can be taken with systems in space but it is easier to attack and disable or destroy than to successfully defend them. Satellites are vulnerable to high altitude nuclear detonations, electronic warfare, blinding of sensors, and hit-to-kill anti-satellite weapons, among other things. They travel in fixed, repeated orbits that are observable from the ground. This enables a determined adversary to target a satellite and make multiple efforts, if necessary, to disable or destroy it.

The US is dominant in military space systems but others are making gains. Russia has the second largest number of systems in space and, after a lull following the break-up of the USSR, has substantially increased spending for its military space program in recent years. Canada, the European states, China, India, Japan, South Korea, Iran and Australia have also launched military satellites or satellites with dual-use military and civilian capabilities. All are investing substantial resources in their space programs. Many of them already possess or are developing dual-use technologies that can support space-based military technologies. An example is precision altitude control, which is applicable to space-based weapons and has been developed by Russia, China, the European Space Agency, France, and Japan. The same technology is under development in India and Israel. Other technologies with military applications under development in foreign countries include global positioning, missile warning and missile tracking, microsattellites, and laser systems. As of this writing, there is a consensus among the political parties in Japan to enact legislation to authorize, for the first time, the non-aggressive military use of space.<sup>11</sup> Following the US lead, Russia, China, Europe, and India are in the process of acquiring space-based capabilities for attacking targets on Earth. Some or all of these countries are also developing precision position maneuverability, missile homing sensors, and large deployable optics, all useful technologies for space weapons.<sup>12</sup> It is unwise and counterproductive to assume that while the US attempts to establish space dominance others will not respond independently or collectively to challenges to their access to space.

## Commercial Uses of Space

The 2006 national space policy directive acknowledges the importance of the commercial space sector. The directive states it is a principle that "The United States is committed to encouraging and facilitating a growing and entrepreneurial US commercial space sector." In the words of the directive, one

of the fundamental goals of space policy is to "enable a dynamic, globally competitive domestic commercial space sector in order to promote innovation, strengthen US leadership, and protect national homeland, and economic security." It is also stated as a principle that "The US is committed to encouraging and facilitating a growing and entrepreneurial US commercial space sector." The question is whether commercial investment will continue to grow in an environment defined by the present military space policy.

There can be no dispute about the trends for space commerce. An indication of the growth and dynamism of the space sector is the increasing number of activities with commercial applications and the increasing number of bilateral and multilateral cooperative arrangements for the exploration of outer space, other scientific research, technology exchange, and commercial projects. There are agreements between Russia and the European Space agency to collaborate in the areas of new technology and communications. A number of countries are working together to measure climate change, including China, the United Kingdom, Turkey, Spain and others. China announced that as of 2006 it had signed 16 agreements with 13 different countries, space agencies and international groups regarding civil space projects. The US is involved in many collaborative civil space projects.

However, continued growth and dynamism, especially in the commercial space sector is dependent on a space environment that is free of conflict. The policy of space dominance threatens that precondition. If there are more anti-satellite tests, or if space-based missile defenses are deployed, it will be difficult to prevent the proliferation of weapons in space. The next step could be the transformation of space from an area of peaceful use into an area of conflict. Once the process of weaponization gets under way, the ability to use the space environment for peaceful purposes will be put at risk, as a number of experts have warned.<sup>13</sup> At some point commercial investors in space will have to consider the security of their investments. It is hard to believe they would place additional resources at risk in a vulnerable area of military conflict.

This raises questions about the present usefulness and economic value of the space environment. What is the size of the space economy and what is its significance to the larger economy? What could be lost with regard to the economy and society at large if there is military conflict in space and critical satellites are destroyed. What if the problem of space debris becomes so serious that peaceful uses of space are seriously impaired or made impossible?

No one can answer questions with precision about the size of the space economy because the relevant facts are not kept in a way that is consistent, comprehensive and up-to-date. We know that there has been remarkable growth in commercial activities in space and that the effects of the space development on the economy have expanded over the past several decades. This is true for the US and many other countries. We are not able to measure the growth and its effects because adequate statistical measures, known as economic indicators, do not yet exist for space. Among the many reasons for this dilemma is the fact that private companies

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engaged in different kinds of activities may report the volume of business in the space sector, but they are not required to break out their space and non-space activities.

The lack of reliable economic indicators represents an important gap in our knowledge of the space economy and a major impediment in the making of rational space policy. Imagine how inappropriate defense policy would be if policymakers' knowledge of the economy here on earth was as imprecise as it is about space. In addition, the lack of economic indicators restricts the information about space available to interested citizens. As a consequence elected representatives, other policymakers and taxpayers do not fully understand where the public interests lie in space policy, and therefore cannot make informed judgments or know how policy might be modified to serve the public interest. This makes it possible for others – including those committed to the goal of space dominance – to tailor policy to their preferences without regard to the needs of commercial space interests, those who have come to depend on the beneficial uses of space, or the general public.

These matters are coming under discussion throughout the industrialized world. A recent report of the Organization for Economic Co-operation and Development (OECD) defines the space economy as:

“All public and private actors involved in developing and providing space-enabled products and services. It comprises a long value-added chain, starting with research and development actors and manufacturing of space hardware (e.g., launch vehicles, satellites, ground stations) and ending with providers of space-enabled products (e.g., navigation equipment, satellite phones) and services (e.g., satellite-based meteorological services or direct-to-home video services) to final users.”

But the report also concludes:

“Paradoxically, despite the critical role that space industry plays in modern society, the space sector is one of the least developed in terms of robust, internationally comparable statistics and data.”<sup>14</sup>

The report goes on to discuss the roles played in space by the space-faring nations, and what is known and unknown about their activities.

Summary information is provided about the space economy, although it is acknowledged that there is a lack of internationally comparable data about the space economy. Worldwide institutional budgets are estimated at \$45 billion in 2005 for OECD countries, and new commercial revenues from space-derived products and services at \$110–120 billion in 2006. Manufacturing revenues for satellites, launchers and the like are estimated at \$12 billion in 2006, and space related services such as satellite television and global positioning systems (GPS) in excess of \$100 billion. Employment in space industry manufacturing is estimated to be 120,000 people in 2006.<sup>15</sup>

The OECD report identifies what it considers to be the major obstacles to improved space statistics. The obstacles include the need to disaggregate space and aircraft data in the aerospace sector, to penetrate the secrecy in dual-use

military and civilian space applications, and to obtain improved quantitative data for space satellite services such as telecommunications and navigation. Further, the report states that greater international cooperation is required to improve the comparability of data. What emerges from this and other surveys is that there has been rapid growth in the commercial space sector as a result of increased investment and growth in consumer demand and that this trend is likely to continue.<sup>16</sup>

Similar findings are shown in two recent non-governmental reports. According to a report by the Futron Corporation, which was prepared for the Satellite Industries Association, there has been world-wide growth in satellite industry revenues (especially in manufacturing and services) for the period 2001–2006. However, the figures in the report combine military and commercial revenue, and the data are derived from surveys e-mailed to companies, with a response rate of 46 percent.<sup>17</sup> Another report, by the Space Foundation, estimates that international space revenue from government and private sources totaled \$251 billion in 2007, reflecting growth of 11 percent over 2006. Data for the report was gleaned from government reports, information from trade associations, and business and industry publications.<sup>18</sup>

Most interesting are the results of a study by the US Federal Aviation Administration attempting to quantify the effects of the commercial space launch industry on the national economy. In its report, the FAA concludes that in 2006 commercial space transportation generated \$139.3 billion in economic activity and over 729,000 jobs throughout the US economy. These figures are up sharply over 1999. Growth in satellite services, led by direct-to-home television, is identified as the major cause of the increasing trend.<sup>19</sup>

There are several categories of benefits from space activities generally not captured in industry or government reports. Those include applications of space-based remote sensing to land-use mapping, crop inventories, water resources, and forestry and environmental assessments. Remote sensing is also being used to assess the effects of the use of fertilizers and pesticides, to assess coastal and marine resources, for urban planning, mineral prospecting, and meteorology. Space-based communications are used for tele-education and tele-medicine in remote areas, and for disaster management and search and rescue operations.

There are now multiple uses of the global positioning system. In addition to its extensive use by vehicle operators and for emergencies and rescues, it is used in air and rail transport, inland waterways and fisheries navigation. Earth observation data have applications in human health and epidemiology, energy management, water management, weather forecasting, inventorying landslides, preparing fire danger maps, and measuring droughts.<sup>20</sup>

Again, the US government does not presently report in a quantitative, systematic and comprehensive way on the basic facts about commercial space activities, the space-based services and benefits mentioned above. The same can be said about the space activities of the non-military agencies of the government such as the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA). Figures for space

# 1. MILITARY AND COMMERCIAL USES OF SPACE

activities are not delineated in the North American Industrial Classification System and are not considered to be a distinct economic activity by government data publications.

There is nothing for the space sector comparable to the Economic Indicators which is a monthly publication prepared for the Joint Economic Committee of the US Congress by the Council of Economic Advisors to the President. That report is based on submissions by the statistical offices of various agencies of the government and is for sale through the Government Printing Office. It can be used to examine specific activities at a glance or to track the trends for production, income, and employment for the economy as a whole. The space sector, as a separate activity, is notably absent from the Economic Indicators.

The key issues raised so far, and others, are analyzed in the remainder of this report. Section 2 assesses military space spending trends and how likely it is that weapons will actually be deployed in space. Section 3 contains a discussion of US and global commercial developments and an approach for developing a time series of economic indicators for the space sector.

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## 2. MILITARY BUDGET TRENDS AND KEY TECHNOLOGIES

### Introduction

On Monday, February 3, 2003, Dov Zakheim, then-Comptroller for United States Department of Defense, gave reporters a routine briefing on the Pentagon's annual budget request.<sup>1</sup>

Zakheim would say very little about space that day. On Saturday, the space shuttle Columbia had broken apart attempting to reenter the earth's atmosphere, killing all the astronauts aboard. "Once again, this country has taken it on the chin," Zakheim began his briefing informally, "and once again we'll get up off the floor." He then moved briskly through the slides, in part because he had given the same briefing, on background, to the same press pool, the Friday before.<sup>2</sup>

Although the budget request for fiscal year 2004 was the third defense budget during the Bush administration, it was, according to Zakheim, "the first real budget that we fully controlled." One of the signs of this, he added, was that reporters would "see as I go through this, a lot of money for transformation."

the overwhelming majority of military space funding has gone to build, launch and operate satellites that carry communications, aid navigation and take images of the earth – a mission referred to as "force enhancement."

The confusingly named "enhance space operations" referred to a different suite of priorities entirely. According to a budget document left on the Pentagon website, "enhance space operations" was a category of programs to perform space control and force projection missions.<sup>5</sup>

Where "force enhancement" is a military term enshrined in the Joint Doctrine on Space Operations, "enhance space operations" was a goal established by the Office of Force Transformation established by Secretary Rumsfeld as his signature effort as Secretary of Defense. The role of space was central to Rumsfeld's vision of transforming the United States military. He referred to space as "the ultimate high ground" and the Congressionally-established Commission on US National Security Space Management and Organization,

### FUNDING TRANSFORMATION GOALS

Budget Authority \$ in Billions

FY04

FY04-FY09

	FY04	FY04-FY09
Protect bases of operation	7.9	55
Project and sustain forces	8.0	96
Deny sanctuary to adversaries	5.2	49
Leverage information technology	2.7	28
Conduct effective information operations	0.2	6
Enhance space operations	0.3	5
<b>TOTAL</b>	<b>24.3</b>	<b>239</b>

When Zakheim reached the slide on transformation (above), he clicked through the bullet points before ending with the administration's plans for space:

"[Enhance] space operations of course is a lot of the space control systems and other elements, many of which are classified. These two you can see – this is the thin edge of the wedge. By the time you get out to the aggregate of the six-year plan you're talking about considerable dollars there, but these are really cutting edge programs.

"Next slide, please."

Although Zakheim didn't say so, he was announcing a very significant set of programs that, if carried through, would result in dramatic changes in how the United States operated in space.

### Space Priorities under Rumsfeld<sup>3</sup>

The FY04 request for \$5 billion dollars over six years to "enhance space operations" was a significant increase over what those programs received in FY03, which itself contained a 145 percent increase for those programs over its predecessor, drafted by the Clinton administration.<sup>4</sup>

The programs funded to "enhance space operations" were really quite different from other space programs. Historically,

which Rumsfeld had chaired before being nominated to serve as Secretary of Defense, called for the ability to "project power in, through, and from space."<sup>6</sup> Advocacy of new military missions in space, including space-based missile defenses, raised significant international concerns about the "weaponization" of space, although the US military generally avoids this term.

Today, Rumsfeld is gone, a similar fate awaits much of the Office of Force Transformation, and the "Enhance Space Operations" budgetary device is obsolete.

When the new Secretary of Defense, Robert Gates, presented the FY08 budget, in February 2007, he spoke of a very different set of priorities in space. As his prepared statement noted:

"The recent test of an anti-satellite weapon by China underscored the need to continue to develop capabilities in space. The policy of the US Government in this area remains consistent with the longstanding principles that were established during the Eisenhower administration, such as the right of free passage and the use of space for peaceful purposes. Space programs are essential to the US military's communications, surveillance, and reconnaissance capabilities. The base budget requests about

## 2. MILITARY BUDGET TRENDS AND KEY TECHNOLOGIES

\$6 billion to continue the development and fielding of systems that will maintain US supremacy while ensuring unfettered, reliable, and secure access to space.”<sup>7</sup>

solidate funding and political capital behind a few programs. By the time Rumsfeld left office, an ardent supporter of his vision for space Senator Wayne Allard (R-CO) could say “I strongly believe the continued mismanagement of our space

### SPACE-BASED AND MISSILE DEFENSE CAPABILITIES

Dollars in Billions

Space Programs		FY07	FY08	FY07-08	Qty
EELV	Evolved Expendable Launch Vehicle	0.9	1.2	+0.3	5
SBIRS-H	Space Based Infrared System	0.7	1.1	0.4	–
TSAT	Transformational Satellite	0.7		0.3	–
GPS	Global Positioning System	0.6		0.3	–
MUOS	Mobile User Objective System	0.7		0.1	–
AEHF	Advanced EHF Satellite	0.6		–	–
WGS	Wideband Gapfiller System	0.4		-0.1	1
MLV	Medium Launch Vehicles	0.2		-0.1	
	<b>TOTAL</b>	<b>4.8</b>	<b>6.0</b>	<b>+1.2</b>	

Missile Defense		FY07	FY08	FY07-08	Qty
MD	Missile Defense	9.4	8.9	-0.5	70
PM CAP	Patriot Meads CAP	0.9	0.9	–	108
JT AMDO	Joint Theater Air and Missile Defense Office	0.1	0.1	-0.5	
	<b>TOTAL</b>	<b>10.4</b>	<b>9.9</b>	<b>-0.5</b>	

Note: Dollar figures include procurement and RDT&E.

Not a single one of the eight programs totaling \$6 billion funding was included in Rumsfeld’s transformational construct, “enhance space operations.” Instead, all of the programs in the FY08 budget are traditional missions of launching and operating satellites that provide communications, navigation and intelligence services. Although many of these programs began under Rumsfeld, and some controversial programs continue, the difference in emphasis is a striking example of the decline of Secretary Rumsfeld’s vision of projecting power in, through, and from space.

In the FY04 and FY05 budgets, the Bush administration made a serious attempt at expanding the military use of space into new and controversial missions – what critics might term the “weaponization” of space. By 2008, however, this effort has foundered, based largely on budgetary constraints, technical barriers and a skeptical Congress. Many of the more ambitious goals for new military missions in space were never realistic from either a technical or a budgetary perspective. Moreover, the Bush administration – despite significant rhetorical support – failed to secure support within Congress for many of the most controversial programs.

Once the transformational space programs supported by the Bush administration to conduct traditional missions – such as the Transformational Satellite Communications System and Space Radar – experienced dramatic cost growth and hit technical barriers, the Bush administration was forced to con-

acquisition programs is a far greater threat to our space dominance than any external danger.”<sup>8</sup>

The remainder of this section examines recent, current, and future trends in military space spending, with an emphasis on the more controversial programs, in light of the collapse of the “transformation” experiment. The vast majority of funding has, and will likely continue to be, dedicated to traditional military missions such as communications, navigation and imaging, as well as space launch. Cost growth within those programs is likely to consume ever-greater resources, placing controversial programs for anti-satellite missions or space-based missile defense under tighter budgetary constraints.

The structural realities of cost-growth in major space programs, technical limitations of the most controversial programs and the lack of a strong bureaucratic advocate for what might be called “new military missions in space” suggest that most controversial programs could remain in the basic research and development phase for the foreseeable future. A constituency still exists for such new missions, as suggested by the National Space Policy directive of 2006, discussed in Section 1 above, which opposes the development of arms control and other legal regimes in outer space.

China’s test of a hit-to-kill system (which China may someday deploy as an operational anti-satellite system) prompted Congress to increase space control spending. However, most

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of the money was appropriated for programs to improve US ability to monitor the space environment, rather than for offensive capabilities that would project power. At the same time, the use of a hit-to-kill system by the US in 2008 raises questions about the future of US space policy.

The public relations guidance for Operation Burnt Frost (the military name for the mission to destroy USA 193, an out-of-control reconnaissance satellite with a tank of hydrazine that may have posed a small risk to human health upon re-entry) demonstrates the political constraints facing proponents of weaponization. The public emphasis on the health risk and effort to downplay the evident anti-satellite implications suggests that the White House understood Congress would not approve funding for an overt ASAT test.

### Problems Tracking Military Space Spending

Tracking military space spending is not a straightforward or obvious endeavor. Space spending is distributed across a bewildering array of intelligence and defense agencies and offices. As the introduction suggests, budgetary constructs may change from year to year as priorities change. The limited visibility into space spending has become a major concern in recent years, with the Department of Defense attempting to make spending more coherent by designating the Air Force as “executive agent” for space and creating a budgetary device called a “virtual” major force program.

These efforts, however, have not been entirely successful. In recent years, the National Security Space Office has refused to release space spending numbers, perhaps because such numbers may be inaccurate or misleading. This section looks at the 2004 and 2005 budgets to provide a baseline against which to understand the FY08 budget.

The Department of Defense does not maintain a single, coherent figure that describes space spending. Spending on military space systems and technologies is spread across the Department of Defense and the services, reflecting diverse organizational priorities and distinct views of the role that space plays.

One example of this incoherence was reflected in US policy toward modernizing the fleet of Global Positioning Satellites (NAVSTAR or GPS) that provide precise time and location data for US military forces. Although Air Force Space Command officials took to describing Operation Iraqi Freedom as “the first war in space” based on Iraqi efforts to jam GPS signals, Air Force officials reduced funding in the same budget for jam-resistant GPS satellites.<sup>9</sup>

### Primary Mission Areas

There is no line item in the budget for “space weapons.” As was mentioned in the introduction, the Department of Defense divides space programs into four areas. According to DOD:

“Within the domain of space operations, there are four primary mission areas: **space control, force enhancement, space support, and force application.**

“**Space control** operations provide freedom of action

in space for friendly forces while, when directed, denying it to an adversary, and include the broad aspect of protection of US and US allied space systems and negation of enemy adversary space systems. Space control operations encompass all elements of the space defense mission and include offensive and defensive operations by friendly forces to gain and maintain space superiority and situational awareness if events impact space operations.

“**Space force enhancement** operations multiply joint force effectiveness by enhancing battlespace awareness and providing needed warfighter support. There are five force enhancement functions: **intelligence, surveillance and reconnaissance; integrated tactical warning and attack assessment; environmental monitoring; communications; and position, velocity, time, and navigation.**

“**Space support** operations consist of operations that launch, deploy, augment, maintain, sustain, replenish, deorbit, and recover space forces, including the command and control network configuration for space operations. Support operations consist of space lift, satellite operations, and deorbiting and recovering space vehicles, if required.

“**Space force application** operations consist of attacks against terrestrial-based targets carried out by military weapons systems operating in or through space. **Currently, there are no space force application assets operating in space.**”<sup>10</sup> (Emphasis in the original.)

The most controversial programs – such as anti-satellite weapons, space-based strike and missile defense systems – would be included in two mission areas: space control and space force projection. Although there were no space-force assets in space, the FY05 budget contained funds for space-based strike and space-based missile defense that might eventually be based in orbit.

In recent years, the Department of Defense has made efforts to increase the visibility and coherence of space spending. In 2003, the Secretary of Defense tasked the National Security Space Office with tracking space spending in the form of the “virtual Major Force Program.”

A *Major Force Program (MFP)* is a budget tool that tracks resources in different functional areas. Currently, the Department of Defense maintains 11 MFPs, covering such areas as strategic programs, general-purpose forces, National Guard and Reserve, and airlift. Funds within MFPs are “decentralized” – i.e., they are managed by different elements of the Defense Department or Armed Services – with the exception of MFP 11 for special operations forces.<sup>11</sup>

Although the Space Commission recommended creating a decentralized MFP for space, as Secretary of Defense, Rumsfeld instead created a “virtual” MFP that provided some additional visibility for space spending and provided for a space-unique acquisition policy.<sup>12</sup> This figure has been “fine tuned” from year to year, however, resulting in uneven

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comparisons. It also omits basic research funds, as well as programs managed by the Missile Defense Agency or Defense Advanced Research Projects Agency (DARPA).<sup>13</sup> The Congressional Research Service warns that such figures “must be used cautiously.”<sup>14</sup>

In many ways, the “virtual” Major Force Program appears to be widely regarded as a failure. The Department of Defense has refused to release vMFP figures from 2006 onward. Congress, in the FY08 appropriations bill, has now directed the Secretary of Defense to create a genuine Major Force Program for space.<sup>15</sup>

### The Fiscal Years 2004 and 2005 Budgets

The FY04 and FY05 budgets are best viewed as a pair that reflects the same priorities, i.e., the Defense Department’s move to a biennial budgeting cycle. Both budgets reflect the same rationale and priorities.<sup>16</sup>

The FY04 and FY05 defense budgets are a sensible starting point for any analysis of recent trends in military space spending. Moreover, the FY04 Budget, sent to Congress in early 2003, was “the first to fully reflect the new defense strategies and policies” of the Bush administration.<sup>17</sup>

The Department of Defense last provided estimates to the Congressional Research Service stating a total, classified and unclassified, space vMFP of \$19.8 billion for FY05, down from a request of about \$22.5 billion.<sup>18</sup> The amount of detail

regarding the 2005 budget is also greater in part because defense officials gave a detailed description of their request to Amy Butler at *Defense Daily*, and Robie Samanta-Roy at the Congressional Budget Office published *The Long-Term Implications of Current Plans for Investment in Major Unclassified Military Space Programs* in September 2005.<sup>19</sup>

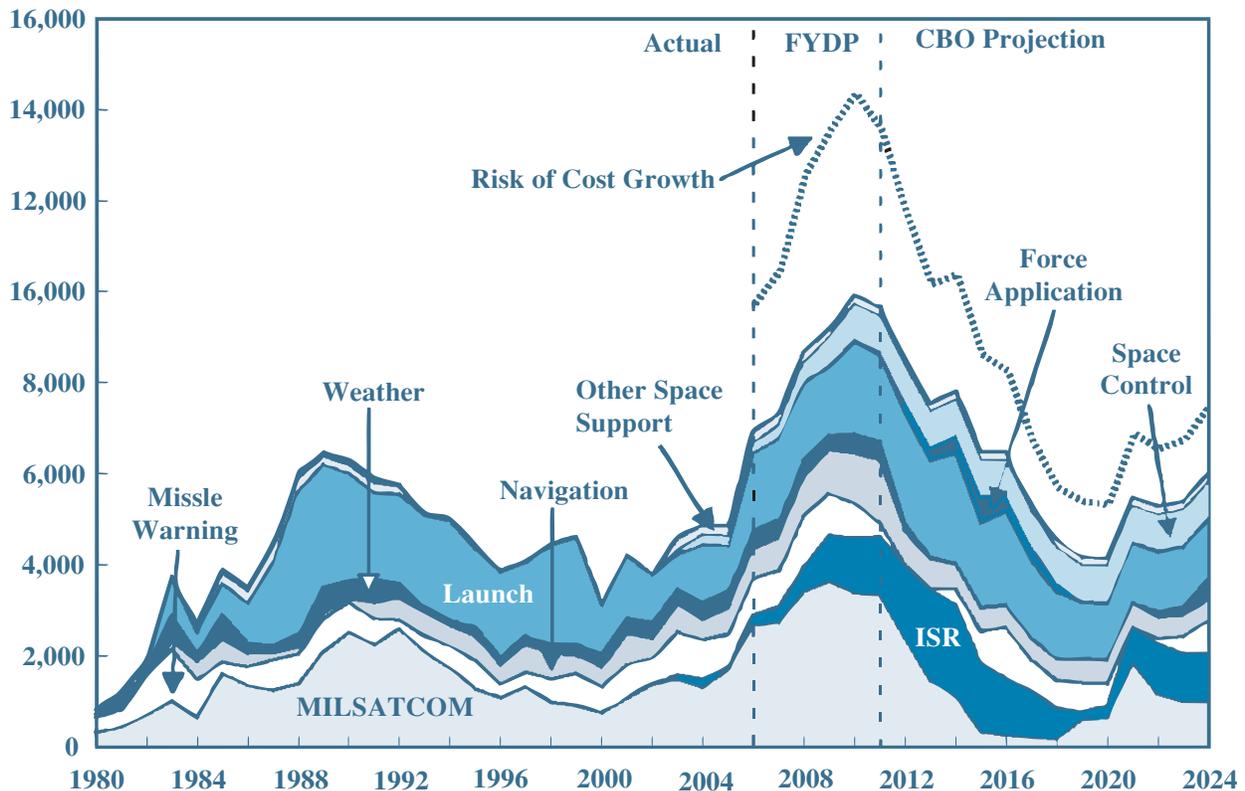
Of the approximately \$20 billion in FY05 space spending, about 40 percent or \$8 billion is classified. Of \$12 billion in unclassified spending, the Defense Department spent about \$7 billion on “investment” – research, development and procurement of new technologies and military systems. (The other funds pay for personnel and operational expenses.)

Essentially, all of the \$7 billion in investment goes to a handful of programs focused on traditional military uses of outer space such as communications, navigation, imaging and launch vehicles.

This is money for the same missions that Secretary Gates highlighted in his FY08 budget speech. These programs are also the subject of the CBO report, *Long Term Implications of Current Plans for Investment in Major Unclassified Military Space Programs*. An examination of the major unclassified programs reveals several trends:

- The vast majority of funding is for traditional military space missions, especially communications and launch.
- Major unclassified programs are anticipated to experience major cost growth that could crowd out other priorities,

## MAJOR UNCLASSIFIED MILITARY SPACE PROGRAMS (2006 \$millions)



Reproduced from CBO, *Long Term Implications of Current Plans for Investment in Major Unclassified Military Space Programs*, page iii

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including basic research and development. For example, CBO found that while the 2006 request for spending was less than three percent greater than for 2005, the investment portion for major unclassified programs was 43 percent higher.<sup>20</sup>

- Major programs have experienced, and are at risk of, substantial budget overruns. “Virtually every major space acquisition program,” the House Armed Services Committee (HASC) has observed, “has experienced or sits dangerously close to a Nunn-McCurdy breach” – a dramatic cost-growth requiring extraordinary intervention to save the program from cancellation.<sup>21</sup>

CBO also noted the significant expenditures for so-called “transformational” systems in traditional areas – specifically the Transformational Satellite Communications System and Space Radar.

The FY04 and FY05 budgets also reflected, albeit at much lower levels of support, significant emphasis on space control and space force application, including prompt global strike and space-based missile defense, under the transformational goal to “enhance space operations.”

Although the initial funding for many of these programs was modest at \$300 million, the FY04 and 2005 budgets initiated many of the programs that formed the centerpiece of the “enhancing space operations” transformational area and included outyear placeholders for approximately \$5 billion in spending through FY09.<sup>22</sup>

Some of the most important programs were:

- **Space Control Technology** In addition to funding for space tracking and general technology development, the FY04 and FY05 budgets included a program to complete development of three counterspace systems: the Counter Satellite Communications System, a mobile communications satellite jammer; the Counter Satellite Reconnaissance System, a ground-based system to temporarily impair enemy reconnaissance satellites; and the Rapid Attack Identification and Reporting System, a defensive system to detect and characterize attacks on friendly satellites.

- **Common Aerospace Vehicle** The common aerospace vehicle is a maneuverable reentry vehicle that could carry multiple payloads and would initially be delivered by a ballistic missile, although might later be mated to a hypersonic vehicle or perhaps based in space. In December 2002 the Department of Defense directed the Air Force and DARPA to establish a joint program office to accelerate the Air Force’s Common Aero Vehicle effort to meet the requirement in the Prompt Global Strike Mission Needs Statement “to globally strike and precisely apply force against specific targets swiftly to achieve desired weapons effects.” In 2003, DARPA would release a solicitation for a hypersonic weapons system called Project FALCON, short for “Force Application and Launch from CONUS,” that would be capable of delivering the CAV or other payload at global ranges in a matter of hours.

- **Space-based Missile Defense** *National Security Presidential Directive 23*, which set the national policy on ballistic missile defense, directed the Secretary of Defense “to examine the full range of available technologies and basing modes for missile defenses” including the “development and testing of space-based defenses.” The Defense Department

reorganized existing space-based interceptor work around two initiatives: the Near Field Infrared Experiment (NFIRE), a satellite that was to fire a “kill vehicle” at a boosting ballistic missile to collect plume data, and Space-based Test Bed. At the time, these two efforts were seen as mutually supporting – the NFIRE lacked many components that would be necessary for an interceptor, including an axial stage to allow the KV to maneuver; the Space Test Bed was designed to fund development of many of these components including liquid and solid axial stages, eventually resulting in a small constellation of 3-5 satellites.

The United States does maintain one unclassified program to develop a dedicated destructive anti-satellite – the Kinetic Energy Anti-satellite or KE ASAT – although it is a footnote to US counterspace capabilities. Citing concerns about debris from a kinetic energy interceptor that would destroy a satellite by slamming into it, the Clinton administration canceled the KE ASAT program in 1993. The program has enjoyed little support from the Armed Services, although members of Congress have periodically provided funds to keep the program on life support. Congress added \$14 million in FY05 under MDA Ballistic Missile Defense Products to support the program. Uneven and episodic support has left the program “in a state of disarray,” although program officers believe they could conduct an on-orbit demonstration for about \$60 million (an amount that would cover two flight-test vehicles and one spare).<sup>23</sup>

The FY04 and, especially, the FY05 budget process, revealed a second major trend – Congressional skepticism over these programs. In 2005, Congress cut significantly or restricted the use of funding for a variety of programs related to new military missions in space.<sup>24</sup>

- **Congress zeroed out the Counter Surveillance Reconnaissance System and Space-based Test Bed** Although the Counter Satellite Communications System, a mobile jammer, was deployed in 2004, Congressional appropriators zeroed out funding for CSRS in the FY05 defense bill, citing an Air Force decision to cancel the program – although the Air Force denied it had wanted CSRS canceled. Why CSRS was canceled remains unclear, although some critics expressed concern that it might blind, rather than simply dazzle, adversary satellites. The demise of the Space-based Test Bed was more straightforward, with Congress cutting more than \$200 million from the program element, resulting in no funds for the Space-based Test Bed.

- **Congress restricted work on the Common Aero Vehicle and NFIRE** The 2005 Appropriations Bill, citing concerns that Russia and China might confuse the launch of a Common Aerospace Vehicle with a nuclear attack, restricted work on CAV to “non-weapons related research, such as micro-satellite or other satellite launch requirements,” prompting the Air Force to reorganize the program as a hypersonics effort and rename the program the “Hypersonic Technology Vehicle.” Under Congressional pressure in August 2005, the Missile Defense Agency voluntarily removed the “kill vehicle” from plans for the NFIRE, replacing it with a German laser communications experiment.

Although not all the programs were canceled, and some,

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such as the NFIRE KV and the Space-base Test Bed, retained supporters in Congress who were influential if few in number, the FY05 budget resulted in substantial across-the-board reductions for programs to “enhance space operations.” This trend would play out in subsequent years.

Many of the most promising systems for space control and force application rely on technologies that are not fully mature, especially those technologies related to directed energy and microsattelites that are capable of so-called “autonomous proximity operations,” that is, close maneuvers around other satellites.<sup>25</sup> These programs have generally been fully funded, although the absolute amount of funds is small and the technologies themselves are applicable to a wide array of missions beyond space control and force application.

Early budget indications suggested that the Department of Defense was seeking more than \$188.5 million for directed energy that might be related to space. However, research on directed energy is scattered throughout the budget with little coordination. (In 2004, the Department of Defense spent \$983 million on high energy lasers.) In 2005, the Defense Department and Congress made efforts to focus spending on directed energy technologies. Also in 2005, the Director of Defense, Research and Engineering (DR&E) drafted a Directed Energy Technology Roadmap, in part based on the advocacy of the Office of Force Transformation. The FY05 Defense Authorization Bill directed the Secretary of Defense to submit a report to Congress on efforts to implement a new management structure for laser technologies and increase the portion of the laser-related funding spent on science and technology projects.

By one account, funding on directed energy research that might be related to space-unique directed energy programs totaled approximately \$215 million, spread across eight different program elements maintained by the Air Force and Army. The Air Force Research Laboratory’s Directed Energy Directorate conducts the work with the most direct anti-satellite applications. In FY05, AFRL requested, and received, \$4.6 million to “perform atmospheric compensation/beam control experiments for applications including anti-satellite weapons, relay mirror systems, satellite tests and diagnostics, and high-resolution satellite imaging.” AFRL conducted this work at the Starfire Optical Range (SOR) at Kirtland Air Force Base in Albuquerque, New Mexico, using two large telescopes that use adaptive optics to compensate for atmospheric effects when tracking satellites and debris, as well as a beam director that is used “primarily for projecting laser beams at space objects.”

Microsatellites – small satellites that weigh between 1 and 100 kilograms – were not part of the “enhance space operations” transformational goal. The rapid development of small satellites capable of performing so-called “proximity operations” – the ability to “conduct missions such as diagnostic inspection of malfunctioning satellites through autonomous guidance, rendezvous, and even docking techniques” – is a significant technological development. While the funding for these programs pre-dated the FY04 and FY05 budgets, two noteworthy satellites were launched in 2005.

- **Demonstration of Autonomous Rendezvous Technology (DART)** A NASA satellite launched in 2005. DART attempted to rendezvous with a DoD communications satellite but collided with the satellite. Orbital Science Corporation’s contract for DART was valued at \$47 million.

- **Experimental Spacecraft System (XSS)** A series of Air Force Research Laboratory satellites designed to demonstrate imaging applications of proximity operations. The first satellite, the XSS-10, was launched in 2003. That satellite maneuvered to within 35 meters of an expended Delta II rocket body, transmitting digital images to Earth, and conducted other on-orbit maneuvers for 24 hours before completing its mission. The second satellite in the series, the XSS-11, was launched in 2005. The XSS-11 remained in orbit for a year and conducted close-proximity operations to multiple targets of opportunity. Total spending on XSS-11 over FY01–FY06 was set at approximately \$73 million (about twice the original estimate).

In addition to these satellites, DARPA developed its own program called Orbital Express to demonstrate the feasibility of using automated spacecraft, though not microsattelites, to refuel, upgrade, and extend the life of on-orbit spacecraft. Boeing has built two satellites for DARPA that launched in 2007: a 700-kilogram Autonomous Space Transport Robotic Operations satellite (ASTRO) and a surrogate next-generation serviceable satellite (NEXTSat) for an on-orbit demonstration of autonomous satellite servicing. Boeing’s contract for ASTRO is valued at \$113 million.

None of these satellites was a dedicated anti-satellite system. Nevertheless, the technologies under development would support such a capability. The three programs, for example, were considered for innocuous “anti-satellite” missions of sorts – NASA considered the three systems as the basis for an autonomous “space tug” that would have deorbited the Hubble Space Telescope.

A note on black programs: in addition to the unclassified satellites listed here, some classified space programs are significant. The FY05 budget contained some classified work on space control. The most significant sums, as in the unclassified budget, appear to have been allocated to traditional missions such as reconnaissance satellites. The National Reconnaissance Office had two major “spy satellite” programs in 2005: The Future Imaging Architecture and the “Misty” stealth satellite.

Although we do not have budget numbers for either program, we know that they suffered the same sort of cost overruns and schedule delays that afflicted unclassified satellites. The Future Imaging Architecture (FIA) was called the “largest intelligence-related contract ever;” according to the Los Angeles Times, it might “dwarf the Manhattan Project.”<sup>26</sup>

Sometime during 2005, NRO restructured FIA for a second time (presumably driven by large cost overrun significant enough to trigger a “Nunn-McCurdy breach”), reducing the constellation’s proposed mission to visual and infrared imaging (it had previously included a radar capability). The delays in FIA were significant – some observers warned that existing reconnaissance satellites might die before FIA replacements could be launched, resulting in a “satellite gap.”<sup>27</sup>

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program because of a kerfuffle during the vote on the FY05 intelligence authorization bill. In December 2004, Senator Jay Rockefeller (D-WV), then-ranking member of the intelligence committee and Vice-chair, refused to support the bill due to his objection “to a particular major funding acquisition program” that he described as a “stunningly expensive acquisition.” Officials later identified the program to the Washington Post as the “Misty” stealth satellite.<sup>28</sup> Although we did not know the amount requested in 2005, the officials said the program was “the largest single-item expenditure in the \$40 billion intelligence budget” and that the total cost of the program was projected to be \$9.5 billion.

### The Fiscal Year 2008 Budget

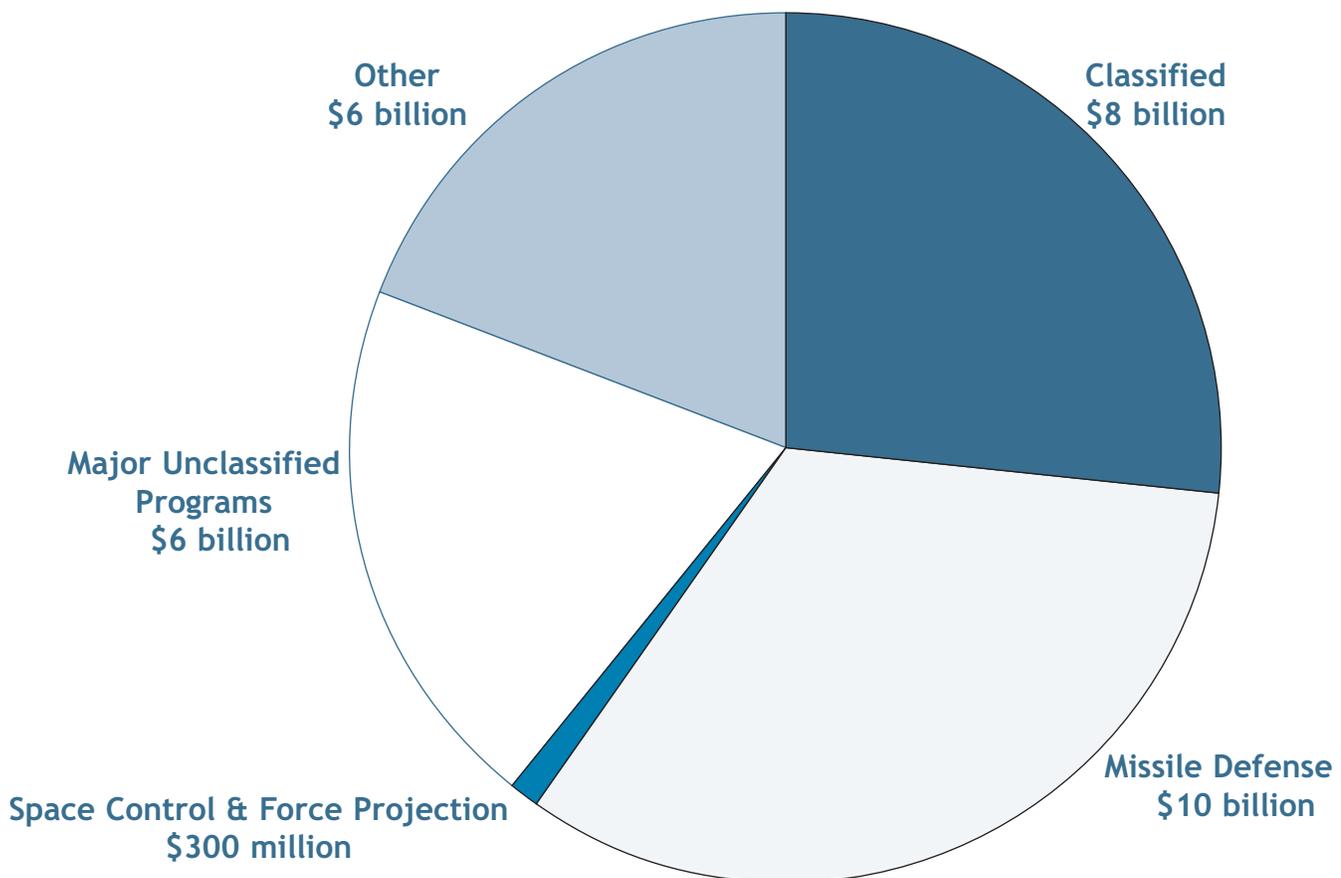
A rough estimate of the 2008 budget can be reconstructed using the 2005 budget as a baseline and adjusting for programmatic changes. Such figures are very rough approximations, but they give a sense of scale as shown here. The

broad trends outlined in the FY05 budget strongly shaped the FY08 budget. In the FY08 budget, the major programs for communications, navigations, reconnaissance and launch continue to dominate the budget, consuming both real as well as political capital within the space arena. Although advocates of new military missions in space continue to press for space control, space situational awareness (rather than offensive counterspace) seems to enjoy priority in a tight budgetary environment.

The crowding out effect is most obvious in the emphasis that Secretary Gates placed on six billion dollars allocated for eight traditional programs. These programs are, essentially, the same programs identified in the 2005 CBO report.<sup>29</sup>

If one compares Secretary Gates’ chart to the CBO projections (see pages 11 and 13), one can see the quite significant cost growth predicted by CBO. Moreover, Congress has constrained the cost-growth by simply cutting funding, causing the first launch of some programs to slip significantly.

### Missile Defense and Space Spending (approximately \$30 billion in 2008)



Note: “Missile Defense” includes funding for the Missile Defense Agency. Some additional missile defense funds are appropriated to the services.

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### Space Control and Force Application Programs

The cost-growth that is evident in these programs has resulted in significantly reduced expectations for space control and force application spending. The select programs related to space control and force projection remain small and poorly funded, and are unlikely to become a reality in the near future.

Although the amount of money has increased for several key programs, the total amount of funding remains relatively small by Defense Department standards. Moreover, as is discussed in the description of various programs, Congress has restricted or refused to fund the most controversial aspects of several programs, such as the Common Aero Vehicle.

- **Space Situational Awareness Systems** This is a new program element, replacing the SPACETRACK PE. The program was restructured to reflect a change in thinking about space tracking, from surveillance of objects, to a broader concept of “situational awareness” that includes the ability to detect and characterize attacks on space assets. Congressional appropriators fully funded the administration’s \$187.8 million request for FY08, as well as a \$9.8 million earmark for the Space Fence.

The Army also funds the development of a ground-based system to acquire counter communications, space surveillance, and counter imagery system under the “Army Missile

**Selected Space Control and Force Application Appropriations, 2005 & 2008**  
(in 2008 US million dollars)

		2005	2008
Space Control Technology	0603438F	15.7	37.6
Counterspace Systems	0604421F	27.5	53.1
Space Situation Awareness	0305910F*	140.0	187.8
Common Aero Vehicle	0604856F	17.4	0.0

\*Then called 0305910F Spacetrack

The Air Force divides “space control” into *offensive counterspace* or attacking adversary satellites; *defensive counterspace* or defending our satellites; and *space situation awareness*, or being aware of the space environment.

Current funding for space control programs is largely conducted by the Air Force, which continues to maintain the same three major unclassified space control program elements that appeared in the FY05 budget.

- **Space Control** This Program Element (PE) contains funds for the development of components and prototypes that might later be used in space control systems. For example, the technologies developed under this budget line were later integrated into the Counter Satellite Communications Systems. Technologies developed within this PE “currently focus on negation technologies which have temporary, localized, and reversible effects.” If the Air Force is developing destructive anti-satellite capabilities, these may be funded under a classified program element. Congressional appropriators fully funded the administration’s \$37.6 million request for FY08, as well as earmarks of \$25 million and \$4 million for two space situational awareness programs.

- **Counterspace Systems** The PE contains funds for offensive and defensive counterspace systems based on the technologies developed in the “space control” PE. The Air Force requested \$53 million for the Counter Satellite Communications System, a ground-based mobile communications jammer, and the Rapid Identification Detection and Reporting System (RAIDRS), a system to detect and characterize attacks on US satellites, as well as funds to support mission planning and command and control capabilities. Congress fully funded the administration’s \$53.1 million request for FY08, as well as a \$5 million earmark, and a \$7 million committee initiative, to fund future RAIDRS development.

Defense Systems Integration” program, although the funding level (\$6.2 million in FY08) suggests rather modest ambitions in the near term.

Space Control funding received a dramatic increase of more than \$100 million in FY08, following the Chinese anti-satellite test. “Improving space situation awareness,” the conferees wrote, “is critical, particularly following the Chinese anti-satellite weapon demonstration last January.”

Much of the \$100 million, however, is earmarked programs that do not reflect a long-term or integrated strategy to protect space systems. The conference report identifies nine programs worth about \$89.1 million. Of these programs, four worth \$38.3 million are earmarks, commonly referred to as congressional “pork” – funds provided by Congress for projects or programs where the congressional direction (in bill or report language) circumvents the Executive Branch allocation process. (see table on following page). Congress added \$131.4 million for space situation awareness (including some space control efforts conducted by the Army). Of that, some \$68.5 million – more than half – are earmarks. All but \$3.2 million of that is for just three states: Alabama, Hawaii and New Mexico.

A handful of these programs are ASAT related. For example, funding for the Applied Counterspace Technology (ACT) Testbed has been used to keep alive the otherwise unloved KE ASAT program.<sup>30</sup> It seems unlikely, therefore, that many of these programs will produce systems or technologies that can be deployed to mitigate the vulnerability of US satellites.

### Space Force Application

The FY08 budget contained limited investment for force application, largely emphasizing hypersonic technology. In the debate over the FY08 budget, interest in force application programs was a footnote to more near-term debates about

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### Congressional Increases for Space Situation Awareness, including Earmarks and Non-earmarks

Item	House	Senate	Amount
Advanced Modular Avionics for Operationally Responsive Space Use	Wilson (NM)	Bingaman, Domenici	\$2,000,000
Applied Counterspace Technology (ACT) Testbed		Cochran	\$5,120,000
Army Missile and Space Technology Initiative		Shelby	\$5,000,000
COTS Technology for Space Situational Awareness	Gerlach	Specter	\$2,000,000
High Accuracy Network Determination System (HANDS)	Abercrombie	Inouye	\$5,200,000
Low-Earth Orbit Nanosatellite Integrated Defense Autonomous Systems	Hirono	Inouye	\$4,000,000
Maui Space Surveillance System (MSSS) Operations & Research		Inouye	\$23,000,000
Multi-mission Deployable Optical System		Inouye	\$4,000,000
PanSTARRS		Inouye	\$9,000,000
Real-time Optical Surveillance Applications		Inouye	\$1,600,000
Satellite Active Imaging National Testbed Program	Wilson (NM)	Bingaman, Domenici	\$2,400,000
Space Control Test Capabilities	Aderholt, Everett	Sessions, Shelby	\$4,000,000
Space Situational Awareness	Edwards		\$1,200,000
<b>Earmarks Total</b>			<b>\$68,520,000</b>
Operationally Responsive Space			\$6,100,000
RAIDRS Block 20			\$7,000,000
Self Aware - Space Situational Awareness			\$25,000,000
Space Situational Awareness Research			\$15,000,000
Space Fence			\$9,800,000
<b>Non-Earmarks Total</b>			<b>\$62,900,000</b>
<b>TOTAL</b>			<b>\$131,420,000</b>

prompt global strike” focused on terrestrial systems such as the Conventional Trident Modification, which was a program to arm US submarine-launched ballistic missiles with conventional warheads. The administration did request funding for two space-oriented programs:

- **FALCON (Force Application and Launch from the Continental United States)** FALCON is a joint project of the Defense Advanced Research Projects Agency and the Air Force (which conducts its work under the program for the Common Aerospace Vehicle). As a result of FY05 restructuring to eliminate “weaponization” work, the FALCON program currently emphasizes the development of hypersonic technologies that could deliver a 12,000 pound payload at a distance of 9,000 nautical miles in two hours. Although Congress fully funded the administration’s \$50.0 million request for FALCON in FY08, the conferees zeroed out the \$32.8 million request for CAV along with the controversial Conventional Trident Modification program in favor of a single \$100 million for a new Prompt Global Strike program element to be used “only for development of promising conventional prompt global strike technologies.”

- **Space Test Bed** The Missile Defense Agency again sought funding to develop components that in later years

might be deployed on a small number of space-based missile defense interceptors that could be used as a “test bed” to test space-based missile defense technologies. Conferees zeroed out the administration’s request of \$10 million for FY08, receding to the Senate’s position that “the request is premature and the costs of a space-based system are unknown and likely unaffordable.” Senator Jon Kyl (R-AZ) attempted to replace the funding for the system on the grounds that it might provide on-orbit protection for US space assets, but his measure was defeated.<sup>31</sup> Some space-based interceptor work may live on in other missile defense programs, such as multiple kill vehicles, but these efforts have also been subjected to budget cuts.

Spending on directed energy technologies remains diverse and poorly monitored. Although DoD spent \$961 million on directed energy technologies in FY07, about 70 percent of this was for major projects such as the Airborne Laser. According to the Defense Science Board, core science and technology investment in directed energy is “diffuse” and spread across six DoD organizations.<sup>32</sup> The Directed Energy Technology roadmap, drafted in 2005, was not approved as of early 2006 and its current status remains uncertain. Unclassified spending on space-specific directed energy technologies appears to

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have decreased to about \$168.4 million. Yet, the overall thrust of directed energy research remains the same. The Starfire Optical Range, for example, continues to conduct beam control experiments, although budget documents no longer refer to “anti-satellite” applications.

Since 2005, microsatellite efforts have evolved considerably as XSS-11 and DART have demonstrated both the promise and the limitations of current capabilities to conduct proximity operations.<sup>33</sup> While the XSS-11 mission was widely perceived as a success, NASA’s DART was not. DART accidentally collided with the satellite around which it was maneuvering. Although DARPA and the Air Force Research Laboratory continue to fund microsatellite efforts, the Missile Defense Agency, for example, has decided to terminate its microsatellite programs.

AFRL now plans a follow-on XSS-12, as well as a second program called “ANGELS” or Autonomous Nanosatellite Guardians to Evaluate Local Space. ANGELS illustrates the limits to current proximity operations. Originally conceived of as a small, inexpensive spacecraft – at \$20 million and 10 kilograms it is lighter and cheaper than the XSS-11 – while demonstrating a more sophisticated mission in geostationary orbit, program officials increased the size and simplified the mission when they realized that “technology was not available to build the type of space surveillance satellite they initially wanted in the tiny package that was envisioned at the beginning of the experiment.”<sup>34</sup> In November 2007, however, AFRL gave Orbital Sciences, which also built the failed DART spacecraft, a \$30 million contract to build a much larger ANGELS satellite – 65-70 kilogram – using technology developed under the XSS-11 program and with a similar space monitoring mission. Only the acronym will remain, although program officials say that they will change the meaning to reflect the simpler mission.

Finally, DARPA has a program called TICS – Tiny, Independent, Coordinating Spacecraft. Funded at \$6 million in FY08, TICS is designed to develop technologies relevant to small, difficult-to-detect nanosatellites (1-10 kilograms).

Were we able to see the classified budget for spy satellites, the FY08 budget would look quite different from the FY05 version. Both the Future Imaging Architecture and the Misty “stealth” satellite have been canceled, raising new questions about the future direction of US reconnaissance capabilities in orbit.

The Future Imaging Architecture was the first to go in September 2005. Director of National Intelligence John Negroponte used new authority over the intelligence budget to cancel the FIA program in FY06, asking Lockheed Martin to simply reopen production of its current generation of reconnaissance satellites – the first of which Lockheed Martin expects to deliver in 2009.<sup>35</sup> NRO continued to develop the radar satellite, with Boeing expected to deliver the first satellite in 2008 or 2009. The Misty satellite, subject to scrutiny after Senator Rockefeller raised it in 2005, was next. In 2007, Mike McConnell, Negroponte’s successor as Director of National Intelligence, canceled the Misty program in one of his

first acts.<sup>36</sup>

### Future Trends

Although the effort to increase funding for space control and force application seems to have foundered, a broad consensus continues to exist that space will be important to US national security interests. In that respect, an open question is whether China’s January 2007 demonstration of hit-to-kill technologies that could be deployed in an operational kinetic energy anti-satellite weapon will dramatically change the funding environment.

Indeed, when asked what programs or technologies he needed to counter Chinese ASAT, General James Cartwright, then-Commander of STRATCOM, said “We do not have to have a space response to that threat” although he added that it was “prudent to improve our... situation awareness in space.”<sup>37</sup> As the previous section indicates, Congress allocated much of the immediate increase in funding for space situation awareness for earmarks in particular Congressional districts, rather than as part of an integrated situation awareness strategy. These programs do not, as of yet, reflect a coordinated response to the potential development of Chinese counter-space capabilities.

There are reasons to suspect that the near-term spike in funding for space situational awareness will be short-term. The budgetary environment continues to be dominated by a few, major space programs in traditional areas that are consuming ever greater portions of the defense budget. This trend is driven by growing US dependence on space and the continued cost-growth in aerospace acquisitions.

The most controversial programs did not survive despite efforts by proponents to link these programs to the Chinese anti-satellite demonstration. The Conventional Trident Modification program was zeroed out, taking the Common Aerospace Vehicle with it, despite an explicit link made by the Commander of US Strategic Command between the ASAT demonstration and the need for prompt global strike capabilities. Similarly, efforts by proponents of the Space-Based Test Bed to link their programs to China’s anti-satellite test proved unsuccessful.

Overall, it appears that a bipartisan consensus emerged in Congress, which is reluctant to antagonize other countries, to refrain from spending large sums on controversial and technologically unproven programs and from demonstrations of anti-satellite capabilities. But the Bush administration was determined to look for opportunities as they arose, such as Operation Burnt Frost.

The administration also continued to oppose a negotiated treaty. Although there appears to be little support for a negotiated treaty, there appears to be bipartisan support in Congress for measures short of a treaty, such as a code of conduct for space-faring nations, that would prevent large expenditures on the more controversial space control and force applications programs. George Pataki, serving as the Public Delegate to the UN General Assembly, summed up that view in a debate over military uses of outer space, noting that

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China's anti-satellite test highlighted "the need for cooperation" and calling for transparency and confidence-building measures in outer space.<sup>38</sup>

### Endnotes

1. Unless otherwise noted, this is drawn from *Under Secretary Zakheim Briefs on the 2004 Defense Budget*, February 3, 2003. Available at: <http://www.defenselink.mil/transcripts/transcript.aspx?transcriptid=1390>.
2. Background Briefing on the Fiscal 2004 Budget Submission, January 31, 2003. Available at: <http://www.defenselink.mil/transcripts/transcript.aspx?transcriptid=1384>.
3. Donald Rumsfeld was the Secretary of Defense for the George W. Bush administration during 2001–2006.
4. This figure appears to include classified, as well as unclassified, spending. It is estimated that the President requested 134.2 million in unclassified spending on "enhancing space operations" in the FY04 defense budget. See Jeffrey Lewis, *Liftoff for Space Weapons? Implications of the Department of Defense's 2004 Budget Request for Space Weaponization*, Center for International and Security Studies at Maryland Working Paper, July 21, 2003. p. 6.
5. The document is entitled *Department of Defense Instructions Transformation Program Detail* and visible using the Google™ cache feature at: <https://snap.pae.osd.mil/PPI/PB2004/TransformationDetailPB04.pdf>. It is no longer available.
6. Testimony of US Secretary of Defense Donald H. Rumsfeld, Prepared For The House/Senate Armed Services Committee 2003 Defense Budget Request, February 5/6, 2002 and *Final Report of the Commission to Assess United States National Security Space Management and Organization*, January 11, 2001, p. xii.
7. Submitted Statement of Secretary of Defense Robert M. Gates, Senate Appropriations Committee, Defense Subcommittee, Wednesday, May 9, 2007. Available at: <http://www.dod.mil/dodgc/olc/docs/testGates070509.pdf>
8. Wayne Allard, *The Greatest Threat to Space Dominance*, in *Space News*, October 3, 2005, page 4A.
9. Jeffrey Lewis, *Space Control Isn't Freedom of Action*. *Ad Astra*, Fall 2005, p. 8.
10. Joint Chiefs of Staff, *Joint Doctrine for Space Operations*. Washington, Joint Chiefs of Staff, August 9, 2002, p. x.
11. The 1987 Nunn-Cohen Amendment to the Goldwater-Nicholls Act empowered the Commander of US Special Operations Command to exercise authority, direction, and control over the expenditure of funds over MFP 11.
12. DoD Directive 5101.1, September 3, 2002. Available at: <http://www.desc.dla.mil/DCM/Files/DoDD%205101.1.pdf>
13. For an excellent summary of the challenges associated with the vMFP, see: General Accountability Office, *Technology Development: New DoD Space Science and Technology Strategy Provides Basis for Optimizing Investments, but Future Versions Need to Be More Robust*, GAO-05-155, January 28, 2005, pp. 12-13.
14. Patricia Moloney Figliola, *US Military Space Programs: An Overview of Appropriations and Current Issues*, RL33601, August 7, 2006, pp. 2-3.
15. For a discussion of different "major force program" constructs, see: Benjamin S. Lambeth, *Mastering the Ultimate High Ground: Next Steps in the Military Uses of Space*, MR-1649 (Washington DC: RAND, 2003) pp. 75-78.
16. For a detailed discussion of the FY04 budget request on military space spending, see: Jeffrey Lewis, *Lift-Off for Space Weapons? Implications of the Department of Defense's 2004 Budget Request for Space Weaponization*, Center for International and Security Studies at Maryland (CISSM) Monograph, July 21, 2003. For a review of the FY05 Defense Budget after the appropriations conference, see: "US Space Weapons: Big Intentions, Little Focus," *Nonproliferation Review*, Vol. 13, No 1, March 2006. Unless otherwise noted, this section is drawn from these two analyses.
17. Remarks as Prepared for Delivery by Secretary of Defense Donald H. Rumsfeld, for the House Armed Services Committee, February 05, 2003.
18. Figliola, *US Military Space Programs*, p. 2.
19. Amy Butler, "Military Space Topline Request Up \$1 Billion in FY05, Continuing Recent Trend," *Defense Daily*, February 2, 2004 and Congressional Budget Office, *Long Term Implications of Current Plans for Investment in Major Unclassified Military Space Programs*, September 12, 2005.
20. *Long Term Implications of Current Plans for Investment in Major Unclassified Military Space Programs*, p. 1.
21. House Armed Services Committee, National Defense Authorization Act for Fiscal Year 2006, Report of the Committee on Armed Services, House of Representatives on H.R. 1815, Report 109-89, May 20, 2005, p. 202. A program suffers a "Nunn-McCurdy breach" when either the Program Acquisition Unit Cost (PAUC) or Average Procurement Unit Cost (APUC) rises 15 percent. In cases where the cost rises 25 percent, the Secretary of Defense must make certain certifications relating to the national security interest at stake, lack of alternatives, reasonableness of new cost estimates and appropriateness of management structures to prevent the automatic termination of the program.
22. Lewis, *Liftoff for Space Weapons*, p. 5.
23. The quotation "in a state of disarray" is from General Accounting Office, KE ASAT Program Status GAO-01-228R (December 5, 2000). Available at <http://www.gao.gov/new.items/d01228r.pdf>. The cost estimate is from Kerry Gildea, "Possible Funding Boost In FY '04 Budget Could Lead To KE-ASAT Flight Test," *Defense Daily* 216:52 (December 17, 2002), np.
24. These restrictions are described in more detail in Hitchens, Katz-Hyman, and Lewis, *US Space Weapons*, pp. 41-47.
25. This section draws on Jeffrey Lewis, "Space Weapons in US Defense Planning," *INESAP Information Bulletin No. 23*, April 2004. An excellent, more recent discussion is

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26. Peter Pae, "Future Imagery Architecture' Project Massive New Top Secret Spy-Satellite Program to Cost up to \$25 Billion," *Los Angeles Times*, March 18, 2001.
  27. Jeffrey T. Richelson, "The Satellite Gap," *Bulletin of the Atomic Scientists*, January/February 2003, pages 48-54.
  28. Dana Priest, "Some Question Price and Need," *Washington Post*, December 11, 2004, A1.
  29. Secretary Gates excluded Space Radar from his chart because, in FY08, the Department of Defense attempted to place Space Radar funding under a classified program element. Congress moved the program out of the black budget citing concerns that the "total program cost, estimated by the Congressional Budget Office as \$35 billion to \$50 billion, is not affordable, the program has significant technical challenges, the moving target indicator mission is currently performed by airborne platforms, and the program is a lower priority than other Defense requirements."
  30. Applied Counterspace Technology Test Bed, the Army Missile and Space Technology Initiative (now Army Space and Missile Technology Initiative) and Space Control Test Capabilities.
  31. An account of the effort, as well as an exchange between Senators Kyl and Bill Nelson (D-FL), can be found in Jeffrey Lewis, "Kyl on Classified Space Spending," *Arms Control Wonk.com*, October 4, 2007. Available at: <http://www.armscontrolwonk.com/1663/kyl-on-classified-space-spending>.
  32. Defense Science Board, Task Force on Directed Energy Weapons, December 2007, p. 8.
  33. Orbital Express was launched in 2007, so it is not funded in the FY08 budget.
  34. Jeremy Singer, "US Air Force To Boost ANGELS' Size, Mission," *Defense News*, November 26, 2007.
  35. Philip Taubman, "In Death of Spy Satellite Program, Lofty Plans and Unrealistic Bids," *New York Times*, November 11, 2007.
  36. Tim Starks, "Fight Over Secret Satellite Program Is Revived," *CQ Today*, June 21, 2007.
  37. *Hearing of the Strategic Forces Subcommittee of the Senate Armed Services Committee; Strategic Forces Programs in Review of the Defense Authorization Request for Fiscal Year 2008 and the Future Years Defense Program*, Federal News Service, March 28, 2007.
  38. Statement by George Pataki, nominated by President George W. Bush to serve as Public Delegate to the 62nd UNGA, at the Thematic Debate on "Outer Space (Disarmament Aspects)" in the First Committee of the General Assembly, October 22, 2007.

### 3. TRENDS IN THE SPACE ECONOMY

#### Introduction

Fifty years have elapsed since the launch of Sputnik in October 1957. This year marks the 50th anniversary of the establishment of NASA as an open, civilian agency dedicated to the peaceful exploration of space for the benefit of mankind. In addition, in 2007 we celebrated the 40th anniversary of the entering into force of the Outer Space Treaty, which has now been ratified or signed by 124 nations, including all of the major space-faring nations.

There have been dramatic changes since 1957. Our knowledge and ability to use space has changed. Technology has changed. And, world geopolitics has changed. Many of the changes have been beneficial, but there are also some ominous trends with regard to the outer space environment that could threaten the basic foundations of the governing international principles of space activity.

The trends that have emerged concerning space began to become apparent in the late 1980s and early 1990s as the industry matured and commercial opportunities opened up. In addition, space became available to many nations and it has grown in its role of supporting security policies as well as becoming a vital component of the economic infrastructure. These trends have accelerated since then.

The political and governmental response to this changing world, particularly in the United States, has been weak, ineffective, and sometimes counterproductive. The World's strongest superpower and largest investor in space has not effectively exercised leadership in support of the basic principle of using space for peaceful activities.

The purpose of this section is to review the major issues facing the security of the economy with respect to space capabilities. Recommendations will be made about first steps towards new approaches to measure the space economy that reflect both economic and security concerns.

#### Developing Patterns

##### *A Short History of the Economic Development of Space Applications*

Major space applications such as telecommunications and remote sensing were government controlled and regulated in the United States until the 1980s. In the very early days of space operations, economic benefits were recognized in official government reports, but mostly for the jobs and contributions to technology that would be created. Not much consideration was given to using space for purely commercial purposes. There were many reasons for this, but primarily it reflected the high costs and risks of getting to space coupled with the defense and security roles of the industry.

Space was almost exclusively a government program, although private firms were building the equipment and providing services to the US government. In the Soviet Union, the only other major investor in space technologies in the 1950s and 1960s, all the programs were strictly owned and operated by the government.

By the mid-1960s there were private space telecommunications activities in the United States. A federally chartered

company, Comsat, was created and became the US representative to Intelsat, a multinational government organization that built and provided an international communications space network. Private sector competition in the operation of this network was not allowed.

Serious commercial activity in space-based terrestrial applications did not emerge until the 1980s.<sup>1</sup> In the United States there were efforts to privatize the remote sensing satellites that were not successful, mainly because the market was not mature enough. (Although as a first step the Landsat program was transferred from NASA, an R&D agency, to NOAA, an operational agency, in the mid-1980s.) Spot Image, a French firm that was heavily subsidized by the French Government, built and launched a remote sensing satellite and began operations in 1986. Spot Image sold imagery worldwide with higher resolutions than were permitted to be sold by US firms.

After the Shuttle Challenger accident in 1986, US policy changed dramatically and incentives were established for private firms to build and operate launch vehicles with the US government as a major customer. At the same time, in Europe, a government supported private firm, Arianespace, had successfully developed and was marketing a launch vehicle optimized for placing communications satellites in geostationary orbits. There was finally a nascent international competitive market developing for space products and services. However, that "market" was heavily subsidized and regulated. Certain space payloads were "captive" and not allowed to be launched on vehicles manufactured and licensed outside of their home countries.

In the 1990s there were a number of very significant developments that formed the basis of private space activities. First, was the advent of the direct satellite television market, which is today the largest private sector space application in terms of revenues. Second, was the free GPS navigation signal (owned and operated by the US Defense Department) that is the source of data for a growing host of private companies marketing receivers and special applications. Third, was the change in US policy on the resolution of remote sensing imagery which allowed imagery with much finer detail to be sold to the public. All of these developments were spurred either by the maturity of the technology and the industry or by the open availability of similar products and services built and offered by foreign nations or foreign companies.

In addition overall regulatory policy in the United States was rapidly shifting away from government controls on economic (i.e., price) regulations. Safety was and still is a government regulatory priority. And the government was also strongly encouraging its agencies to outsource, that is, to become customers of private companies rather than do many activities in-house. Taken together, these changes in policy had the desired effect of providing the basis for large government purchases of space services such as remote sensing imagery, telecommunications services, and launch vehicles. This enabled a potential market large enough to warrant private investment and risk capital in space systems.

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With the exception of the recession in the early 2000s and the resultant temporary set-back in commercial space activity, the development of a robust private sector space economy has grown fast and is likely to continue to grow in the future. And, as mentioned above, the rapid development of competitive systems and products being produced in many other nations will add to the mix of new products and services from space.

#### *Globalization*

The analysis of specific trends begins with two important non-space developments: economic globalization and the position of the United States vis-à-vis the rest of the world. Following that discussion, specific trends in space activities are developed.

The first major trend to consider is the growth of economic and commercial globalization. This is one of the most visible trends in today's world and is clearly apparent in a number of modes including: the growth of multinational firms, the ease of international financial transactions, and the spread of ideas, culture, and entertainment through the advances in communication technologies. Space technologies and capabilities have contributed to the rapid acceleration of economic globalization and space activities are also the beneficiary of economic globalization through the development of potentially larger markets.

It is important to separate economic globalization from other global activities where the trends are not so clear. Nations are built on the concept that sovereignty and territorial rights are paramount to maintaining their existence. Therefore, it is the rare exception (e.g., the European Union) rather than the rule that nations cede such powers. Even in the EU most of the early stages of unity focused on coordination in monetary matters, and the members of the EU still retain most aspects of territorial rights.

Space policy presents a very interesting set of contradictions. Space and the use of space, by international agreement, has no sovereignty.<sup>2</sup> It is a place for any nation to freely use. However, the ability to use space emerged during the Cold War and initially was developed by both the United States and the Soviet Union to show technological prowess. Closely related to those advances were the dual-use (civilian and military) capabilities that are possible in space. Over time technologies and uses of space have matured to the point where there are many profitable commercial opportunities and access to space is now available to any nation or company with the money to purchase services.

There are many good economic reasons that explain why commercial space activities need to be global in nature to survive in a competitive world. Primarily, it is the satellite capability to connect to ground stations anywhere in the world and to transmit data and information globally. To make a profit on an investment that has high technological risk and very high up-front demands, a large market is essential. The additional cost of adding a new ground station is very small in comparison to the cost of the space system. Since satellites have global coverage, having a global market becomes an attractive profit

potential. It can be easily argued that many space services are "natural monopolies." That is, one large provider can have the ability to serve all customers much more inexpensively than multiple providers.<sup>3</sup>

Globalization is not a new phenomenon, nor is it inevitable.<sup>4</sup> Decreases in barriers to trade, most recently through the North American Free Trade Association (NAFTA) and the World Trade Organization (WTO), but in other bilateral agreements in the past as well, and better coordination among nations characterized the decade of the 1990s. Similar eras of increased interaction among peoples have existed before the most recent times, but have then been followed by wars, economic depressions, or other occurrences, which slowed or stopped the trend toward globalization. This can even be seen in our current century; the events of 9/11 changed US policies and attitudes toward international security, slowing the rapid pace of 1990s globalization, at least temporarily.<sup>5</sup>

Other economic influences may also slow economic globalization. As described by Abdelah and Segal, the speed of globalization may not be as rapid in the upcoming years for the following reasons: politicians are more nervous about letting capital goods and people move more freely across borders, energy is the object of intense resource nationalism, and bilateral agreements appear to be replacing multilateral agreements in part because of recent US skepticism of "global rulemaking."<sup>6</sup>

Although there has been a trend toward multinational firms and a global economic regime, history has shown that there is no assurance this trend will continue on a smooth path. Current economic globalization is dependent on nations moving toward a free market-based economy that also implies some form of democratic government. Economic globalization is also dependent on the establishment of a relatively uniform regulatory system that is predictable, fair, and enforceable.

Space is a global industry. Within limits established by the political system, companies compete for launch services internationally. Satellite manufacturing, once virtually dependent on US companies, is now conducted internationally with companies located around the world. Space services are also available internationally. However, because of the dual-use nature of many space activities, there are regulatory and legal limits on the degree of international trade that can occur in this industry.

#### *The Role and Position of the US in the World*

The second overall trend concerns the position of the United States in the world and in the space sector. The US is a dominant force in the world. Its wealth, military power, and influence are enormous, and have been since the end of the Second World War. The nature of the US leadership is slowly and significantly changing. Many nations and regions of the world have developed the technological and economic capacity to effectively compete with the US in the production and distribution of quality goods and services. A significant number of nations also have powerful military establishments.

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Although the US continues to grow and to lead, its share of economic and military power has decreased. This phenomenon should be viewed as an inevitable and on-going evolution of a world where economic growth has spread to many nations and wealth has been accumulated in many nations. It is only the US share of the world economy that has decreased. The US economy remains powerful and is likely to continue growing. However, US policy often seems to treat this trend as a situation to be controlled and stymied through actions that close borders to trade and that attempt to keep technology and power concentrated within the US. In the longer run, policies that isolate the US from the world will backfire and weaken the US position, not strengthen it.

In particular, policies of pre-emption coupled with a policy of not engaging other nations in multilateral negotiations, and a policy of strict export controls, already have isolated the United States in many important areas, including space activities. US space policies established over the past seven years are needlessly aggressive in tone, upsetting to other nations, and most likely counterproductive to US commercial and military interests.<sup>7</sup> In addition, they offset other long-standing policies of free-trade, competition, and international cooperation that have been hallmarks of the growth and prestige of overall US economic leadership.

#### *Specific Trends in the Space Sector*

The following is a list of major trends in space activities since 1990 that have strengthened and are expected to continue for the indefinite future.

- The broadening of access to space (i.e., the control over launch vehicles, technology, and facilities) from just two nations (the US and the Soviet Union) to at least 10 nations
- A change in the balance of power in the world from a competition between two superpowers to one that is divided between one superpower and a diffused set of nations, religions, and interest groups; all with potential access to space capabilities
- An increase in international private-sector competition in the manufacture and launch of highly sophisticated and reliable satellites and other equipment used in space that has made governments more dependent on, and vulnerable to, the marketplace
- The dependence of a large part of the economic infrastructure on space assets including communications, navigation, climate and weather information, and other Earth observation and resource monitoring instruments. The use of space assets for business and consumer services is a stimulus for globalization as well as a product of economic globalization
- Evidence that climatic conditions are changing and a lack of adequate planning for this change including its political and security dimensions. The role of space operations for monitoring climate change will be of increasing importance
- Development in other nations, even among some of the closest US allies, of policies for funding the development of “independent” space capabilities coupled with new alliances and partnerships for future space projects that exclude the US

Space policy and economic policy are not normally connected in the thinking of government officials. Similarly, defense and security policy officials tend to view space policy as just one part of a broader national perspective. It is, therefore, not surprising that space policy is sometimes at the bottom of the policy chain – trumped by both overall defense policy and overall monetary and fiscal policies.

In part this reflects the fact that space is a relative newcomer on the block; in part, it reflects the small fraction of the US budget devoted to space. What is often overlooked is that space capabilities and applications have quietly grown from being an adjunct or alternative way of doing business to a network of enterprises that are now an integral part of our government, our security, our economy, and our society. Most of this growth occurred over the past 20 years. Growth is still accelerating rapidly today and the trend is projected to continue indefinitely.

We neither fully understand this change, nor do we have any adequate measures of the impact of space on our economy. It will be essential to develop better economic indicators and metrics of the space sector for several reasons:

- Space will have a very important role in monitoring and intelligence gathering for a variety of purposes: environmental, resources, health, climate, and military
  - Military and other security uses of space operations will expand. It is presently unclear whether this will threaten the principle of peaceful uses of space – for example, through the deployment of weapons into space – or whether it will be limited to monitoring, communications, observations, and other non-aggressive activities
  - Space imagery and navigation services, combined with other information tools such as Google Earth or Microsoft’s Virtual Earth will grow more rapidly as consumer services based on those capabilities are popularized
  - Population demographic changes, particularly in Europe, the US, Japan, and Russia portend problems with an aging workforce that won’t be easily replaced
  - There are nations with younger populations, such as China and India, where the emphasis is on educating the scientists and engineers who will vie for future leadership in space technologies
  - The commercial opportunities for all types of space activities will continue to grow and will become an even larger share of all space economic endeavors
- Two contradictory trends will emerge in space industry. One is the proliferation of duplicative services as nations develop independent capabilities for access to space, earth observations, and telecommunications (all mainly for government use and security purposes but most will also be dual-use and have commercial markets). The other is the increase in economic concentration through mergers of private companies, providing consumer space services. This increase will be driven by a large amount of expensive duplication in competing systems, and the possibilities of great profits through economies of scale. The X-M/Sirius merger is a good example of this trend.<sup>8</sup>

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These trends are likely to result in an unstable economic situation where there will be multiple sources of some space goods and services produced by governments' defense efforts that are essentially considered public goods and are relatively cost and price insensitive. At the same time, an oligopolistic commercial market is developing where larger private space assets are driven by the promise of economies of scale. Since most space goods and services have dual uses, the potential instability created by governments subsidizing and marketing their products commercially and competing with private production will be wasteful and possibly a long-term disincentive to private space development. One fairly obvious solution would be to have governments make their purchases from private suppliers. However, barriers to international trade in space commodities limit this option.

As the space environment becomes more crowded with more companies and nations offering satellites and services, there will be an increasing effort to develop mechanisms for international regulation and governance of sensitive and threatening activities. These might include issues of space debris, space traffic management, and allocation of rights to orbits, locations, and even celestial bodies that eventually prove to have valuable resources.

#### Problems with US Economic and Space Policies

Besides the official administration presidential directives and decisions on space activities, there are numerous other social, technological, budgetary, political, and economic actions that are decided by all branches of the government, Executive, Legislative, and Judicial. Some are related to space issues but are handled through other agencies and channels. Anti-trust reviews, for example, which are the responsibility of the Department of Justice and the Federal Trade Commission, often have far-reaching implications when dealing with firms engaged in space activities. The list of direct and tangential actions with an impact on space would span virtually the entire spectrum of government activities, from securities regulations to decisions by the Courts.

Some examples follow.<sup>9</sup> The major issue for consideration is that many actions taken by the Government for valid purposes that are unrelated to space may create conditions that negate the ability to carry out space policies. Many of these non-space policies and actions may have had the effect of accelerating the development of robust space capabilities in other nations which, in turn, has weakened the economic leadership of the US in space and diluted the power of the US in space systems development as well as in the technology and use of space applications.<sup>10</sup>

The examples are:

- **The philosophy of the US Government toward economic deregulation of industry** Deregulation, along with policies to avoid developing government enterprises, is oriented toward letting the market and price system allocate resources more efficiently than by government fiat. This works well in a truly competitive industry with many producers and many consumers. Unfortunately, space is an industry charac-

terized by only a few producers and with governments as the major purchasers. What has occurred is a shift in power and human resource capability from governments to large corporations. Whether this is advantageous to the development of space commerce is a matter of empirical analysis and further research.

A hint of the effects might be found in the telecommunications sector where COMSAT, as the US monopoly representative to INTELSAT was supposed to do, advanced telecommunications R&D. The government, after COMSAT was formed, did not fund much new basic research in that area. However, COMSAT, as a private company, had other research objectives, mainly developing new products rather than doing more fundamental R&D. NASA, with great political difficulty finally did establish a new R&D program in telecommunications (the ACTS program) in the 1980s to attempt to catch-up to other nations that had continued government funding in that area.

- **The overall government attempts to privatize and outsource functions** The attempted privatization of the remote sensing satellites, first in the late 1970s and again in the mid-1980s were premature and not very successful. In fact, the suggestion that the satellite weather service be privatized resulted in Congress declaring that meteorology and the satellite-based weather system was a "public good" and would not be privatized. The private market for space goods and services has not developed as rapidly as was expected although most of the privatization proposals have not been implemented due mainly to a lack of a sizable non-government market as well as to the large up-front investment requirements.

- **The DoD incentives for mergers and combinations of firms beginning in the 1990s** As discussed below, this has encouraged a more oligopolistic space industry in the United States. It also encouraged similar combinations abroad as the only way other nations could compete with US companies. Lower-tier suppliers have been subsumed within larger companies and the result has been a different type of competition than existed before these developments in the space sector. It has also created more powerful and capable foreign competition.

Examples from space-related decisions:

- **The imposition of very strict export controls on space systems and high technology products** US and foreign industry as well as foreign governments have bitterly complained about the very strict enforcement of export control laws since the late 1990s. It is increasingly difficult to share R&D information, to sell US space goods and services abroad, and to cooperate with foreign nations, even on government projects. The hardest hit sector of space industry has been satellite manufacturing in the United States. Foreign competitors are building and selling equipment worldwide at the expense of a market that formerly was controlled and dominated by US firms.

- **Sunset provisions on indemnification of space third-party liability** Most foreign launch companies fully indemnify

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their domestic industry from the unlikely, but possibly very expensive, liability claims that could accrue if there were a major disaster from a space object destroying property or taking lives upon re-entering Earth's atmosphere. The US requires private insurance and indemnifies firms (with a cap) on claims above what insurance would pay. That is a reasonable policy, but it has not been made permanent. Congress has consistently put a sunset provision into the authorizing legislation and therefore has increased the risk of investment for US launch firms compared to our foreign competitors.

- **The decision in the 1970s to put all commercial payloads on the shuttle instead of funding new R&D for expendable vehicles** The economic results of the Challenger disaster in 1986 clearly highlighted the problems that were waiting to happen with this policy. In particular, Arianespace, the French/European launch vehicle company, was developing a series of commercial vehicles mainly designed for the commercial market in geosynchronous telecommunication satellites. As a result of the US falling behind in R&D and manufacturing of expendable rockets and the change in policy towards commercial shuttle launches after Challenger, Arianespace was able to capture up to 60% of the launch market. It took the US over a decade and required a major policy shift toward stimulating commercial launch developments before it regained some of the lost market share.

- **The decision not to authorize launches of foreign operational telecommunications satellites on US launch vehicles.** Again, as with other similar restrictive policies, foreign nations were given the incentive to develop independent capabilities. And, with the ensuing maturation of launch and satellite technologies, they were able to build very competitive and capable equipment without US components or assistance.

- **The decision to retain control of the global positioning system (GPS) in the DoD** Even though the GPS system was funded, designed, built, and operated by the DoD, it had provided an unencrypted free signal for worldwide use as part of the program. Use of this signal has grown into a global multi-billion dollar industry. Receivers are manufactured in many nations, and currently the system has become one of the important infrastructure services offered from space. It is important now to both the military and to civilian communications and timing systems. From the mid-1990s to today, it is the only fully operating space navigation system. That is about to change as Europe, Russia, and possibly China develop their own systems. From a military view, not giving up any control of a critical technology is understandable, but from a practical and economic perspective, the US likely could have maintained a dominant position, or at least delayed foreign competition, with a different policy.

- **The long delayed decision to allow higher resolution images from earth observations satellites to be released for civil and commercial purposes** The US Government had a policy of restricting the release of satellite imagery that had a resolution of 30 meters or less. That restriction applied

to photographs from space as well as to the Landsat series of civilian earth observation satellites. The first Landsat was launched in 1972. However, in 1986 the French Government sponsored the SPOT remote sensing satellites that sold commercial imagery at less than a 10 meter resolution. India in 1988, ESA in 1990, Japan also in 1990, and Canada in 1991 all launched civilian remote sensing satellites with imagery that had higher resolutions than what the US companies were allowed to sell. It took until 1994 for the US Government to officially remove the restrictions and let US companies freely compete with foreign providers. Again, as in the above examples, nations with aggressive economic and industry space policies were able to capture market share from US companies hindered by policies designed for security, not commercial purposes.

#### Developing a New Perspective on the Space Economy

As described above, a dynamic historical analysis of the space sector shows the spreading wave of economic dependence on space. Many space applications have even reached the stage of public utilities, or at least providing public goods and services that are integral parts of the social and economic infrastructure. The irony is that most of the general public is unaware of the existence of space applications in everyday life.

The space economy is no longer only the sum of what governments and private companies spend on R&D and procurement of satellites and launchers (along with a multiplier effect and perhaps some spin-off products). Significant parts of the space economy now provide essential services which if interrupted would cause serious inconvenience and economic losses rivaling those of major disasters such as massive electrical blackouts and hurricanes. The difference is that space outages could have a global impact rather than regional or localized consequences.

An example of just how the space economy has changed can be seen in the subject matter discussed at conferences on space and its impacts on the economy. One of the first was held in Europe in 1980. The papers were essentially focused on jobs created, multiplier effects of government expenditures and spin-off technologies. Studies of that era employed econometric models to measure productivity and growth from space R&D and case studies of successful technology transfers. (Even though Velcro and Tang were minor examples and not necessarily developed for the space program, they became the public's image of space technology used by consumers. In some circles they still are.)

Today's economic conferences do pay homage to the same types of measures employed in the 1970s and 1980s. But they are now focused on bigger issues. The satellite industry has its own trade association and conducts its own conferences devoted to the many profitable and widespread uses of all types of telecommunications satellites. The private firms developing space applications ranging from "tourism" to satellite servicing now get a large amount of media attention and substantial funds are invested in developing new launch-

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ing capability. The remote sensing industry includes several private companies that have invested in satellites and are marketing services to governments, industries, and private citizens. The list can be extended, but the point is that many sectors of the space economy are large enough to sustain themselves, have trade associations, and profitably market their goods and services.

#### The Need for Developing Better Economic Indicators

Following is a definition of the space economy developed recently by NASA:

The Space Economy is the full range of activities and the use of resources that create and provide value and benefits to human beings in the course of exploring, understanding and utilizing space.<sup>11</sup>

This sweeping definition marks a significant change in thinking. Most prior definitions were as simple as adding up space expenditures and revenues from governments and companies with the vague recognition of the influence of space on our economy. But it is possible to measure the value of space to our society taking into account the pervasiveness of space activities in our lives.

We can and do measure these activities. Sometimes data collection and accuracy are limited for many reasons,<sup>12</sup> but at least we have a fairly good idea of the magnitude of the worldwide government and commercial space sector. Estimates range from \$200 to \$300 billion in activity per year. Global estimates of employment in space activities are not available, but in the United States the National Science Foundation reports 81,100 people are aerospace engineers.<sup>13</sup> NASA alone has 18,100 employees.<sup>14</sup> In Europe, an estimate of those employed in space industries is about 29,000.<sup>15</sup> Total space employment is a sizable amount,<sup>16</sup> but it must be put into perspective. In a world with a GDP well above \$50 trillion, space sector jobs and income do not represent a large share of the global economy.

It is also important to stress that non-military government activities in space in the United States are not limited to NASA. There are at least six other agencies with space budgets that include the Departments of Energy, Commerce, Interior, Agriculture, and Transportation, as well as the

National Science Foundation. Together, they account for about 10% of the US civilian space expenditures.

What's missing from the conventional measures? Two things. First, an adequate appreciation of the growth rate of space activity over the past 50 years. A good time series of the data discussed above can provide that segment.

The second missing link is much more difficult to describe and capture in quantitative terms. It is an appreciation of the economic dependence on the space sector. For example, without satellite-based support, many systems in daily use would not function including cable and satellite TV, navigation aids, and the electronic coordination and timing of pagers, and radio transmissions. "Fun" applications, such as Google Earth, could not exist, at least not until replacements are developed, without space technologies.

The military depends on space-based command and control communications equipment for many essential tasks. Industry is a major user of satellite services. Consumers benefit from many space applications ranging from better weather forecasts, to cell phones, to search and rescue capabilities. One the biggest dependencies is in the financial sector where electronic transfers of money, of signatures, of commercial paper, and of credit card purchases, banking communications, and even advertising and price lists are satellite applications. And, we haven't even mentioned the consumer entertainment and information sectors that are growing rapidly and are among the largest users of space technology.

Adding up the value of the space equipment, the ground-based receiving equipment, and the revenues from these services only begins to measure the space economy. What would the cost be to the economy of turning off all of the satellites, some of the satellites, or parts (e.g. transponders) of the satellites? Eventually, substitutes and alternatives would be found. But what would be the disruption costs in the meantime? There lies much of the true value of this essential infrastructure component that has fast developed into a necessity. And, it has emerged so quickly and so quietly that most people are unaware of it. Figure 1 below illustrates the type of growth that we need to measure – the "outer ring" – the utility aspect of space-based services.<sup>17</sup>

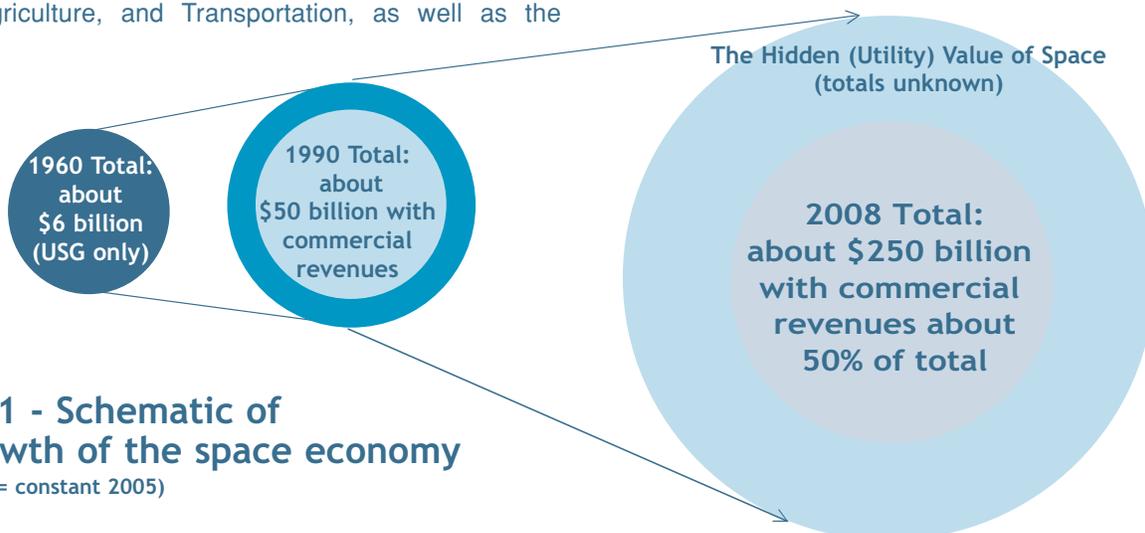


Figure 1 - Schematic of the growth of the space economy

(\$ = constant 2005)

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The lack of awareness exists not only because the space sector has emerged so fast, but also because it is “silent” in the sense that the consuming public is hardly aware or hardly cares about satellite operations. Most of us do not know how our voices travel from our phones as long as the call is clear and uninterrupted. The same lack of knowledge exists with many other satellite services. The general public is unaware of the fragility and vulnerability of these satellite-based systems.

Thus, what can be measured as an expanding wave of economic activity using the more traditional measurements and statistics becomes an exponential growth pattern when viewed as an economic necessity and as infrastructure for a multitude of activities permeating virtually all sectors of an advanced industrial nation.

We need to develop new methodologies and data for measuring the space sector. Several approaches can be used to initiate this effort:

1. The first step is to look for parallels in history. In the early 1900s, over a fairly short period of time, new technologies completely replaced their predecessors: the telephone replaced prior means of communicating, and electricity replaced former methods of lighting, cooking, heating, etc. Some data exist from either intentional or accidental disruptions, and the costs of the loss of services. It is evident in the cases of electricity and telephone that the usage and dependence on these technologies became so important that they became utilities. A detailed search of the economic literature on the value of utilities to society may also yield interesting insights into finding methods of quantitatively evaluating the changing importance of those utilities.

2. The second step is to document as many government and commercial categories of users and uses of satellite and space-based information as can be identified. This is a research effort that should start with a search of published information and available research studies and reports (of which there are many). It would be necessary to talk with a variety of satellite service providers to confirm the results of the research, and add additional real-time information about their customers and known applications. The resulting mapping of the spectrum of users can be categorized, and those uses that are now essential to the smooth operations of society and the economy (essentially those which are now utilities) identified. Examples are likely to be in the area of financial communications (e.g., V-sats used for credit card and ATM transfers) or in direct broadcast television. Other space-related essential operations include navigation and timing information and various telecommunication services. It is expected that the space component for many applications in this category is now the major supplier of the service. And if there are found to be few close substitutes and/or redundancies in providers or methods of providing similar services, this category of applications will become a prime candidate for further economic analysis of the total impact of space on the economy.

3. The third step (in coordination with, and following the

mapping exercise) in evaluating the hidden value of space is to perform a current analysis of some examples of space and satellite outages and a projection of what future outages might imply as satellite services continue to expand. Data are scarce, as governments are unwilling to reveal critical satellite interruptions for security reasons and the private sector is often unwilling to reveal problems due to investor concerns. Therefore, a different methodology would be applied to estimate the potential losses from not having the space infrastructure available. (Of course, these “losses” are hypothetical and actually result in a tracing of the current somewhat hidden “benefits” and dependence the economy has on space assets.)

To begin to measure the effects of interruptions of services, an off-the-record and non-attributable survey/interview process can be initiated with people familiar with the problems. The information obtained can then be aggregated and the results, although not precise, will begin to yield estimates. It should be noted that interruption of satellite service is not a simple problem — we are not simply left “with” or “without” satellites. There are different types of satellite disruptions ranging from correctable minor anomalies to total loss of the hardware, each with different types and levels of impacts on users. There are many possible mitigation strategies that can be employed to reduce risks. Examples include: backup satellites; repositioning satellites to either avoid possible damage and/or to provide temporary operating coverage; using alternate (and possibly less capable) technologies; and using ground-base equipment.

The result, therefore, would be a net effect—the value of the total or partial loss of space assets less the costs of efforts to mitigate the outages, as well as the costs of recovery. This is a complicated effort since the cost to mitigate damages might include the moving of satellites, the launching of replacement satellites, or even the development of redundant non-space systems. Other possible measures of the costs would include the purchase of more robust satellites and/or developing the technology to harden future space hardware.

It must be noted that not all space-related hardware and equipment is in space. Ground receiving stations are equally important to the space infrastructure and possible disruptions to those facilities should also be included in the analysis.

It is also important to look toward future developments. Data points concerning corporate R&D and new product development may also provide insights into the growth and potential of new infrastructure services and eventually new “dependencies” on space assets.

Although none of the methods will initially provide precise quantitative measures, this project will be a groundbreaking effort in starting the process of developing new economic indicators for the space sector that will capture the hidden value of space assets. This information about the space economy will become essential in educating both the public and decision makers on the importance and dependence we all have on space assets. It will provide concrete evidence of what we know but can't easily explain—the reason such a relatively

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small economic investment as measured by traditional methods has become a very major and integral part of the economy over a relatively short period of time.

In summary this new approach transcends the more traditional measurement methodologies. It builds on those data and should result in a much more comprehensive, larger, more accurate, and more realistic estimate of the space economic sector.

#### Conclusions

Economic indicators have many applications, including:

- Aid in understanding the importance of commercial space to the government and the economy
- Aid for businesses in developing better business plans
- Aid in analyzing the impact of all policies on space and vice versa
- Aid for understanding the full impact of space policy decisions on security issues
- Aid in developing strategies for mitigating losses if fragile space assets are disrupted by either natural or man-made causes
- Aid in encouraging nations to seriously negotiate international agreements aimed at maintaining and preserving the space environment so it can continue to develop as a productive means of enabling commerce and public goods and services.

The last bullet deserves some additional explanation and is very important since it provides a link between the space economy and the overriding issues of national defense and security.

Developing a new methodology aimed at expanding the scope of the space economy to encompass today's reality (and tomorrow's growth) will help document both the importance of space to all nations, peoples, and economies as well as highlight the fragility and dependence many institutions around the world have on space assets which are not readily recognized.

The educational value alone in creating and spreading an understanding among all space-faring nations of what and how everyone might be affected if space capabilities were threatened by either human or natural means will help to underscore and give tangible meaning to the importance of space capabilities.

Beyond that, there is an increasing concern about nations possibly violating the long-standing legal principle that space should be used for peaceful purposes and the space environment be preserved so that all nations can safely operate their space-based equipment. The purposeful Chinese destruction of their weather satellite in January 2007 that created an enormous amount of space debris was seen as an international wake-up call to reaffirm the world's convictions on the orderly use of space.

Although different from the Chinese action, the recent US destruction in February 2008 of the out-of-control defense satellite 123 is considered by some to again raise the political issue of space weapons. These defense capabilities, even if

never used in actual warfare, clearly illustrate the developing potential to disrupt the use of space for commercial and economic gain. If the risk of this disruption increases, funding for business ventures will decrease, reversing the fast-paced trends of the past 15 years. Much more will be lost than a few less commercial operations. The impact on economic growth, on people's daily lives, and on many services we now take for granted could be very large.

The important conclusion is the need to develop additional methods to make people and governments aware of the magnitude of our dependence on all types of space applications that have emerged and become part of our lives. There needs to be a better appreciation of the size and significance of the space economy, and of how much more all nations collectively have to lose than to gain by endangering space assets. We currently have no reliable measure of this dependence.

#### Endnotes

1. A value-added sector had developed for space applications. These firms purchased or received government data from space systems and then processed, packaged, and sold the information to clients in various industries.
2. *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies* (1967), art II, 18 UST 2410, 2413 (1969).
3. That does not guarantee that the prices charged to customers will necessarily be lower than if the industry were competitive (i.e., multiple providers offering services to the same customers). Economic theory tells us otherwise. Monopoly means higher prices and less quantity offered on the market. Regulatory licensing, oversight, and enforcement can compensate for this. The trade-off in the case of space is one of avoiding duplication of expensive assets coupled with the space power inherent with a monopoly that is owned by a company within the United States and under the supervision of US laws. Arguments that the space sector should be "competitive" and respond fully to market prices sound persuasive, but fail to recognize the reality that space economic activity is, at best, the province of a handful of companies and is beholden to large purchases from governments—both factors clearly prevent space enterprise from fitting any textbook definition of a price-competitive sector. Competition in the space sector has to be viewed as a goal, not a reality.
4. See, Fischer, Stanley, *Globalization and Its Challenges*, Papers and Proceedings, American Economic Association, May 2003, Vol. 3, No. 2, p. 3.
5. Some actions such as the tightening of visa requirements for entrance to the United States have had a definite effect on the number of foreign students in US universities. These actions have also made it more difficult for professionals to attend conferences and workshops in the US; both are evidence of a slowing of at least some global

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### 3. TRENDS IN THE SPACE ECONOMY

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communications links. Globalization is also closely linked with overall economic growth trends. The period of the early 2000's was marked by a slowdown in growth that may have temporarily slowed globalization trends. The 9/11 events had a particularly strong influence on US policies. It is unclear how much those policies affected other nations.

6. Abdelal, Rawi, and Segal, Adam, "Has Globalization Passed its Peak?" *Foreign Affairs*, January/February 2007, pp. 103-114.
7. US National Space Policy, August 31, 2006
8. Both companies have been losing money. They argued that the merger would change those individual losses into profits for the new firm.
9. A full analysis of this issue is far too lengthy and complex for this review paper, but would be a useful topic for further research.
10. Given the overall maturity of parts of the space industry and the very obvious advantages of having space systems, foreign technological and economic development of competing systems is inevitable and advantageous in many cases. However, the argument given above, relates to unilateral US actions that have created unusually strong incentives for foreign development of competing systems and resulted in a competitive disadvantage for US industry.
11. *NASA Strategic Communications Framework*, NASA, Washington DC, June, 2007.
12. For a more complete analysis of the state of space economic data see: H. Hertzfeld, *Space Economic Data*, US Department of Commerce, Office of Space Commercialization, December 2002. (<http://www.ta.doc.gov/space/library/reports/#data-2002>)
13. National Science Board. 2008. *Science and Engineering Indicators 2008*. Two volumes. Arlington, VA: National Science Foundation (volume 1, NSB 08-01; volume 2, NSB 08-01A). Volume II, pp. A3-5.
14. NASA, FY08 Budget Request, p. SD-7. Data are for FY07.
15. *Eurospace*, The European Space Industry, 2006.
16. Note that these employment estimates do not include people working in related industries such as information systems, telecommunications, and life sciences. An estimate developed for the FAA Office of Commercial Space that includes all multiplier effects of space expenditures in the US reports over 500,000 jobs are directly and indirectly created by the space and supporting industries.
17. Note that this diagram is not drawn to scale.



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Richard Kaufman is a member of the board of directors and a vice chair of Economists for Peace and Security, and Director of Bethesda Research Institute, which he founded. He was formerly a staff economist and general counsel of the Joint Economic Committee of the US Congress. At the Joint Economic Committee he directed numerous investigations of the Pentagon and its spending and contracting practices. As he would point out, that was at a time when there was more rigorous and relevant congressional oversight than we have had over the past 6 years, and when oversight meant to look hard, not to hardly look.

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Jeffrey G. Lewis is Director of the Nuclear Strategy and Nonproliferation Initiative at the New America Foundation. The Nuclear Strategy and Nonproliferation Initiative seeks to reduce the role of nuclear weapons in international security and renew the fundamental bargain contained in the Nuclear Non-Proliferation Treaty. The author of *Minimum Means of Retaliation: China's Search for Security in the Nuclear Age* (MIT Press, 2007), Dr. Lewis is also a research affiliate with the Center for International and Security Studies at the University of Maryland School of Public Policy (CISSM) and a member of the Editorial Advisory Board of the *Bulletin of the Atomic Scientists*. He founded and maintains the leading blog on nuclear arms control and nonproliferation, ArmsControlWonk.com.

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