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Alternative Futures: United States Commercial Satellite Imagery in 2020

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Foreword

This independent study, sponsored by the U.S. Department of Commerce in late 2010, posits three alternative futures for U.S. commercial satellite imagery in 2020. It begins with a detailed history of the U.S. policy and regulatory environment for remote sensing commercialization, including many of the assumptions made about U.S. government and commercial interests, international competition, security issues that relate to the proliferation of remote sensing data and technology, and others. In many ways, it reflects a brilliant American vision that has sometimes stumbled in implementation.

Following a discussion about remote sensing technologies, and how they are changing, the report goes on to describe three alternative futures for U.S. commercial satellite imagery in 2020, with a special emphasis on the U.S. high-resolution electro-optical firms. The reader should note that, by definition, none of these futures is "correct" nor reflects a prediction or a preference in any way. Alternative futures methodologies are designed to identify plausible futures, and their underlying factors and drivers, in such a way as to allow stakeholders to understand important directions for a given issue, including important signposts to monitor as reflective of movement toward those (or perhaps other) futures. Alternative futures also allow decision-makers to adapt strategy in the face of these changes, including mitigation or elimination of futures with negative outcomes or consequences. For this study, the near-term timeframe of 2020 was chosen to reflect the truly dynamic changes in global thinking and global markets about this topic.

The report concludes with our independent observations and options about the future role of the U.S. Department of Commerce and NOAA in the governance of space-based remote sensing. For both U.S. and international remote sensing countries, space policy and regulation is becoming less relevant (but not irrelevant) to the governance of remote sensing as the sensed data is being fused with other data sets (e.g., navigational data) and incorporated into powerful public and commercial applications.

Three appendices are included at the back of this report. The first highlights key areas of remote sensing policy and regulation and how they might be re-considered for the 2020 timeframe. The final two appendices map European and Japanese approaches to remote sensing over the past few decades. Here, the reader might take note of two different aspects of those comparative approaches: first, the simple differences in the national approaches, and second, the extent to which U.S. assumptions about foreign behavior were correct, incorrect, or stimulated unintended consequences. In looking to the future, foreign remote sensing programs will reflect complex calculations about cooperation and competition that will have to be assessed critically and objectively.

The research in this report was concluded in April of 2011. While there have continued to be many dynamic developments in global remote sensing (such as Surrey's sale of three 1-meter satellites to China; the success of ORS-1 and NRO launches; shifts in development and launch schedules for Pleiades and ASNARO; and the emergence of new U.S. licensees like Skybox and others), we believe that the approach taken within this report will help U.S. government and commercial decision-makers think creatively about the future.

Indeed, creative thinking is needed in these challenging times. We need to change a 50-year mindset about how and why we use space for vital civil and national security missions, as well as the ways that we do it. It would be unfortunate for the national debate about the future of remote sensing to devolve into a feckless "commercial versus NTM" debate during a time of fiscal constraint and extraordinary innovation in technical and commercial applications. We will need to draw upon the comparative advantages of each sector in order to maintain and advance the exquisite contributions that remote sensing and satellite imagery bring to our science, safety, and security, every single day.

Finally, on a personal note, space-based remote sensing is "at the leading edge of global transparency" as I wrote about it (in *Commercial Observation Satellites: At the Leading Edge of Global Transparency* with John Baker and Ray Williamson) over a decade ago. The key difference is that it is only one dimension of a whirlwind of data and technology, and of new information applications and innovation. Our more transparent world creates challenges and opportunities for almost every dimension of governance, security, and commerce, in ways that require substantial re-thinking.

We hope that this report is informative and helpful.

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Summary

Commercial satellites capable of collecting one meter or better resolution imagery have been in space since 1999. Two companies operating these satellites, GeoEye, Inc. and DigitalGlobe, Inc., are largely dependent on U.S. Government funding, such as the 10-year, $7.3 billion two- contract award announced on 6 August 2010 by the National Geospatial-Intelligence Agency (NGA). Averaged over ten years from 2010 – 2020, this amounts to $730 million per year, or 100 times more than NGA (then NIMA) paid for commercial imagery in Fiscal Year 1999.

For over 30 years, the U.S. Government in policy, law, and regulation has been an advocate for commercial satellite imagery, noting repeatedly that Government funding should not be the basis for long-term success of the industry. Reality is the opposite. Changes in funding, or a major contribution by disruptive technologies such as small satellites, would have much more impact than changes in U.S. Government policy, law and regulation because thus far the Government itself is the business case for this commercial activity.

This alternative futures paper includes decade-spaced reference points since 1980, and projections by experts in the field that point to possible 2020 outcomes for U.S. commercial imagery suppliers. Annexes are included on developments in Europe and Japan to track their progress since a 1980 view by U.S. intelligence that French and Japanese programs would become serious competitors.

Aside from Federal funding, which may contract due to concerns about the national debt, the 2020 outlook for U.S. commercial imagery companies depends largely on the scope of foreign competition and the reason for having such satellites in the first place.

- By 2020, foreign competition likely will strengthen. France, Germany, India, Israel, Japan, and South Korea all should have mature commercial programs for optical, sub-meter imagery. Operators in other countries could also impact the market. Nothing can be done to slow this technology development because the United States does not control it.

- Commercial satellite imagery programs gained traction in the United States because the data are unclassified and sharable. The satellites for NGA, however, are becoming more capable and more expensive due to performance demands. In the long-run, the need for three kinds of imagery satellites for defense and intelligence (classified, commercial and tactical) may face declining budget reality.

- Experts agree that the main purpose of the geospatial industry is to track changes on the planet and changes in physical resources, such as food, water and minerals. If analysts are correct that the international geo-political-economic system as we know it will be almost unrecognizable in 2025, high-resolution commercial imagery satellites should make a much greater contribution than today for non-military purposes.

Alternative Futures: United States Commercial Satellite Imagery in 2020

November 2011

Purpose and Scope

This paper outlines three alternative futures for U.S. commercial, one meter or better resolution, satellite imagery in 2020.[1] Satellites capable of collecting this imagery have been in space since 1999. Two companies who have these satellites, GeoEye, Inc. and DigitalGlobe, Inc., are largely dependent on U.S. Government funding, such as the 10-year, $7.3 billion two-contract award announced on 6 August 2010 by the National Geospatial-Intelligence Agency (NGA).[2][3] Because non-U.S. companies are moving ahead in this sector, the alternative futures build on decade-spaced reference points since 1980, and projections by experts in the field, that point to possible 2020 outcomes for U.S. commercial imagery suppliers. Although the U.S. Government has for decades had a supportive policy regarding commercial satellite imagery, the 2020 outlook for U.S. companies depends largely on the annual amount of Federal funding, the reason for having such satellites, and the scope of foreign competition. Because GeoEye and DigitalGlobe cite Government rules and regulations as risk factors for their business, the paper includes an appendix listing key points in current statute and regulation adapted to 2020.

National Legal, Policy, and Regulatory Environment

Projections on the future health of U.S. commercial satellite imagery activities cannot be made in a vacuum because Federal law, policy, and regulation affect the conduct of commercial business in this sector. United States earth observation law, policy, and regulations are generally not issued together. What is common in all three, however, is that the Department of Defense, Department of State, and Intelligence Community have a major role in setting the rules for operating commercial earth observation systems. The Department of Commerce is the licensing authority, but other departments have a major voice in the decisions. The outcome of earth observation licensing decisions reflects agency-specific needs and interests, not just the substance of the license application.

United States law and regulation are more important than earth observation policy because licenses are issued and enforced according to legal and regulatory criteria, not policy. Policies are open to interpretation and have no penalties. Law and regulation are specific,

[1] There are other types of commercial earth observation satellites licensed by the National Oceanic and Atmospheric Administration in the Department of Commerce (http://www.licensing.noaa.gov/licenses.html), but this paper is focused on the future of one-meter or better electro-optical imagery due to large U.S. defense and intelligence outlays for these data.
[2] NGA News Release, NGA Awards EnhancedView Commercial Imagery Contract, 6 August 2010.
[3] Warren Ferster, NGA Awards Big Satellite Imagery Contracts, SpaceNews, 6 August 2010.

enforceable, and intertwined. Tracking rules and regulations since 1978 is useful because it gives context for risks to business cited by DigitalGlobe and GeoEye in their 2009 and 2010 Annual Reports. Cyber security is a risk first cited in 2010, but specific threats were not listed.[4][5][6][7] Countries such as China and Russia could be suspects.[8][9][10][11][12]

2010: DigitalGlobe, Inc.	2010: GeoEye, Inc.
Loss or reduction in scope of any of primary contracts, mostly with U.S. government agencies.	Substantial portion of revenue from U.S. government agencies.
Changes in U.S. government policy.	***Changes in U.S. government policy.***
Interruption or failure of infrastructure.	Satellites have life limits and are expensive.
Satellites may not operate as intended.	Satellites may not operate as designed.
Failure of ImageLibrary could affect business.	Satellites may have construction & launch delays.
Market may not accept products and services.	Industry is highly competitive and specialized.
Competition may cause company to reduce prices or lose market share.	U.S. and other governments may operate their own systems.
Changes in U.S. or foreign laws and regulations.	Success depends on market acceptance.
Failure to obtain regulatory approvals.	Failure of infrastructure.
Global economic condition could affect results.	Reliance on resellers who could fail.
Dependence on resellers who could fail.	Insurance coverage may be difficult or costly.
Dependence on third parties for aerial imagery.	Global financial crisis may affect financial results.
International business exposes company to risks.	Business is capital intensive.
Inability to attract and retain key employees.	***Failure to obtain regulatory approvals.***
Satellites have life limits and are expensive.	International business exposes company to risks.
Limited insurance coverage and availability.	Success hinges on small number of key personnel.
Substantial debt.	Government audit could affect cash position.
Stock price will fluctuate substantially.	Effective income tax rate may vary.
Amended Delaware certificate might affect stock.	Acquisitions, investments, alliances, and ventures could affect operational results.
Do not pay dividends on common stock.	Company has substantial indebtedness; servicing debt requires significant cash.
Breach of system security could result in loss of business.	Information and security systems may be subject to intrusion.

[4] DigitalGlobe, Inc., 2009 Annual Report, U.S. Security and Exchange Commission Form 10-K, 24 February 2010.
[5] GeoEye, Inc., 2009 Annual Report, U.S. Security and Exchange Commission Form 10-K, 12 March 2010.
[6] DigitalGlobe, Inc., 2010 Annual Report, U.S. Securities and Exchange Commission Form 10-K, February 2011.
[7] GeoEye, Inc. 2010 Annual Report, U.S. Securities and Exchange Commission Form 10-K, March 2011.
[8] Ken Dilanian, Virtual war a real threat, Los Angeles Times, 28 March 2011.
[9] DigitalGlobe, Inc., Press release on major milestone for imagery collection of China, 22 March 2011.
[10] http://finance.yahoo.com/news/DigitalGlobe-Reaches-Major-Milestone, Marketwire, 22 March 2011.
[11] GeoEye signs reseller contracts, Geospatial World, 19 March 2009.
[12] Department of Defense, Military and Security Developments Involving the People's Republic of China, 2010.

Space Commercialization in the 1970s

The United States first deployed the government-developed and operated Landsat imagery satellite in 1972. There were no commercial U.S. imagery satellites in that decade. Nonetheless, in May 1978, President Jimmy Carter signed a directive giving the U.S. Government authority to regulate remote sensing, noting that commercial use of space could provide economic benefit.[13]

- "The United States shall encourage domestic commercial exploitation of space capabilities and systems for economic benefit and to promote the technological position of the United States, except that all United States earth-oriented remote sensing satellites will require United States Government authorization and supervision or regulation."

In October 1978, when noting that the United States had photoreconnaissance satellites for monitoring arms agreements, President Carter described the value and contribution of the American investment in space programs.[14]

- "We have invested so far some $100 billion over the history of our American space programs. It's now time for us to capitalize on that major investment even more."

- "Earth resources satellites have already proved their value to many countries through remote sensing. They tell us about everything from the location of mineral and energy deposits to the condition of our crops, from the motion of icebergs to the health of the oceans. We will continue to develop and to use these satellites for the benefit of all people of the world."

Early 1980s Policy, Legal, and Regulatory Framework

Although the 1970s U.S. experience with Landsat was positive, what to do about the future of the program was uncertain. Competition was expected from France and Japan. The Acting Director of Central Intelligence wrote to the Secretary of Commerce with views on what to do about a Landsat follow-on system.[15]

- "…the remote sensing field will become far more dynamic in the next few years as U.S. leadership is challenged by the ongoing programs of France and Japan…This SPOT program has been under development for a number of years and was approved in late 1977 by the French government…The Japanese satellite program can also be expected to be a strong competitor."

[13] The White House, National Space Policy, Presidential Directive / NSC-37, 1978.
[14] Weekly Compilation of Presidential Documents, 9 October 1978.
[15] Frank C.Carlucci to Philip M. Klutznik, 14 October 1980.

- "…an inadequate or poorly implemented system of capital investments poses the risk of developing and inefficient or unreliable remote sensing system…this will only serve to further stimulate foreign competition in the international market…the Europeans and Japanese are already making major remote sensing advances…"

1980 Reference Point: U.S. Concerns in Retrospect about France and Japan

The benefit of time shows that the concerns were more about preserving Landsat than foreign commercial competition. In fact, the United States did not try to privatize Landsat operations until 1986, the same year that France launched its first SPOT-1 satellite. In 2005, 25 years after U.S. concern about French competition, SPOT Chairman and CEO Herve Buchwalter projected that gaining a foothold in the high resolution imagery market would be a major challenge.[16] Nonetheless, he said that "…we are looking to carve out a substantial share of a market that today is a virtual monopoly of the United States…The shift towards higher resolution, facilitating wider access to strategic information, is also viewed by the international community as something that will stabilize the geopolitical context." His company begins that quest in 2011 with the launch of its first Pleiades sub-meter resolution imagery satellite. This could be a basis for renewed U.S. concern over foreign competition.

Regarding Japan, since 1987 the government has deployed a range of earth observation satellites. But, a 2009 Japanese government report states that the commercial benefit has been weak to non-existent;[17] "…the international competitiveness of Japan's space industry is weak…Especially for observing sensors, in the area of optical sensors, which is implemented commercially, Japan has not gained much competitiveness…In light of these circumstances, it is important to strengthen the international competitiveness by developing Japan's space industry into a strategic industry for the 21st century after the electronics and automobile industries."

The Japanese company NEC offers a 0.5 meter resolution small satellite in a space products catalog.[18] This may indicate a move to compete in this sector, using an optics contribution by a U.S. firm,[19] not just field such a system for national security purposes.[20] An observer of Japanese space-related developments also indicates that it may be an attempt by NEC to compete with Mitsubishi for a next generation spy satellite project.[21]

[16] Spot Magazine, No. 40, 2nd Semester 2005, pp. 14-17.
[17] Japan's Strategic Headquarters for Space Policy, Basic Plan for Space Policy, 2 June 2009.
[18] The Society of Japanese Aerospace Companies, Directory of Japanese Space Products & Services, 2009.
[19] Goodrich Press Release, Goodrich to Support Japan's Next Generation Advanced Observation Satellite, 11 February 2009.
[20] Bob Weber, Japan: Spy Satellite Program Advances Despite Barriers, April 2010.
[21] http://milspacejapan.blogspot.com/, 18 October 2010.

President Reagan took office in January 1981. He issued a new National Space Policy.[22] Guidance to spur commercial use of space was included.

- "The United States encourages domestic commercial exploration of space capabilities, technology, and systems for national benefit. These activities must be consistent with national security concerns, treaties, and international agreements."

- Moreover, regarding cooperation in Federal civil activities such as Landsat, the policy was to "Support the public, nondiscriminatory direct readout of data from Federal civil systems to foreign ground stations and provision of data to foreign users under specified conditions."

President Carter and President Reagan each issued policy that affected earth observation, but the first U.S. law on this subject was not passed until 1984.[23] The law was based on the Reagan Administration's view that commercial enterprise in the United States could do certain things more effectively than the Government. For this reason, the law was an attempt to privatize Landsat system operations. Nonetheless, the findings of the Congress retained a role for the Government because it was not clear that earth observation would succeed as a commercial activity.

- "…the national interest of the United States lies in maintaining international leadership in civil remote sensing and in broadly promoting the beneficial use of remote sensing data."

- "…competitive, market-driven private sector involvement in land remote sensing is in the national interest of the United States."

- "…there is doubt that the private sector alone can currently develop a total land remote sensing system because of the high risk and large capital expenditure involved."

The principle of nondiscriminatory access to data was upheld in the 1984 law. This meant that provision of data could not favor one buyer or class of buyers over another.

- The key part of the law that affects commercial earth observation licensing today was the requirement for the Secretary of Commerce to consult with the Secretary of Defense on all matters about the law that would affect national security, and for

[22] The White House, National Space Policy, National Security Decision Directive Number 42, 4 July 1982.
[23] U.S. Congress, Land Remote Sensing Commercialization Act, Public Law 98-365, 17 July 1984.

Defense to notify Commerce about relevant conditions needed in a commercial license.

- Moreover, the Secretary of Commerce was required to consult with the Secretary of State on all matters about the law that could affect the international obligations of the United States, and for State to notify Commerce about conditions needed in a commercial license.

The law also required the operator to notify Commerce of any agreements with foreign nations or entities, provide to the U.S. Government the technical specifications of the system, and permit inspection of the company's equipment, facilities and financial records. These rules were in effect before the first SPOT satellite was launched in 1986. Only one license was issued under the 1984 law; it took until 1987 for Commerce to issue licensing regulations that set forth procedures for submission and Government review of license applications.[24] These regulations are known as 15 CFR Part 960. CFR means Consolidated Federal Regulations.

1986 – 1990 Policy Framework

1986 was a pivotal year that further defined the importance of the U.S. Government's role regarding the operation of earth observation systems.

- SPOT 1 was launched in February, just weeks after a launch accident involving the U.S. Space Shuttle Challenger, and before a reported April launch failure for a U.S. reconnaissance satellite.[25] As a result, there was much focus on space policy and performance in the United States.

- The Chernobyl reactor in the USSR exploded two months after SPOT's launch, giving news organizations worldwide their best overhead view of the scene, and a way to "penetrate Soviet secrecy."[26]

A new U.S. National Space Policy was released in February 1988, near the end of President Reagan's administration.[27] The fundamental objective was space leadership, but the policy stated that "Leadership in an increasingly competitive international environment does not require United States preeminence in all areas and disciplines of space enterprise." The

[24] Department of Commerce to Office of the Federal Register, 27 November 1995.
[25] Wikipedia, KH-9 Hexagon, 2 September 2009.
[26] On 2 May 1986, The Washington Post ran a lengthy article on "The Nuclear Accident at Chernobyl." In June 1986, the Washington Journalism Review used a SPOT photo of Chernobyl to discuss the possible public impact of high-quality imaging from space. The USA Today called SPOT "the ultimate skycam". On 11 August, in a front page The Washington Times story, titled "Photo satellites for media worry intelligence brass", a former CIA official said he was "…not used to seeing pictures like that outside the agency."
[27] The White House, Fact Sheet on Presidential Directive on National Space Policy, 11 February 1988.

policy also made key points about commercial space activities, including earth observation, and how to stimulate it.

- "The United States shall encourage and not preclude the commercial use and exploitation of space technologies and systems for national economic benefit without direct Federal subsidy. These commercial activities must be consistent with national security interests, and international and domestic legal obligations."

- "The United States shall encourage other countries to engage in free and fair trade in commercial space goods and services."

- "Commercial space activities shall be supervised or regulated only to the extent required by law, national security, international obligations, and public safety."

- "The United States Government will encourage the development of commercial systems which image the Earth from space competitive with or superior to foreign-operated civil or commercial systems."

- "To stimulate private sector investment, ownership, and operation of space assets, the United States Government will facilitate private sector access to appropriate U.S. space-related hardware and facilities, and encourage the private sector to undertake commercial space ventures."

The policy also stated that the Department of Commerce would commission a study to provide information for future policy and program decisions on options for a commercial advanced earth remote sensing system.

Within weeks after the policy was issued, however, a law firm representing several news media entities petitioned the Department of Commerce to amend the regulations for private remote sensing systems.[28] The news media alleged that the regulations were so vague "that they chill commercial interest in remote sensing", and were not consistent with the new Reagan policy.[29] Commerce believed that the regulations encouraged a climate for the growth of commercial remote sensing, but agreed to consider clarifying certain principles.

The 1989 transition to the term of President George H.W. Bush resulted in a directive that was a continuation of the Reagan guidance to encourage to the maximum extent feasible

[28] Kathleen A. Kirby to Michael Mignono, 2 February 1996.
[29] Federal Register, Vol. 54, Notice on Licensing of Private Remote Sensing Space Systems, 18 January 1989.

the development and use of United States private sector space capabilities, but was more specific about earth observation.[30] The Government would:

- "ensure the continuity of Landsat-type satellites."
- " discuss remote sensing issues and activities with foreign governments operating or regulating the private operation of remote sensing systems."
- "encourage the development of commercial systems, which image the Earth from space, competitive with, or superior to, foreign operated civil or commercial systems."

This directive meant that the U.S. Government would encourage commercial operators to operate systems at least as capable as commercial systems such as SPOT, or civil systems such as Europe's Earth Resources Satellite (ERS).

1990 Reference Point: U.S. Government Policy

The late 1989 policy of President George H. W. Bush encouraged United States competition with foreign civil and commercial imaging systems, not one or the other.[31] The logic was sound because neither France nor Japan had made leaps in this field. Deploying commercial systems better than SPOT, and Japan's first Marine Observation Satellite launched in 1987 was not a technical issue. MOS-1 was designed to monitor natural resources, even though *Aviation Week and Space Technology* reported that it could image airfields.[32] U.S. industry could meet that test because U.S. intelligence satellites collected better than one-meter resolution imagery by 1966.[33]

By early 1991, Government guidance supported using anchor tenancy as a model for supporting commercial business ventures.[34] Initial contractual support for Government purchase of product or service would spur industry in the short term, but give way on grounds that long-term viability and growth must come primarily from the sale of product or service to customers outside the U.S. Government. Twenty years later, however, according to DigitalGlobe and GeoEye annual reports, potential loss of Government funding is a risk factor. The risk is substantial because much of the companies' revenue derives from the Government, which is subject to annual appropriation.

[30] The White House, National Space Policy Directive Number 1, 2 November 1989.
[31] Ibid.
[32] Aviation Week and Space Technology, 23 March 1987.
[33] Brochure from Historical Imagery Declassification Conference, 20 September 2002, page 3.
[34] The White House, National Space Policy Directive 3, 11 February 1991.

1991-1994 Policy, Legal, and Regulatory Framework

U.S. commercial space policy guidelines were issued in February 1991.[35] Remote sensing was listed as one of five specific commercial space-related areas. For the purposes of the guidance, remote sensing was "…the private development, manufacture, and operation of remote sensing satellites and the marketing of remote sensing data." As a matter of policy, commercial space objectives would not involve the use of direct Federal subsidies because "…the commercial market ultimately determines the viability of the activity."

The guidance was crafted to allow companies involved in remote sensing to succeed or fail on their own merit, without Government support. Nonetheless, U.S. Government agencies were encouraged to use commercial services.

- "U.S. Government agencies shall actively consider, at the earliest appropriate time, the feasibility of using commercially available products and services in agency programs and activities."

- "U.S. Government agencies shall enter into appropriate cooperative agreements to encourage and advance private sector basic research, development, and operations. Agencies may reduce initial private sector risk by agreeing to future use of privately supplied space products and services where appropriate."

One of the keys to the guidance was the kind of Government arrangement with companies that would provide initial Government support, but not be the long-term basis for success of the business venture. Anchor tenancy was cited as a method.

- "Anchor tenancy is an example of an arrangement whereby U.S. Government agencies can provide initial support to a venture by contracting for enough of the future product or service to make the venture viable in the short term. Long-term viability and growth must come primarily from the sale of product or service to customers outside the U.S. Government."

The White House put in place a policy foundation supporting commercial remote sensing business ventures, but within one year Congress passed a law that reestablished Landsat as a Government program. [36] The law was a sign that the mid-1980s attempt to privatize system operations failed. In House of Representatives Report 102-539, foreign competition was cited by the House Committee on Science, Space, and Technology as a factor

[35] Ibid.
[36] U.S. Congress, "Land Remote Sensing Act of 1992", Public Law 102-555, 28 October 1992.

that was not in play when the 1984 law was passed. The fact that SPOT began operating in 1986 had an impact on the 1992 law: "These [foreign] systems operate within a commercial marketplace in which [U.S.] national security constraints can cause significant competitive disadvantages."

The Committee made an important statement, but it did not become law and apparently has not been a serious consideration for almost 20 years: "U.S. land remote sensing systems should be permitted to provide whatever level of spatial resolution or other technical specifications may be of interest for civilian or commercial applications." As a result, U.S. Government agencies spend much time debating system characteristics that involve national security and foreign policy issues.

1993 – 1995 Policy Push

The 1992 law resulted in extensive discussion and debate in 1993 about relevant Government regulations needed under President Clinton's administration to ensure compliance. Private companies wanted to operate commercial earth observation systems, and testified to Congress about the need for a flexible regulatory environment that would not stifle business. In informal review of draft regulations issued by the Department of Commerce, a government working group with expertise on national security matters reminded Commerce via letter from the Central Intelligence Agency of text in its Notice of Proposed Rulemaking:

- "There is a presumption that the Government can resolve national security concerns through conditions in a license rather than by outright denial except in the case of systems with ground resolutions of better than one meter."[37]

This gave an indication that commercial systems with better than one meter capability would be a challenge to license for operation.

On 10 March 1994, the Department of Commerce hailed the Clinton administration's "New Policy on Remote Sensing Space Capabilities."[38] This was described as an effort to increase global market access for American business, and help create jobs. The market for space-based imagery was projected to be in the range of $5 to $15 billion by 2000, including the market for geographic information systems. There was a presumption that licenses would be granted to operate commercial systems with performance characteristics already available or planned for availability in the marketplace, such as SPOT.

Six weeks after the Department of Commerce announcement, a license was granted to Lockheed Missiles and Space Company to operate a private remote sensing system, about ten

[37] Darlene M. Connelly to John Milholland, 14 September 1993.
[38] The White House, Presidential Decision Directive 23, 10 March 1994.

months after the company filed a license application.[39] One of the key points in the license, and in subsequent licenses for other companies, was the requirement to comply with the 1992 law. Specifically, "The Licensee shall operate the system in a manner that preserves the national security and observes the international obligations and foreign policies of the United States." The Licensee was not authorized to decide on its own how to comply with this rule. As a result, U.S. Government experts from multiple agencies set the conditions.

In December 1995, the Department of Commerce sought public comment on how the Department could best implement regulations consistent with the 1994 White House policy.[40] This is consistent with the practice of "open" government in the United States. Almost seven months elapsed before a public hearing was held to amend 15 CFR 960.[41] Nonetheless, nine licenses to operate private remote sensing systems were issued from 1993 – 1995, compliant with the 1992 law.[42]

1990 - 2000 Commercial Satellite Imagery Projections

In 1992, the commercial satellite imagery data market had $100 million in annual sales, and was growing at 20-30 percent annually.[43] This was only a fraction of the size of the Geographic Information Systems (GIS) industry valued at $5.3 billion. Nonetheless, observers did not expect sales of imagery to pay for the construction of new satellites anytime soon. Sales of imagery in 1991 from the French SPOT system were $40 million, enough to cover the costs of satellite operations. For the same year, revenue from sale of Landsat data and services was $32 million.[44] By mid-1994, when the Government championed a vibrant way ahead for commercial satellite imagery, estimates of the data market ranged from $80 to $400 million per year.[45] In 1995, the Department of Commerce indicated the market for this imagery was $315 million.[46]

The path for U.S. commercial satellite imagery success was shaped by operational parameters permitted for such satellites. In 1996, an independent panel reviewed possible future satellite designs by the National Reconnaissance Office (NRO). The panel stated that it did not believe "…our key needs can be met by the products of the current commercial space

[39] Robert S. Winokur to Albert E. Smith, 22 April 1994.
[40] Federal Register, Vol. 61, Notice of Inquiry and Request for Public Comment on 15 CFR 960, 4 December 1995.
[41] Federal Register, Vol. 61, Notice of Public Hearing on 15 CFR 960, 15 May 1996.
[42] Department of Commerce to Office of the Federal Register, 27 November 1995.
[43] Remote Sensing Sales Grow With Expanding Data Needs, Aviation Week and Space Technology, 13 July 1992.
[44] Scott N. Pace, Public-Private Sector Collaboration to Demonstrate Advanced Remote Sensing Technologies, 27 October 1992.
[45] Tim Bauer and Chris Hassapis, Commercial Remote Sensing Systems and the Market, Project West Wing, August 1994.
[46] Katherine McIntire Peters, Space Wars, GovExec.com, April 1998.

imaging companies."[47] Almost as if defining a line between the capabilities of NRO satellites and commercial counterparts, the panel encouraged the Government to use products from companies who could provide imagery from 1 to 4 meter resolution systems.

- An author in 1997 noted that commercial imagery could be a threat to the imaging dominance of the NRO.[48] But, he assessed that future military reconnaissance could become more closely tied with private sector systems.

- The director of the French space agency CNES said that the U.S. commercial imagery strategy was to meet the international demand for intelligence imagery without giving up control of national technology.[49]

- The MITRE Corporation concluded that U.S. commercial imagery companies would require U.S. military and intelligence users to fund them for years.[50]

In January 1999, the President of the International Society for Photogrammetry and Remote Sensing (ISPRS) assessed in a presentation to his membership that the impact of high-resolution satellite imagery could be "major" regarding many aspects of human activity.[51] He appealed to the membership to bring to public attention the benefits and applications of the industry. A market research firm estimated that the $173 million imaging market would grow to $419 million in 2005.[52]

In 1999, an expert who tracks the planning and deployment of earth observation systems, reported that only the United States and Israel were expected to have one meter or better resolution satellite systems by the end of 2001.[53] Meanwhile, the Director of the National Imagery and Mapping Agency (NIMA) told commercial imagery managers that Fiscal Year 1999 NIMA purchases of imagery and production support using commercial imagery would be $7.3 million dollars.[54] He estimated this would increase to $29 million in Fiscal Year 2000, more than a 1998 NIMA projection,[55] and $201 million in Fiscal Year 2005. This aligned with a

[47] Independent Panel Review of Small Satellites, Director of Central Intelligence, 29 June 1996.
[48] Bill Sweetman, Spy Satellites: The Next Leap Forward, International Defense Review, 1 January 1997.
[49] Ibid.
[50] E. Lee Tilton III and Pitt G. Thome, Commercial Remote Sensing Infrastructure and Related Services, The MITRE Corporation, November 1997.
[51] Lawrence W. Fritz, High Resolution Commercial Remote Sensing Satellites and Spatial Information Systems, July 1999.
[52] Frost & Sullivan, Projection for Worldwide Revenues for Commercial Satellite Imagery, 1999.
[53] Willam E. Stoney, Summary of Land Imaging Satellites Planned to be Operational by 2003, 18 May 1999.
[54] LTG James King, IGC-Commercial Remote Sensing Industry Forum, 22 October 1999.
[55] Warren Ferster, NIMA Funds Bolster Private Imagery Firms, SpaceNews, 23 March 1998.

construct by the Director, National Reconnaissance Office (NRO) to give commercial companies "some incentive to know that as their capabilities increase, the amount of purchases by the U.S. Government will also likely increase."[56] A user market analysis by the National Remote Sensing Centre in the UK noted that spatial resolution and frequency of acquisition are the two most important factors to support military needs.[57]

The President of ISPRS was not alone in his assessment that commercial satellite imagery would flourish. Years earlier a staff study by the Permanent Select Committee on Intelligence declared that "Commercial [imagery] systems will allow everyone, including our foes, to have access to high resolution imagery."[58] With regard to arms control, a study found that wider availability of such imagery could reduce U.S. Government influence due to its previous near-monopoly on such imagery, and increase the time needed to achieve consensus among governments.[59] According to *The New York Times*, competition in the satellite imagery sector heated up as Russia entered the fray.[60] The article included a Russian photo of lower Manhattan, including the World Trade Center with shadows falling on the Hudson River, 15 months before 9/11.

1996 – 2000 Buildup to Commercial Imagery Satellite Operations

The White House released a new National Space Policy just before the end of President Clinton's first term.[61] There was continued Government support for commercial earth observation capabilities, including technology development partnerships with industry. Use of Public Private Partnerships normally associated with similar projects in Europe was not specified in the policy. With regard to international cooperation, the policy stated that "…the U.S. Government will seek mutually beneficial cooperation with U.S. commercial and other national and international Earth observation system developers and operators."

The 1994 and 1996 policies did not eliminate all concerns about earth observation system licensing by potential operators. There was no movement for years on a 1993

[56] NRO May Shift Routine Work to Commercial Operators, Aviation Week Space Business, 19 July 1999.
[57] NRO Profile and Commercial Policy for Satellite Imagery, CSP Associates, Inc., 24 February 1999,
[58] HPSCI. The Intelligence Community in the 21st Century. 9 April 1996.
[59] Lewis Dunn and Richard Davis, Implications of Commercial Satellite Imagery on Arms Control, Science Applications International Corporation, 5 April 1999.
[60] Russian Agency Sells Close-up Images from Far Away, The New York Times, 20 June 2000.
[61] The White House, Fact Sheet on National Space Policy, 19 September 1996.

suggestion by Congressman George Brown of California "…to put up a dual-purpose radar satellite, let the intelligence agencies use it, and sell the products on the commercial market."[62]

- In 1997, former Senator Dennis DeConcini expressed concern that "no U.S. company has been licensed to sell high resolution radar imagery."[63] Noting that 12 U.S. companies had been granted licenses since 1992, but none for radar, he argued that "If [Commerce] does not license a radar satellite system, then a foreign owned radar system, with a one meter or less capability, will enter the market leaving the U.S. government with no effective control in this area."

- DeConcini made his argument one week before a letter from senators on the intelligence and appropriations committees was sent to the Director, NRO seeking an unclassified technology demonstration for a radar satellite.[64] DoD reportedly wanted restrictions on commercial radar satellites that companies believed would impair business.[65]

- In May 1998, former Senator Tom Daschle wrote to the Pentagon noting that "If currently proposed restrictions on U.S. commercial remote sensing satellites are not revised, the capabilities of foreign SAR systems will quickly exceed those of the United States."[66] DoD's reply was that policy was to approve any license requests submitted by U.S. firms, "…contingent only upon the inclusion of operational and data distribution restrictions necessary to protect national security."[67] The specific license conditions were important because Canada's planned Radarsat-2 system would result in products better than could be sold by U.S. companies.[68]

- A radar satellite operating license was granted to a U.S. company in June 1998, but revoked two years later due to contract fraud against the U.S. Government.[6970]

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[62] Congressional Record. Congressman Brown wanted to invest in dual-use satellites to save money on classified ones because the cost was causing "…a tremendous gap in our intelligence. We know nothing about what is going on in the Muslim world. There is a hiatus in terms of human intelligence about the great revolutionary movement shaking the world." 3 August 1993. p. H5698.
[63] Dennis DeConcini to David Strauss, 8 April 1997.
[64] Richard Shelby, Robert Kerrey, Ted Stevens, and Daniel Inouye to Keith Hall, 15 April 1997.
[65] Warren Ferster, DoD Imperils Private Radar Satellites, SpaceNews, 24 November 1997.
[66] Tom Daschle to John Hamre, 6 May 1998.
[67] John Hamre to Tom Daschle, 7 August 1998.
[68] Warren Ferster, U.S. Firms Demand Parity to Radarsat-2, SpaceNews, 9 March 1998.
[69] Warren Ferster, RDL Nabs First License for U.S. Radar Satellite, SpaceNews, 22 June 1998.
[70] www.janes.com/articles/Janes-Defence-Weekly-98; Los Angeles Times, 14 September 1998; www.spaceref.com/news/viewpr.html?pid=3006; www.justice.gov/opa/pr/2000/November/649.civ.html

In March 1998, four years after PDD-23, The White House issued guidance on how the President's policy would be implemented.[71] The focus of the guidance was on proposals by U.S. companies to export advanced remote sensing systems. One of the guiding prerequisites for an export decision was whether the proposed export had performance characteristics "…already available commercially or planned for availability on the international market." Decisions on actual exports of systems on the U.S. Munitions List were to be made in accord with existing laws and regulations, including the Arms Export Control Act, and the International Traffic in Arms Regulations (ITAR).

United States earth observation law, policy, and regulation were aligned by 1999 when the first IKONOS commercial imaging satellite was launched. The January 1999 version of 15 CFR 960 specified what is in an operator's license.

- The name and address of the person to whom the license is being issued, effective date, and license duration.

- The characteristics of the system, including range of orbits and authorized altitudes.

- The range of spatial resolution or instantaneous field of view authorized, and the spectral bands authorized.

Also included in licenses are terms and conditions necessary to ensure "Compliance with any national security concerns and any international obligations specified by the Department of Defense and State respectively." This factor remained as important as it was in the 1984 and 1992 laws. In January 2000, The White House Office of Science and Technology Policy stated that U.S. Defense, State, and Intelligence leaders had agreed on "interagency procedures on commercial imaging systems."[72] The Memorandum of Understanding took into account equities in various U.S. Government agencies, and indicated that the Secretary of Commerce would make decisions on license applications within 120 days after submission.

The Department of Commerce in July 2000 sought comments on an Interim Final Rule regarding licensing of private remote sensing systems.[73] The Rule would take into account the interagency MOU. The concern about licensing commercial radar systems, however, was not the only public concern on licensing of private imaging systems. The Department of Commerce received 24 replies after its November 1997 request for comments that would be factored into

[71] The White House, Implementation Guidance on NSC/PDD-23, 18 March 1998.
[72] The White House, Fact Sheet on MOU Concerning the Licensing of Private Remote Sensing Satellite Systems, 13 January 2000.
[73] Federal Register, Vol. 65, Interim Final Rule on Licensing of Private Remote Sensing Space Systems, 31 July 2000.

the Interim Final Rule for 15 CFR 960. Three U.S. companies reacted negatively in an October 2000 letter.[74]

- "…we believe that the Interim Rule is an impossible abdication by the Department of Commerce of its Congressionally delegated licensing authority and its authority to resolve conflicts between national security, foreign obligations, and commercial interests. These are duties that can be undertaken only by the Secretary of Commerce and cannot be delegated to a vague and indefinite interagency process… The licensing regime affected by the Interim Final Rule represents a profound threat to the survival of our still-embryonic industry."

Notwithstanding the interagency process, in 2000 the U.S. firm Space Imaging had Ikonos as an operational system, and ended the year with a license to operate a half-meter resolution commercial satellite, according to a company press release and a February 2001 report to Congress by The Office of Space Commercialization in the Department of Commerce.[7576] Space Imaging anticipated that it would launch a new satellite in 2004.

2000 Reference Point: Commercial Satellites Operational; Regulatory Debate Continues

The U.S. firm Earthwatch, Inc. was successful in its 24 December 1997 launch of a 3-meter resolution commercial imagery satellite, but it failed in orbit. Earthwatch grew out of a business formed in 1991 to be a supplier of imagery to GIS, mapping, resource management, and environmental monitoring markets.[77] Owing to the satellite's resolution, Government concerns about its operation were not as significant as for 1-meter systems. U.S. industry concerns about Government regulatory behavior were not assuaged, however, by the success of the Ikonos 1-meter satellite, and approval for companies to operate commercial satellites that could provide 0.5m resolution optical imagery. The decision fulfilled the Government's objective to allow U.S. companies to operate systems on par with, or better than, non-U.S. competitors. In 2000, neither France nor Japan had such systems. Nonetheless, a report on the 21st Century projected that over the next 25 years "many other countries will learn to launch satellites to communicate and spy."[78]

[74] Herbert Satterlee, Gilbert Rye, and John Copple to Charles Wooldridge, 26 October 2000.
[75] Space Imaging Press Release, 6 December 2000.
[76] www.space.commerce.gov/library/reports/2001-02-congress.shtml
[77] Walter Scott, Prepared Statement to the Senate Select Committee on Intelligence, 17 November 1993.
[78] U.S. Commission on National Security / 21st Century, Major Themes and Implications, 15 September 1999.

2000 – 2010 Commercial Satellite Imagery Projections

In January 2000, the IKONOS imagery satellite began operations, opening a new era for high resolution commercial space-based imaging. Nonetheless, an industry observer wrote that the United States was mired in uncertainty and complexity, "…creating not only the opportunity but the incentive for others to participate…" in commercial remote sensing.[79] One of the uncertainties was a large new U.S. spy satellite program that would be launched in 2005. Media reporting indicated the program would cost $25 billion over 20 years.[80]

Based on research by Frost & Sullivan, Space Imaging, Inc. estimated in 2000 that the market for 0.5 to 1 meter resolution imagery would grow from 29 percent to 44 percent in 2005.[81] The estimate was optimistic, as was an estimate in a wide-ranging study conceived in 1999, published in 2004, by the American Society of Photogrammetry and Remote Sensing (ASPRS) forecasting that sale of satellite imagery by 2010 would be $2 billion per year. [82] Nonetheless, the ASPRS data implied that users would want more imagery better than 1 meter in resolution.

The National Imagery and Mapping Agency planned to "purchase first and second-generation commercial imagery and imagery-derived products, gradually increasing purchases over the next few years as the number and capabilities of commercial systems grow."[83] In Fiscal Year 2001, the agency allocated $25 million for these purposes.[84] Although NIMA reportedly bought all rights to commercial imagery of Afghanistan after the 9/11 terrorist attacks, the director of NIMA later said "It's pretty unlikely we would do that again."[8586] Frost & Sullivan estimated that the DoD and other Government agency share of the market would decrease from over 60 percent in 2003, to less than 56 percent in 2010. [87]

Projections for commercial satellite imagery competition were important for U.S. Government regulators as well as private sector satellite operators. For example, ImageSat International of Israel announced in February 2001 that it would field by 2003 a satellite called EROS B capable of collecting better than one meter resolution imagery.[88899091] Space Imaging

[79] Kevin O'Connell, Commercial Remote Sensing Next Generation Licenses, 26 July 2000.
[80] Joseph Fitchett, Spying from Space: U.S. to Sharpen the Focus, International Herald Tribune, 10 April 2001.
[81] Briefing Chart by Space Imaging sourced to Frost and Sullivan. Commercial Remote Sensing Data Market. 2000.
[82] Photogrammetric Engineering and Remote Sensing, Volume 70, Number 1, January 2004.
[83] National Imagery and Mapping Agency. Questions and Answers on Use of Commercial Satellite Imagery, 20 October 2000.
[84] NIMA, NIMA Plans for Commercial Imagery Expenditures, 22 January 2001.
[85] David Whitehouse, US Buys Afghan Image Rights, BBC online, 17 October 2001.
[86] Kerry Gildea, NIMA Unlikely to Enter Future Exclusive Access Deals for Commercial Imagery, Defense Daily, 5 June 2002.
[87] Frost & Sullivan, North American Remote Sensing Vertical Market Analysis, 2004.
[88] Barbara Opall-Rome, EROS A1 Satellite Returning First Images, SpaceNews, 10 January 2001.

stated that whereas U.S. companies had a "commercial only" business model, companies in France and Israel were government subsidized.[92] An expert industry observer reported in October 2004 that 13 countries would have mid-to-high resolution imagery satellites in orbit by 2010.[93] In mid-2005, a research analyst at Frost & Sullivan told an Indian newspaper that worldwide sale of satellite image data would be around $1 billion for that year.[94] According to the CEO of SPOT Image, the entire earth observation chain would shift away from full funding by governments to public-private partnerships.[95] In a Congressional Research Service report, DigitalGlobe and GeoEye's precursor named ORBIMAGE were reportedly struggling due to a limited market for their products.[96] The ORBIMAGE / GeoEye CEO noted that a well supported industry provides great value to the Government because it provides more capacity, redundancy and sharable data.[97]

By 2007, U.S. commercial satellite imagery companies had gained years of operating experience, and NIMA's October 2003 transformation into the NGA was well underway. Shortly after a report was published on the role of commercial imagery in NGA-related activities, the Director, NGA noted that technology developments over time would lead to more overlap than in the past regarding government and commercial imagery programs.[9899] Survey data by ASPRS in 2008 suggested that both satellite and aerial high resolution imagery would remain in demand.[100] About 17 percent of respondents to an ASPRS survey indicated use of 0.5 to 1 meter imagery, but 45 percent said they use 0.05 to 0.5 meter data. At around the same time, the satellite consulting firm Euroconsult estimated that commercial satellite data sales would increase from $735 million in 2007 to $2.5 - $3.4 billion in 2017.[101]

Making commercial satellites more capable increases their utility for military and other purposes.

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[89] Barbara Opall-Rome, Israeli Firm Cancels Plan for EROS A2 Imaging Satellite, SpaceNews, 20 February 2001.
[90] Robert Wall, ImageSat to Expand Satellites, Customers, Aviation Week and Space Technology, 8 July 2002.
[91] Israeli-Built Imaging Satellite Begins Operations, Jane's International Defense Review, February 2001.
[92] John R. Copple, Global Remote Sensing Programs, 6 December 2000.
[93] W.E. Stoney, ASPRS Guide to Land Imaging Satellites, Special Edition, GeoTech 2004, 12 October 2004.
[94] N. Gopal Raj, Mapping the Earth from a New High, The Hindu, 7 May 2005.
[95] Interview with Herve Buchwalter, SPOT Magazine, No. 40, 2nd Semeseter 2005.
[96] Patricia Moloney Figliola, CRS Report on U.S. Space Programs: Civilian, Commercial, and Military, 13 June 2006.
[97] Matthew O'Connell, The Role of Commercial Earth Observation in National Security, 10 May 2006.
[98] Peter Marino, Independent Study of the Roles of Commercial Remote Sensing in the Future National System for Geospatial Intelligence, 16 July 2007.
[99] Warren Ferster, Profile of U.S. Navy Vice Admiral Robert B. Murrett, SpaceNews, 19 October 2007.
[100] Charles Mondello, ASPRS Ten-Year Remote Sensing Industry Forecast, Photogrammetric Engineering and Remote Sensing, November 2008.
[101] Adam Keith, Euroconsult, Earth Observation Remote Sensing Trends, Briefing for the ACCRES, 7 October 2008.

- The German Space Agency (DLR) reported in September 2009 that future high-resolution satellite imagery could render aerial photogrammetry obsolete.[102] DLR stated that the Hubble Telescope has a 2.4 meter diameter mirror. This number matched a comment by a U.S. intelligence official that 2.4 meters is also relevant to imaging satellites.[103]

- Sentiment in Congress favored pursuit of 1.5 meter diameter aperture for a commercial satellite, an increase from what is now orbit.[104][105] An NGA official stated that the agency was seeking a capability "approaching a quarter meter" in resolution in a project called EnhancedView.[106]

- Meanwhile, the Director, NRO focused on classified Government imagery programs, noting that the NRO would launch a classified satellite within 15-18 months, and bump a commercial satellite launch, if necessary.[107]

Non-U.S. commercial satellite imagery projects advanced while U.S. Government insiders and outsiders were fixated on aperture size. An industry observer notes that developing spacecraft to collect better than one meter resolution imagery is no longer technologically risky.[108] France's first Pleiades satellite, with an aperture diameter of 0.650 meters, is no match for the technology in U.S. Government or commercial satellites, but French engineers assessed that the performance of Proto Flight Model optics had outstanding image quality performance compared to the technical requirement.[109] The Charged Coupled Devices in the imaging sensor were made by a UK company, based on chips made by a U.S. firm known as QP Semiconductor before it was acquired by the UK company.[110]

In 2009, the future of commercial imagery seemed bright, including for selective national security requirements, even though Government experts assessed that commercial systems do not provide the quality, volume or timeliness of national systems.[111]

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[102] Andreas Eckhardt, The Bright Future of High Resolution Satellites, 9 September 2009.
[103] Warren Ferster, U.S. Intelligence Official Drops Hint About Next-Gen Spy Sat Capability, SpaceNews, 20 October 2009.
[104] Chris Strom, Hill Sends Mixed Signals to Imagery Firms, Government Executive.com. 13 October 2009.
[105] National Defense Authorization Act for Fiscal Year 2010, Senate Committee on Armed Services, 2 July 2009.
[106] Turner Brinton, NGA to Seek Higher Resolution Commercial Satellite Imagery, SpaceNews, 25 September 2009.
[107] Colin Clark, NRO Pledges on Budget Spy Sats, DoD Buzz, 21 October 2009.
[108] Bill Sweetman, Imaging from Space, Jane's International Defense Review, 4 April 2007.
[109] Catherine Gaudin-Delrieu, The High Resolution Optical Instruments for the Pleiades HR Earth Observation Satellites, Thalesaleniaspace.com, 2008.
[110] http://www.e2v.com/news. 25 March 2009.
[111] Space Posture Review, Interim Report, 2009.

- The deputy director of NGA indicated that the agency expected to increase use of both domestic and foreign commercial imagery, particularly in the next five to seven years.[112]

- In a 3rd Quarter 2009 results conference call with investors and customers, the GeoEye CEO stated that the worldwide demand for both surveillance and change monitoring imagery is recession resistant.[113] He termed this capability a highly coveted tool. DigitalGlobe also reported strong results for the Quarter.[114]

- Euroconsult reported that commercial satellite data sales would top $1 billion for 2009, and quadruple in the coming decade.[115] GeoEye projected that 2010 revenue would increase 12 to 16 percent.[116]

In Germany, DLR had designed a fleet of three 0.5 meter resolution optical satellites called HiROS and was looking for partners on this program. A payload related to HiROS was built for South Korea's Kompsat-3 satellite scheduled to launch in 2011 on a Japanese rocket.[117][118][119][120] Frost & Sullivan reported that the global remote sensing industry, including imagery, software and value-added services could grow to $8.34 billion by 2010.[121]

2001 – 2009 Policy, Regulatory, and Fiscal Framework

The success and increased sales projections for the commercial satellite imagery industry was related, in part, to a policy stimulus by the President George W. Bush administration that took office in January 2001. Forward-leaning policy and regulation, however, was no match for the impact on industry created by the flood of post-9/11 funds appropriated by Congress. Defense outlays have doubled in the last ten years, from $300 billion in FY01 to over $700 billion projected for FY11.[122] In September 2009, the Director of National Intelligence stated that overall spending on intelligence budget is $75 billion year.[123][124]

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[112] Tom Marlowe, Worldwide Imagery, Geospatial Intelligence Forum, June 2009.
[113] GeoEye, Inc. Q3 2009 Earnings Call Transcript, 10 November 2009.
[114] Space News Staff, DigitalGlobe Raises Outlook on Strong 3Q Results, SpaceNews, 13 November 2009.
[115] Euroconsult press release, 3 September 2009.
[116] Peter B. deSelding, GeoEye Reports Sharply Higher Earnings, 11 November 2009.
[117] Peter B. deSelding, Germany Eyes Teaming with Industry for Its Own Optical Satellite System, SpaceNews, 19 October 2009.
[118] Mitsubishi to Launch Korea's Kompsat-3, www.asmmag.com/news/mitsubishi, 14 January 2009.
[119] Mitsubishi Heavy Industries News Release No. 1270, MHI Receives Order for Launch Services of Korea Multipurpose Satellite-3, 12 January 2009.
[120] Wikipedia, H-IIA, November 2010.
[121] A New Age in Digital Satellite Imagery, Satmagazine.com, October 2009.
[122] Department of Defense. FY 2011 Defense Budget, February 2010.
[123] Dennis C. Blair, ODNI Transcript of Conference Call on 2009 National Intelligence Strategy, 15 September 2009.

This was up from the aggregate intelligence budget of $26.7 billion announced by the Director of Central Intelligence in March 1998.[125]

Since it is a virtual custom for Presidents to put their own stamp on space-related policies, in May 2002 the Bush White House began their review.[126] The review included the policy on commercial remote sensing and foreign access to U.S. remote sensing capabilities.[127] The President signed this guidance just three weeks after the Director of Central Intelligence wrote to the Director of the National Imagery and Mapping Agency about commercial imagery.[128][129][130][131]

- "It is the policy of the Intelligence Community to use commercial space imagery to the greatest extent feasible."

- "My goal in establishing this policy is to stimulate, as quickly as possible, and maintain, for the foreseeable future, a robust US commercial space industry."

Three months after the President's guidance, the Department of Commerce held the first meeting of the Advisory Committee on Commercial Remote Sensing (ACCRES).[132][133] The ACCRES was set up for Commerce to obtain a broad range of input from government, industry, and the non-profit sector regarding licensing issues for commercial remote sensing. During the meeting, the Department of Commerce reported that 18 licenses had thus far been granted for 41 satellites representing about $2 billion in investment. Nonetheless, according to the minutes of the meeting, the first two questions posed by the Chairman to the Committee involved U.S. leadership in the field.

- "How can [Commerce] license U.S. systems to compete effectively with new, advanced foreign systems?"

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[124] Walter Pincus, DNI Cites $75 Billion Intelligence Tab, The Washington Post, 17 September 2009.
[125] CIA Press Release, Disclosure of the Aggregate Intelligence Budget for FY98, 20 March 1998.
[126] The White House. Space Policy Review, Draft National Security Presidential Directive, 8 May 2002.
[127] The White House, National Security Presidential Directive/NSPD-15, 28 June 2002.
[128] George J. Tenet to Director, National Imagery and Mapping Agency, 7 June 2002.
[129] James Risen, CIA Instructs Spy Agencies to Use More Commercial Imagery, The New York Times, 26 June 2002
[130] NextView Will Provide the Vision and Solutions for New US Policy on Commercial Imagery, NIMA Pathfinder, July/August 2003.
[131] CIA Chief Orders Agencies to Rely on Private Satellites, International Herald Tribune, 27 June 2002.
[132] Department of Commerce. Charter of the Advisory Committee on Commercial Remote Sensing, amended 3 September 2004.
[133] Department of Commerce. ACCRES Meeting Minutes, 30 September 2002.

- "How can [Commerce], working with other USG agencies and foreign governments, help facilitate a better international business environment for U.S. commercial remote sensing firms?"

In April 2003, the White House issued another policy on commercial remote sensing.[134] This policy amplified the desire of the Government to help make U.S. commercial remote sensing more competitive in the global market. Key goals are to:

- "Rely to the maximum practical extent on U.S. commercial remote sensing capabilities for filling imagery and geospatial needs for both national security and civil agencies."

- "Enable industry to compete successfully as a provider of remote sensing capabilities for foreign governments and foreign commercial users…"

The policies, guidance and injection of about $1 billion in Government funds spurred a major advance in U.S. commercial satellite imagery. NGA announced in September 2004 that it awarded a second NextView contract to then-ORBIMAGE, Inc. (now GeoEye), for about $500 million.[135] This followed the September 2003 award to DigitalGlobe for a similar amount, and hundreds of millions spent on data from pre-2003 activity known as ClearView. According to NGA, the 2004 award would give the agency "assured availability" of 0.5m resolution imagery.

While Government money flowed to industry, the regulatory process continued. In 2004, according to the Department of Commerce, the average processing time for commercial operating license applications submitted since the 2000 interagency MOU was 234 days.[136] Making decisions about "precedent setting" license applications – such as granting a license for a commercial 0.25m instead of a 0.5m resolution system -- was the reason for review taking almost twice as long as specified in the MOU. From mid-2005 to mid-2006, according to ACCRES meeting minutes, the U.S. Government still on average needed about 200 days to review such license requests.[137] The number of licenses issued, however, and overall value of investment in earth observation satellites continued to increase. As of May 2006, 26 licenses had been granted with a system investment valued at $3.5 billion.[138]

As is custom in the United States, space policies are revised, updated and reissued to adapt to changing situations. In 2006, President Bush issued a comprehensive National Space

[134] The White House. National Security Presidential Directive/NSPD-27, 25 April 2003.
[135] NGA Media Release, NGA Awards NextView Second Vendor Agreement, NGA-04-04, 30 September 2004.
[136] Department of Commerce. NOAA Briefing for ACCRES, 27 August 2004.
[137] Department of Commerce, ACCRES Meeting Minutes, 12 September 2006.
[138] Kay Weston, Department of Commerce, The Economics of Data Policy, 10 May 2006.

Policy.[139] He did so only four months after the Department of Commerce issued its most recent "Final Rule" on licensing private remote sensing systems, 15 CFR 960.[140] Together with the 1992 law, the 2006 version of the regulations are the key guiding documents for commercial earth observation operators. Current policy, consistent over the last 30 years, is that the United States is "committed to encouraging and facilitating a growing and entrepreneurial U.S. commercial space sector."

A key goal in 2006 National Space Policy was to "Enable a dynamic, globally competitive domestic commercial space sector in order to promote innovation, strengthen U.S. leadership, and protect national, homeland and economic security." The United States was not leading, however, with regard to space-based commercial radar imaging systems. Although the Government granted a 1 meter resolution radar imaging license in 2000, the licensee was not authorized to sell better than 3 meter resolution imagery. Years passed while non-U.S. suppliers improved their capabilities. For example, the German Space Agency (DLR), and a German company (Infoterra GmbH) briefed the ACCRES on 20 September 2007 on Germany's pending satellite data security law, and the status of TerraSAR-X just launched in June. The first point in the Infoterra briefing was that TerraSAR-X is a "Market-driven system using innovative technology."[141] The first system characteristic listed was "1 meter imagery." The briefing was given two years before the 15th ACCRES meeting, when the Department of Commerce announced that a license had been granted to the Northrop Grumman to operate a radar imaging satellite capable of generating one-meter resolution imagery for commercial sale.[142][143]

U.S. Government licensing of high resolution commercial radar satellite imagery lagged compared with the pace for licensing optical systems (see text box below). Concerns over what adversaries might be able to do with all-weather, day-night imagery were magnified after 9/11 due to U.S. military operations in Afghanistan and Iraq. No one knew how the wars would turn out, and reports of U.S. military casualties filled the airwaves. Companies such as Halliburton were seen as profiting from the war,[144] and there was no appetite in the Government to give an adversary access to radar imagery just to support a company's bottom line. Moreover, caution in licensing seemed to make sense due to assertions that radar imagery processed on the ground results in better resolution than a system is designed to collect, regardless of analysis by Sandia National Laboratories indicating this is not possible. Image enhancement techniques to

[139] The White House. Presidential Decision Directive 49 / PDD-49, 31 August 2006.
[140] Federal Register, Vol. 71, Final Rule on Licensing of Private Land Remote Sensing Space Systems, 25 April 2006.
[141] Department of Commerce, ACCRES Meeting Minutes, 20 September 2007.
[142] Department of Commerce, ACCRES Meeting Minutes, 8 October 2009; Trinidad Private Remote Sensing License Public Summary, 2 October 2009; www.space.commerce.gov/news/2009
[143] Turner Brinton, U.S. Loosens Restrictions on Commercial Radar Satellites, SpaceNews, 8 October 2009.
[144] http://www.halliburtonwatch.org/news/waxman_120904.html, 9 December 2004.

make a scene "better looking" do not equate to increased resolution. Coupled with doubt over the commercial viability of commercial radar satellites, and concern over imagery proliferation with software to manipulate the data, there was little incentive to seize a leading global role in fielding such satellites. Although Google Earth was not released until June 2005, a tool called Keyhole Earthviewer to help users better view imagery was released in June 2001.

In late 2009, the Director, NGA credited operational success in his agency to various factors, including arrangements with commercial and international space providers.[145] His agency was well aware that foreign radar satellites were becoming available and could have immense value.[146] He said that success in geospatial intelligence hinges on moving toward an integrated, sensor-neutral architecture. Contracts were awarded by NGA for commercial radar imagery, valued up to $85 million each, from suppliers deriving data from three kinds of satellites, one each made in Canada, Germany and Italy.[147][148] An NGA study of TerraSAR-X showed that it had high accuracy, consistent with the advertised performance.[149][150][151] In May 2010, however, one of the contractors reported "sluggish" sales to the U.S. Government.[152] It is not unusual to evaluate non-U.S. data for relevance and utility, and buy it as needed. The former U.S. Defense Mapping Agency ordered test images in 1991 from a Soviet radar satellite,[153] and in the late 1990s the National Imagery and Mapping Agency assessed 48 Radarsat-1 images.[154]

There was no contract for Northrop Grumman, even though it had just received a license to operate a commercial radar satellite called Trinidad based on a satellite made in Israel.[155] The Israelis announced willingness to export such a system in 2005.[156] Northrop Grumman stated that Trinidad could provide access four times per day to mid-latitude targets,

[145] Robert B. Murrett, Comments at Strategic Space Symposium, www.strategicspacesymposium.org/media. 4 November 2009.
[146] Michael Hales, Foreign SAR Satellites on the Rise, Earth Imaging Journal, January 2008.
[147] Turner Brinton, NGA Solicits Proposals for Commercial Radar Imagery, SpaceNews, 11 September 2009.
[148] NGA News Release. NGA Awards Contracts for Commercial Satellite Radar Imagery, Data, and Downlink Services, Public Release Number 09-12, 29 December 2009.
[149] Infoterra Press Release, TerraSAR-X performance confirmed by NGA, 12 March 2009.
[150] www.geoconnexion.com, TerraSAR-X performance confirmed by NGA, 12 March 2009.
[151] EADS Astrium press release, TerraSAR-X marks two successful year in orbit, 15 June 2009.
[152] Peter B. deSelding, Canada's MDA Sees Business Case for In-Orbit Servicing, SpaceNews, 6 May 2010.
[153] Aviation Week and Space Technology, 1 July 1991.
[154] James Vrabel and Jon Leachtenauer, Civil and Commercial Applications Project for Satellite Imaging Systems, undated.
[155] Stew Magnuson, Israel Pushes New Satellite as Solution to U.S. Space Radar Needs, National Defense Magazine, January 2010.
[156] Barbara Opall-Rome, Israel Unveils Newest Spy Satellite for Export Market, SpaceNews, 13 June 2005.

would use flexible beam control techniques and offer rapid data downlink to transportable terminals.[157]

[157] Northrop Grumman, Trinidad Private Remote Sensing License Public Summary, 2 October 2009.

Licensing of High-Resolution Commercial Radar Imaging Satellites

These are selected key points regarding U.S. Government process, foreign technical developments, and U.S. business interests that are the basis on why there is no current operational U.S. commercial radar satellite.

November 1995: Canada's Radarsat 1 collects first image.[158] The system was capable of collecting 10-meter resolution data. Commercial sale of the data was planned for February 1996.

November 1997: Citing national security concerns, DoD opposes commercial sale of radar satellite imagery better than 5-meter resolution.[159] Based on two successful 1994 flights of the X-SAR radar sensor, Germany held a leading technical capability with good prospects for commercial use.[160]

June – November 1998: A U.S. company obtains a license to operate a 1-meter resolution commercial radar satellite, but data sold could not be better than 5-meters.[161] U.S. companies press for relief on the resolution limit due to Canada's future Radarsat 2 3-meter system.[162]

June – December 1999: The Government of Canada agrees with the United States that controls on commercial imaging satellites are needed.[163] An evaluation by NIMA finds that Radarsat 1 imagery can be used for some military tasks, such as detecting the presence of large aircraft (e.g., bombers).[164]

November 2000: A second U.S. company obtains a license to operate a commercial radar satellite, but resolution restrictions apply. Three-meter resolution imagery eventually is allowed for sale for parity with Canada.[165]

May 2001 – June 2001: A report by Sandia National Laboratories indicates that data from a radar satellite cannot be processed on the ground to provide better resolution than the design specifications of the satellite.[166] First release of Keyhole Earthviewer; after several updates, the product was released in June 2005 as Google Earth.[167]

September 2001: 9/11 terrorist attack on United States. Project start by Germany for a future 1-meter resolution radar satellite called TerraSAR-X.[168]

April 2003: United States attacks Iraq.

2004 – 2005: The Government considers, but does not issue a 1-meter commercial radar satellite license.

June – December 2007: TerraSAR-X is launched; Italy's COSMO-Skymed 1 is launched. These launches are followed in December by Radarsat-2, and COSMO-Skymed 2.

October 2009: Department of Commerce authorizes commercial sale of 1-meter resolution radar imagery.

[158] David Hughes, Radarsat Delivers First SAR Image, Aviation Week & Space Technology, 1 January 1996.
[159] Warren Ferster, DoD Imperils Private Radar Satellites, SpaceNews, 24 November 1997.
[160] Rolf-Peter Oesberge, Germany's International Space Commitment, Bonn Luft und Raumfahrt, October 1997.
[161] Warren Ferster, RDL Nabs First License For U.S. Radar Satellite, SpaceNews, June 1998.
[162] Warren Ferster, U.S. Firms Demand Parity To Radarsat 2, SpaceNews, 9 November 1998.
[163] Government of Canada News Release, Canada to Control Imaging Satellites, 9 June 1999.
[164] NIMA, Civil and Commercial Applications Project: Phase I (Radarsat) Final Report, December 1999.
[165] Department of Commerce, Commercial Remote Sensing Licensing Program, 18 October 2006.
[166] Sandia National Laboratories, Superresolution and Synthetic Aperture Radar, May 2001.
[167] Wikipedia, Google Earth, November 2010.
[168] DLR, TerraSAR-X Mission, undated.

2010: More White House Policy and Commercial Imagery Developments

President Barack Obama took office in January 2009. He ordered a review of national space policy known as Presidential Study Directive 3. According to the White House Director of Space Policy at a space-based ISR conference on 28 October 2009, U.S. space policies going back decades are sound, but there were problems regarding implementation.[169] The common thread in previous policies is to increase U.S. competitiveness, and strengthen the industrial base. Citing low tolerance for risk, he added that the tendency in the United States is to study and restudy the problems. He advised that the U.S. needs to learn by building and operating space systems, not just study what systems to have. An announcement on a new policy was expected in April 2010.[170] The policy was issued on 28 June.[171]

The commercial satellite imagery industry's results and outlook have been positive in 2010. DigitalGlobe's new WorldView-2 satellite reached full operational capability in January.[172] DigitalGlobe is challenging users in a contest to come up with new ways to use the satellite's 8-band multispectral capability.[173] GeoEye announced that it selected Lockheed Martin to build the future GeoEye-2 satellite that would have improved resolution when the satellite is launched as soon as the end of 2012.[174] The satellite's 1.1m diameter aperture flown in a 500km orbit would support collecting better resolution imagery than GeoEye-1's 0.41 quality, a capability supported by the Senate Armed Services Committee.[175][176][177] With GeoEye-2 in space, the company estimates that in 2013 it would have about 40 percent of the overall collection capacity by very high resolution color commercial imagery satellites. DigitalGlobe would have about 20 percent (absent another WorldView-2 type satellite), and France would have a similar amount from two forthcoming Pleiades satellites.[178] Turkey's Gokturk satellite scheduled for launch in 2013, similar to Pleaides, would provide another fraction of high resolution coverage.[179]

The way ahead for commercial satellite imagery is a largely a matter of available U.S. Government funding and capability needed by the military. National space policy likely will remain steady because the Constitution of the United States assures that President Obama's

[169] Peter Marquez, Comments at Space-Based ISR Conference, Alexandria, Virginia, 28 October 2009.
[170] SpaceNews, 15 January 2010; SpaceNews, 11 March 2010.
[171] The White House, National Space Policy of the United States of America. 28 June 2010.
[172] DigitalGlobe Press Release, WorldView-2 Reaches Full Operational Capability on Schedule, 4 January 2010.
[173] www.satnews.com, 29 July 2010.
[174] GeoEye News Release, GeoEye Selects Lockheed Martin to Begin Engineering and Manufacturing of GeoEye-2, 11 March 2010.
[175] GeoEye Investor Presentation at J.P. Morgan Global Technology Conference, May 2010.
[176] Mark Brender, Industry Interview, Geospatial Intelligence Forum, June 2009.
[177] James Mazol, Considering the FY2010 National Security Space Budget, George C. Marshall Institute, July 2009.
[178] Bill Shuster, GeoEye Briefing at International Commercial Remote Sensing Symposium, March 2010.
[179] Peter B. deSelding, Thales Alenia Begins Work on Turkish Imaging Satellite, SpaceNews, 7 September 2010.

Space Policy will remain in effect through 2012 or 2016, depending on election results.[180] Since the Policy gives latitude for both the Secretary of Defense and Director of National Intelligence to procure satellites, who buys what is an important factor.

- The Secretary of Defense stated in January 2009 that his priority on defense procurement is to pursue greater quantities of systems that provide the "75 percent" solution instead of smaller quantities of "99 percent" exquisite systems.[181] This aligns with the 2010 Quadrennial Defense Review (QDR) that states DoD "can no longer afford the quixotic pursuit of high-tech perfection that incurs unacceptable cost and risk."[182] The Undersecretary of Defense for Acquisition indicates that procurement of capabilities for contingency operations must be accelerated.[183]

- Regarding the use of space assets, the QDR indicates that DoD "will explore opportunities to leverage growing international and commercial expertise to enhance U.S. capabilities and reduce the vulnerability of space systems."[184]

- The Director, NGA considers the use of commercial imagery to be an opportunity because military missions place a very strong emphasis on flexibility supported with unclassified products.[185]

Observers of the commercial satellite imagery industry expect growth over the next few years. According to Northern Sky Research at the end of 2009, the market for data from such satellites should grow to $2.2 billion in 2018.[186] In April 2010, a study by Forecast International found that government and military agencies are the leading users of the data.[187]

[180] The Constitution of the United States of America, XXII Amendment, 27 February 1951.
[181] Robert M. Gates, Secretary of Defense Statement for the Senate Armed Services Committee, 27 January 2009.
[182] Quadrennial Defense Review Report, February 2010.
[183] John Reed, Institutionalization Proposed Weapons Buying for Contingency Ops, DoD Buzz, 28 March 2011.
[184] Ibid.
[185] Robert B. Murrett, Satellite Firms Should See Growth As Need for Imagery Mounts, Defense Daily, 14 July 2010.
[186] NSR Press Release, Satellite-Based Earth Observation Market Entering Phase of Impressive Growth, 19 November 2009.
[187] Jeffrey Bradford, Government Imagery Needs Drive Remote Sensing Market, www.defenseprocurementnews.com, 12 April 2010.

2010 Reference Point: Another Space Policy

The Obama Administration's National Space Policy pledges "strengthened international collaboration and reinvigorated U.S. leadership."[188] The policy states that a robust and competitive commercial space sector is vital to continued progress in space. According to the policy, this means the Government is "…committed to encouraging and facilitating the growth of a U.S. commercial space sector…that is globally competitive, and advances U.S. leadership…" This includes developing "…governmental space systems only when it is in the national interest and there is no suitable, cost-effective U.S. commercial or, as appropriate, foreign commercial service or system that is or will be available."

The new policy is consistent with previous White House policies that promoted commercial space activities, including remote sensing. The policy is silent on the meaning of "national interest", but surely it means that the Government always will procure classified national reconnaissance satellites. According to an expert panel report to NGA and NRO on the role of commercial imagery, "The U.S. Government cannot rely on or be dependent on any external entity to responsively get needed data."[189] The national satellites are considered "exquisite"; to the panel and a Congressional Research Service expert this means they each cost $1 billion or more.[190] The DNI stated in 2009 that these unique, Government-owned satellites would evolve from existing designs and be built by the National Reconnaissance Office.[191] The Lockheed Martin Corporation expects to receive "multibillions of dollars worth of orders" in 2012 for such satellites.[192]

The policy charged departments and agencies to identify areas for potential international cooperation, including Earth science and observation, and geospatial information products and services. This was consistent with a 2009 comment by the Undersecretary of Defense for Acquisition, noting that European products are part of the global industrial base and deserve consideration for procurement, especially if their items can be procured for less cost.[193] He made this point shortly before the first two Soyuz launchers were delivered to French Guyana, one for the future Pleiades imaging satellite, and before the successful launch of Helios-2B that refreshed France's national classified reconnaissance program.[194][195][196]

[188] Ibid.
[189] Peter Marino, Independent Study of the Roles of Commercial Remote Sensing, 16 July 2007.
[190] Richard Best, ISR Acquisition: Issues for Congress, 15 June 2010.
[191] ODNI News Release No. 12-09, DNI Blair Announces Plan for the Next Generation of Electro-Optical Satellites, 7 April 2009.
[192] Peter B. deSelding, Lockheed Hints a Classified Satellite Order is in the Offing for 2012, SpaceNews, 28 July 2010.
[193] Amy Butler, Carter Sets the Table for the Next Supper, Aviation Week Defense Technology International, 4 September 2009.
[194] Arianespace Marks a First – Twice -- For Russia, Satnews Daily, 24 November 2009.
[195] Peter B. deSelding, Ariane 5 Satellite Launch Boosts French-Led Recon Program, SpaceNews, 18 December 2009.
[196] Arianespace Press Release, Arianespace Delivers Helios-2B Into Orbit, 18 December 2009.

In June 2010, Euroconsult released a report that indicates the market for defense and security use of the imagery data will grow from $735 million in 2009 to $2.6 billion by 2019.[197][198][199][200] Defense customers accounted for 62 percent of commercial satellite imagery data sales in 2009. DoD, according to Euroconsult, is by far the largest investor in defense earth observation programs.[201] According to the MITRE Corporation, NGA's contracting method for NextView, which became fully operational in February 2009, was exceptional because it required a stable industry-Government tie for five or more years.[202]

The rosy estimates on the future of commercial satellite imagery rest largely on continued DoD funding. Changes in U.S. Government policy, statute, and regulation would have less effect because thus far the Government itself is the business case for this commercial activity. According to NGA, the Obama administration in 2010 urged a strong increase in unclassified commercial imagery to support deployed forces, i.e., the EnhancedView project effective through 2020.[203]

Remote Sensing Technology Developments

Maintaining U.S. Government awareness of global advances, and global industrial ties in remote sensing technology is essential as long as commercial industry in this sector is regulated. Changing regulations regarding imagery satellite operations, for example, may not have much effect if regulators do not understand how the utility of a satellite's data may be enhanced when fused with other imagery sources in ground processing systems.

In 1992, when the Land Remote Sensing Act was passed, a Department of Commerce official noted that lowering the cost of remote sensing satellites and ground processing equipment would be vital to opening up new markets and attracting investment.[204]. He argued that suppliers and users of remote sensing data would benefit most from a market which includes many buyers and sellers. He added that emerging commercial opportunities would be exploited by others, if the United States did not do so. Small satellites built by Surrey Satellite Technology Limited of the United Kingdom (UK) are an example of such competition. SSTL's motto is "Changing the economics of space."

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[197] Euroconsult, Earth Observation: Defense & Security, World Prospects to 2019, June 2010.
[198] Satellite-Based Earth Observation Market to Grow, www.asmmag.com/features, 29 June 2010.
[199] Euroconsult Projects Government Earth Observation Market to Reach $2.6 Billion in 2019, www.satellitemarkets.com, 16 June 2010.
[200] Adam Keith, Euroconsult, Intel…Growing Government Demand for Image Intelligence, www.earsc.eu/news, 16 July 2010.
[201] Euroconsult, Government Space Markets: World Prospects to 2017, 2008 Edition.
[202] The MITRE Corporation, How to Buy Satellite Images by the Thousands, April 2010.
[203] NGA Wrapping Up Bid for Next Generation Earth Imaging Capability, Inside the Pentagon, 17 June 2010.
[204] Scott N. Pace, Public-Private Sector Collaboration to Demonstrate Advanced Remote Sensing Technologies, 27 October 1992.

SSTL has been building small satellites for over two decades.[205] Licensing for launch and operation of such satellites is governed by the Outer Space Act of 1986.[206] The first British "spy satellite" called TopSat was revealed in 2002 to cost only about $20 million dollars, but the resolution did not match commercial U.S. standards.[207] Nonetheless, SSTL and its industry partner QinetQ termed TopSat "revolutionary."[208] When launched in 2005, it was considered to be on the cutting edge of British innovation.[209][210] The first images were returned within a few weeks.[211]

Reducing the size and weight of satellites is not a new idea. In 1996, a panel of experts wrote to the Director of Central Intelligence stating that the nation had an opportunity to create smaller, less expensive satellites. They wrote that satellite cost, in general, is linear with weight, and that NRO satellites 20 percent of the weight of then-current satellites could still provide half the capability.[212] But, this was only the beginning of the impetus for new solutions. A German-Israeli joint industry idea funded by the European Commission thought a 12-band, super-spectral system, weighing less than 200kg, could meet both commercial and scientific needs, but it was not fielded.[213][214][215] Currently, the U.S. Army Space & Missile Defense Command has a concept called Kestrel Eye that would provide 1.5 meter resolution imagery using nanosatellite technology (i.e., 10kg per satellite) directly to individual soldiers.[216] An Army prototype nanosatellite was aboard the first launch of SpaceX's Falcon 9 rocket in December 2010.[217]

On 20 April 2010, the Department of Commerce granted a license to Skybox Imaging Inc. for a satellite known as Skysat-1 to collect sub-meter resolution panchromatic and multispectral images. Although the public summary of the Skybox license does not provide satellite specifications, the CEO and CTO of the company co-authored a 2008 paper focused on a new way to achieve low-cost, small imaging satellites. They gained knowledge and experience working with the Space Systems Development Laboratory at Stanford University, where the CubeSat concept and program started in 1999.[218] They claimed that "With anticipated order-

[205] Wikipedia, Surrey Satellite Technology, 2010.
[206] Outer Space Act of 1986, www.ukspaceagency.bis.gov.uk.
[207] Michael Smith, Britain's first spy satellite is a cheap option, 25 July 2002.
[208] QinetQ Press Release, TopSat, July 2002.
[209] QinetQ News Release, Successful first launch for TopSat micro-satellite, 27 October 2005.
[210] Andrew Chuter, Experimental UK Satellite Takes Wing, DefenseNews, 7 November 2005.
[211] QinetQ News Release, New era of low-cost Earth observation dawns, 19 December 2005.
[212] Director of Central Intelligence, Independent Panel Review of Small Satellites, 29 June 1996.
[213] B. Penne et al., EKOSAT/DIAMANT and the Earth observation program at OHB-System, 11 September 1994.
[214] Amnon Ginati et al., Commercial Earth Observation with Small Satellites at OHB-System, August 1999.
[215] Brochure on MSRS / DIAMANT, OHB-System.
[216] Brochure by U.S. Army Space & Missile Defense Command, KESTREL EYE, 2010.
[217] Army Satellite Success with SpaceX Launch, Satnews Daily, 10 December 2010.
[218] CubeSat Concept and Deployer Services, http://directory.eoportal.org/presentations/7053.8502.html.

of-magnitude cost savings compared to current commercial offerings, the lifetime system cost should represent an extremely attractive proposition to consumers of satellite imagery that wish to own and operate their own assets."[219] The CTO's biography claims expertise and interest in nanosatellites.[220] Camera designs for such satellites are advancing.[221]

While much attention is paid to DigitalGlobe's and GeoEye's competitive landscape with traditional foes in the remote sensing industry (France, Germany, Israel, India, Japan, and South Korea), a satellite cost and performance battle may be emerging between SSTL and Skybox, or other possible smallsat suppliers such as Berlin Space Technologies[222] or a Japanese consortium that aims to build microsatellites costing $500,000 to $2,000,000 each.[223] Prior to an annual Mideast conference on space-related issues, the Chairman of SSTL stated that "Small satellites are at the forefront of space innovation."[224] The goal is to greatly drive down the cost of satellites for earth observation. The Vice Chairman of the Joint Chiefs of Staff has indicated he would rather own half of four satellites instead of all of two because he could increase coverage and resistance to attack.[225]

Technology used in satellite imaging sensors has a direct relationship to the size and weight of a satellite because the type of sensor impacts the need for power and associated electronics. There are two kinds of image sensors for digital cameras.[226] One type is Charged Coupled Devices (CCD), and the other is Complimentary Metal Oxide Semiconductor (CMOS).[227] Because CMOS chips use less power and can be fabricated on a standard silicon production line, they are less expensive and give great opportunity for weight saving in a sensor and satellite. CCD technology, on the other hand, has a longer track record.

Astrium engineers wrote in 2005 that the price of a complete imaging function would be lower using CMOS "…instead of CCD for a great number of space applications."[228] They added that "…mastering CMOS capabilities is a necessity for a team willing to manufacture a new generation of optical sensors and instruments." Experts at Surrey are also working on

[219] Andrew Kalman, Adam Reif, Dan Berkenstock, Julian Mann, and James Cutler, MISC—A Novel Approach to Low Cost Imaging Satellites, 2008.
[220] www.skyboximaging.com
[221] Kashif Gulzar, Camera Design for Pico and Nano Satellite Applications, Masters Thesis, 2010.
[222] Berlin Space Technologies, LEOS Platform, Small Satellites Made in Berlin, 2010.
[223] Paul Kallender-Umezu, Japan Advances University-led Microsatellite Constellation, SpaceNews, 3 December 2010.
[224] Region to benefit from high-tech commercial opportunities in space, www.gssforum.com, 2 February 2011.
[225] Dwayne Day, Gum in the Keyhole, www.spacereview.com, 22 June 2009.
[226] What is the difference between CCD and CMOS image sensors in a digital camera?, http://electronics.howstuffworks.com/cameras, 2010.
[227] DALSA Corporation, CCD vs. CMOS, http://www.dalsa.com, 2010.
[228] EADS Astrium, The CMOS Breakthrough For Space Optical Detection: Recent Advances and Short Term Perspectives, 13 July 2005.

using CMOS camera systems for earth observation.[229] The UK Space Agency announced in March 2011 that a CMOS imaging demonstrator will be flying with a UK-designed nano-satellite in early 2010.[230] Although France's Pleiades satellite will use CCD technology vice CMOS, a U.S. firm that builds devices for aerospace purposes (QP Semiconductor) was acquired in 2008 by a UK-headquartered firm known as e2v.[231] e2v made the CCDs for the Pleiades sensor. QP Semiconductor is now known as e2v aerospace & defense inc.[232]

SSTL also has a low-cost, CCD-type satellite system, first advertised in 2007, offering a greatly reduced mission cost for high resolution imagery.[233] SSTL announced in September 2010 that three satellites, with a combination of high and medium resolution, would be available for $150 million in one launch by the end of 2013.[234] The Chairman of SSTL indicates that Surrey's technology has improved and is able to produce 1 meter resolution imagery, but he also claims SSTL is working on satellites with even better technology.[235] Although the British military is not likely a customer for such satellites due to deep budget cuts, there is export potential.[236237238] A Chinese firm called Beijing Landview Mapping Information Technology Co. Ltd. (BLMIT) is a candidate because SSTL and BLMIT recently celebrated the 5th anniversary of operations of a low resolution satellite built by SSTL and sold to BLMIT for $18 million.[239240] Export of a more capable system aligns with UK policy to increase trade with China.[241242]

The newly formed UK Space Agency is taking advantage of SSTL's capabilities. The equivalent of roughly one million U.S. dollars has been provided to SSTL to work on a TechDemoSat, aimed at giving UK space businesses a competitive edge.[243244] According to SSTL,

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[229] http://www.ee.surrey.ac.uk/SSC/research/environments/introduction, 2010.
[230] UK Space Agency….UKube-1Passengers Announced, www.satnewsdaily.com, 23 March 2011.
[231] Jessica Broom, e2v News Items, 25 March 2009.
[232] QP Semiconductor now part of e2v aerospace and defense inc. BusinessWire, 22 October 2010.
[233] M. Cutter, P. Davies, A. Baker, M. Sweeting, A High Performance EO small satellite platform and optical sensor suite, 27 May 2010.
[234] Jonathan Amos, Surrey satellite unveils high-resolution space project, BBC News, 27 September 2010.
[235] Ellie Zolfagharifard, Sir Martin Sweeting, Chairman of Surrey Satellite Technology, theEngineer, 1 November 2010.
[236] D-day for Defence in 36 billion pound crisis, http://www.Timesonline.co.uk, 15 December 2009.
[237] Anthony Faiola, British military faces deep cuts, The Washington Post, 20 October 2010.
[238] Anthony Failoa, Britain moves to slash deficit, The Washington Post, 21 October 2010.
[239] Dr. Mike Cutter et al, A High Performance EO Small Satellite Platform (SSTL-300), 2010.
[240] UK Foreign and Commonwealth Office, UK Embassy to China Highlights Beijing-1 Small Satellite's 5th Anniversary Celebration Event, http://ukinchina.fco.gov.uk/en/news/?view=PressR&id=23097449, 26 October 2010.
[241] UK Foreign and Commonwealth Office, PM trumpets UK-China Partners for Growth potential, http://ukinchina.fco.gov.uk/en/news/?view=PressR&id=29638682, 9 November 2010.
[242] UK Government, PM leads largest ever trade delegation to China, http://number10.gov/uk/news/latest-news/2010/11/pm-leads, 9 November 2010.
[243] UK Space Agency News Release, UK Space Agency welcomes start of TechDemoSat design program, 18 October 2010.
[244] Jonathan Amos, Satellite to demonstrate UK tech, BBC News, 18 October 2010.

the demonstration satellite is a response to the Space Agency's Innovation and Growth Strategy.[245] SSTL is seeking the "business sweet spot" for small satellites.[246]

What may be of more concern to U.S. regulators than SSTL capabilities is the fact that Astrium bought SSTL, giving Astrium control of a small satellite production line, including a satellite advertised as an agile, sub-meter imaging system.[247][248] This means Astrium has the ability to produce a range of high, medium, and low resolution remote sensing satellites. Within days of Astrium's acquisition of SSTL, the company announced it could field a sub-meter resolution mapping satellite for $70 million USD, far less than the cost of a conventional spacecraft.[249] Astrium later signed a contract for SpaceX launch services because SSTL has several missions weighing less than 500kg that need to be launched in coming years.[250] The list price for the Falcon 1 launcher was $10.9 million through October 2010. Constellations of satellites may be the way of the future, but large satellites that require an expensive launcher dampen prospects for economic viability. This should give Astrium / SSTL an advantage.

Funding for space-related activities in the UK is now centralized, and Astrium led an industrial consortium to create the new International Space Innovation Centre in the UK.[251][252][253] Astrium's revenue increased 11 percent in 2009.[254] The British government announced in March 2010 that it would centralize all civil space funding.[255] Whether Britain deploys a national remote sensing capability called Skysight is uncertain, but SSTL believes investments in this sector pay back many times over.[256][257][258] Regardless of a UK government commitment, and even if the satellites are not exported as a package to China, SSTL's three one-meter resolution satellites launched in 2013 would be part of its Disaster Monitoring Constellation International Imaging (DMCii) business unit, where satellite imaging capacity is leased to different international customers.[259][260] Although the satellites have U.S.-made ITAR

[245] SSTL News Release, SSTL's TechDemoSat-1 to demonstrate UK innovation in space, October 2010.
[246] From Micro to Nano…Seeking the Business Sweet Spot, www.satmagazine.com, January 2011.
[247] Astrium buys up Surrey Satellite, http://bbc.co.uk/2/hi/science/nature/7826301.stm, 13 January 2009.
[248] SSTL Description of SSTL 300 S1, 2010.
[249] Jonathan Amos, UK sat firm plans low cost mapper, BBC News, 22 January 2009.
[250] Peter B. deSelding, Astrium to Market SpaceX Falcon 1 Launches in Europe, SpaceNews, 9 September 2010.
[251] SatNews Daily, Satellites Industry Now Has a New Exec Agency, 13 December 2009.
[252] Britain Replacing BNSC with New National Space Agency, SpaceNews, 11 December 2009.
[253] Pallab Ghosh, UK to open earth observation hub, BBC News, 21 July 2010.
[254] Peter B. deSelding, Astrium 2009 Revenue Up Despite Galileo Loss, SpaceNews, 19 January 2010.
[255] Peter B. deSelding, New Space Agency to Centralize British Space Spending, SpaceNews, 23 March 2010.
[256] Douglas Barrie, Threat to MilSpace Funding Concerns UK, Aviation Week and Space Technology, 16 March 2009.
[257] Jonathan Amos, UK mulls sovereign Earth observing satellite service, BBC News, 22 July 2010.
[258] Jonathan Amos, How public investments in space can pay back, www.bbc.co.uk, 28 September 2010.
[259] UK company plans survey satellite fleet, EOmag, September 2010.
[260] Wikipedia, Disaster Monitoring Constellation, November 2010.

parts, DMCii does not consider ITAR an issue because SSTL is supplying hardware to a UK-based service company, not others.[261]

Monitoring technology developments on the ground is also critical because such developments directly affect user needs and interests. Demand for commercial imagery has risen, in part due to technologies like Google Earth that require the data for a host of restricted and public purposes, including at NGA.[262] The integration of commercial imagery with GPS technologies, including cell phones, is pushing the private sector to invent new innovative ways of integrating and packaging data. Trimble Navigation Ltd., for example, has created technology that enables users to link the "where" and "when" in a rapid orthoimage product.[263] Trimble is also forging a path in a joint venture with the Russians on GLONASS that likely would result in even stronger prospects for fusion of imagery and navigation data.[264][265] A global race may be on to provide satellite-supported location-based services.[266][267][268][269]

Experts who assess and forecast technical advances indicate a move toward "ubiquitous geo-positioning", i.e., the integration of GPS into all aspects of geospatial technology. These experts also use terminology such as "beyond fusion", "participatory sensing" and "visual analytics" as the underlying techniques that optimize human use of spatial data.[270] NGA seeks experts in a visiting scientists program to advance knowledge with regard to large and complex geospatial data sets, spatial statistics, data mining and quantitative methods regarding human geography.[271]

DigitalGlobe and GeoEye know that coming up with new ways for users to access and manipulate commercial imagery is important.[272] DigitalGlobe advertises its ImageConnect service as a way to retrieve via the Internet GIS-ready imagery from DigitalGlobe's archive.[273] Pixel Factory by Infoterra of France is marketed as a multi-source "industrial solution" because

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[261] DMC International Imaging, DMC3 Constellation, August 2010.
[262] James Rosen, Spy Agency Amends No-Bid Contract Notice, But Google Still Favored, www.foxnews.com, 24 August 2010.
[263] Trimble, Tactical mapping imagery: when you need to know where…and when, Imaging Notes, Vol. 25, No. 4, Fall 2010.
[264] Peter B. deSelding, Trimble to Help Market GLONASS Equipment, SpaceNews, 28 May 2010.
[265] Glonass Gets the Putin Push, www.satnews.com, 16 February 2010.
[266] Jonathan Amos, UK over reliant on GPS signals, engineers ward, www.bbc.co.uk, 7 March 2011.
[267] Marc Boucher, COM DEV Financial Results See Military Segment Rise but Civil and Commercial Segments Decline, http://spaceref.ca, 25 March 2011.
[268] Peter B. deSelding, China and Europe Still at Odds Over Navigation Spectrum, SpaceNews, 4 March 2011.
[269] Peter B. deSelding, Neck & Neck Race to Be First in Tracking Ships from Space, SpaceNews, 25 March 2011.
[270] The National Academies Press, New Research Directions for the National Geospatial-Intelligence Agency, May 2010.
[271] NGA. Visiting Scientist Fellowship Program, http://jobs.phds.org, 25 February 2011.
[272] Elevating Insight Three Powerful Ways, Earth Imaging Journal, September / October 2010.
[273] ImageConnect. www.digitalglobe.com. 2010.

it can integrate many different sources.[274] Each source has been added one by one, but the cumulative effect of a "brick by brick" approach in Pixel Factory development could be detrimental to the two U.S. companies. Pixel Factory software can be acquired with a license, reportedly costing $6.5 to $8 millon.[275] Google became a licensee in 2009.

The importance of providing multi-source solutions and service is increasing. SPOT Image and Infoterra announced in October 2010 that they are joining forces and will be named Astrium GEO-Information Services.[276] The company indicates that the "new look" will result in an expanded offering of GEO-Information and services.[277] The changes could be bold. In 1998, the French first sold a 5-meter resolution satellite in SE Asia,[278] but now a customer need not buy a satellite because customer-controlled tasking of the upcoming Pleiades satellites is possible. The service is called Pleiades Direct Tasking. Nonetheless, Astrium will continue to export imagery satellites. An Astrium official indicates that technology transfer accounts for 20 percent of the value of a satellite export, but this is acceptable now that U.S. competitors are more active on a global basis.[279]

Rapid changes in remote sensing are global. In India, for example, growth of the geospatial market through 2014 is expected to be greater than in the rest of the world.[280] The industry plays a major role in national planning and development. Moreover, the applications for use of location-based information from navigation satellites and satellite imagery could go well beyond what experts thought in the late 1990s.[281] A French firm specializing in maritime tracking services, for example, purchased a Spanish imagery company to blend sources and increase revenue.[282] China has unveiled a mapping service similar to Google Earth.[283]

The NGA is well aware of the need for new approaches regarding access to commercial geospatial information. A project called Rapid Delivery of Geospatial Intelligence (RDOG) is designed to provide a mixture of on-line services and off-line products to meet U.S. military, first responder, and humanitarian needs.[284] The new Director, NGA wants to "fundamentally

[274] Infoterra, Pixel Factory, 2010.
[275] Adam Baddeley, Affordable Military Space, Asian Military Review, August 2009.
[276] SPOT Image Corporation. SPOTLight, October 2010.
[277] SPOT Image: From 3D to Services, www.asmmag.com, 30 May 2010.
[278] Peter B. deSelding, Matra Makes Inroads in Asian Satellite Market, SpaceNews, 6 October 1997.
[279] Peter B. deSelding, Astrium Views Technology Transfer as a Cost of Winning Business, SpaceNews, 26 November 2010.
[280] India on a roll, Geospatial World, September 2010.
[281] Katherine McIntire Peters, Space Wars, Government Executive, April 1998.
[282] Peter B. deSelding, CLS Continues Expansion with Purchase of Spanish Radar Imagery Firm, SpaceNews, 2 September 2010.
[283] China Unveils Mapping Service Similar to Google Earth, redOrbit, 22 October 2010.
[284] DigitalGlobe, Inc. Rapid Delivery of Online Geospatial-Intelligence (RDOG), 2010.

change the users' experience" by creating an apps store to allow access to data at soldier level.[285][286]

With regard to commercial radar imagery, a year-long Joint Capabilities Test Demonstration is in progress and intended to blend together various sources of imagery.[287] According to NGA, commercial radar imagery is valuable for a range of defense, intelligence, and humanitarian missions.[288] International SAR systems are also a factor in a study of radar imaging options led by the Office of the DNI.[289]

2020 Future One: U.S. Commercial Satellite Imagery is a Thriving Business

In this alternative future, U.S. companies count on a steady stream of Government funding, and also increase sales to commercial clients. DigitalGlobe and GeoEye know statistics such as the ASPRS 2008 survey which found that polled users of better than 0.5m resolution imagery said they needed better quality; in contrast, users of 0.5m and lesser quality imagery said the resolution of data used was better than needed.[290] The companies seize on a statement by the Vice Chairman of the Joint Chiefs of Staff that 90 percent of the military's imaging needs can be met by commercial satellites,[291] and take advantage of a debt reduction task force recommendation to make "greater use of commercial imagery" as a way for the nation to "transition to less expensive satellite imagery."[292]

When all funding options are exercised, NGA's EnhancedView funding stream to DigitalGlobe and GeoEye from 2010 – 2020 averages $730 million per year, one hundred times more than NGA spent on commercial imagery in Fiscal Year 1999. GeoEye gained $337 million in Government funding to build the GeoEye-2 satellite,[293] and has a long run of success after being named in 2010 by Fortune Magazine as one of the 100 fastest growing companies,[294] and Earth Observation Operator of the Year by Euroconsult.[295] Although overall U.S. defense spending declines due to reduced funding for Overseas Contingency Operations, such as

[285] Colin Clark, NGA Touts App Store Idea, www.dodbuzz.com, 2 November 2010.
[286] Peter B. deSelding, NGA Looking at Amazon and Apple for Imagery Distribution Ideas, SpaceNews, 3 November 2010.
[287] NGA, Commercial Radar Imagery Demonstration Support, www.fbo.gov, 21 September 2010.
[288] Peter Buxbaum, SAR Boosts Imagery Power, Geospatial Intelligence Forum, Volume 8, March 2010.
[289] Turner Brinton, ODNI Commissions Study of Radar Imaging Options, SpaceNews, 3 November 2010.
[290] http://www.asprs.org/publications/pers/2008/journal/november/highlight2.pdf, 2008
[291] Dwayne Day, Space policy 101: military space 2009, www.spacereview.com, 15 June 2009.
[292] Pete Domenici and Alice Rivlin, Reviving the Economy, Cutting Spending and Debt, and Creating a Simple, Pro-Growth Tax System, November 2010.
[293] Peter B. deSelding, NGA to Contribute $337 Million to GeoEye's Next Satellite, SpaceNews, 10 August 2010.
[294] GeoEye…A Member of the Exclusive FORTUNE 100 Club, www.satenews.com, 3 September 2010.
[295] GeoEye, Inc. has been named Earth Observation Operator of the Year by Euroconsult, www.satnews.com, 9 September 2009.

conflict in Afghanistan, the base DoD budget remains favorable for new procurement opportunities.[296]

In 2009, the U.S. Government provided 75 percent of revenue for DigitalGlobe.[297][298] In 2010, NGA accounted for 62.2 percent of the company's revenue.[299] Global defense and intelligence customers accounted for almost 82 percent in 2009 and 78 percent in 2010. Revenue ratios for GeoEye also favor defense and intelligence customers.

- Commercial revenue, flat for DigitalGlobe for 2007-2009, turns upward due to the company's aggressive push to provide "business intelligence" as a service, thereby helping clients shape decision space.[300] DigitalGlobe is successful at turning space-based monitoring into insight for clients, and providing "location based intelligence", i.e., private sector GEOINT. The company expected in 2010 that revenue from its commercial segment would at least double and perhaps triple by 2015.[301] In February 2011, the company said it expects 25 percent growth in commercial sales for the year.[302] Promoting web and cloud services is vital for success.[303]

- GeoEye also uses the construct of providing "insight" for clients, not just image data. GeoEye still relies on large sums from the U.S. Government (67 percent in 2009; 77 percent for April – June 2010), but the company takes advantage of the convergence of navigation and social networking technologies with imagery to feed a large demand for imagery information products.[304][305] GeoEye sees a growing and diversified customer base as powerful search engines increase public awareness of commercial imagery.[306] The earthquake and tsunami disaster in Japan provides an opportunity to showcase commercial imagery capability,[307] just as the imagery played a role regarding Hurricane Katrina in 2005.[308]

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[296] Scott Sacknoff, White House's Proposed FY-2012 Defense Budget Creates Opportunities for Investors, www.seekingalpha.com, 8 March 2011.
[297] Peter B. deSelding, With U.S. Contracts Delayed, DigitalGlobe Looks Elsewhere for 2010 Growth, SpaceNews, 25 February 2010.
[298] DigitalGlobe, Inc., 2009 Annual Report, U.S. Security and Exchange Commission Form 10-K, 24 February 2010.
[299] DigitalGlobe, Inc. 2010 Annual Report, U.S. Security and Exchange Commission Form 10-K, February 2011.
[300] John Oechsle, DigitalGlobe, Inc., Critical Information and Insight: The Key to Growth, 2010.
[301] Peter B. deSelding, DigitalGlobe Expects Revenue to More Than Double Within 5 Years, SpaceNews, 24 September 2010.
[302] Peter B. deSelding, DigitalGlobe Expects 25 Percent Commercial Sales Growth in 2011, SpaceNews, 1 March 2011.
[303] DigitalGlobe, Inc. Cloud Services 3.0, 2010.
[304] GeoEye, Inc., 2009 Annual Report, U.S. Security and Exchange Commission Form 10-K, 12 March 2010.
[305] Peter B. deSelding, NGA to Contribute $377 Million to GeoEye's Next Satellite, SpaceNews, 10 August 2010.
[306] Kevin Corbley, Earth Imaging for the Masses, Earth Imaging Journal, 2010.
[307] Colin Clark, Sat Pics Flowed Within Hour of Quake, www.dodbuzz.com, 18 March 2011.
[308] Charles Devarics, Private Eyes, C4ISR Journal, November / December 2005.

- Both companies focus on GIS-ready applications and retool. They agree that expanding private sector and foreign government use are vital to success.[309][310] They know that GIS technologies have exploded in capability and relevance in the nearly 20 years now elapsed since computerized maps were projected to be "one of the hottest tools on the business landscape."[311] Mindful that worldwide spending on space-related activities may flatten in the next few years,[312] they help the U.S. Government adapt to robust online collaboration.[313] They focus increasingly on resource-oriented clients who need data and assessments on food, water, minerals and demographics. They engage with a wide array of companies in the World Economic Forum who have written future scenarios and corporate strategies for water, agriculture and mining.[314][315] The imagery companies focus heavily on applications and solutions that matter to the public and business users, not just military and intelligence customers.[316]

Commercial satellite imagery remains robust and successful because the military wants its own satellites and satellite data sources. According to National Space Policy, both the Secretary of Defense and the Director of National Intelligence have responsibility to "develop, acquire, and operate space systems and supporting information systems and networks…" In DoD, this includes Operationally Responsive Space (ORS) projects such as small imaging satellites. Funding for ORS from 2010-2015, however, remains uncertain, thereby causing little near-term threat to commercial satellite operators.[317][318][319][320] The projected ORS budget for small satellites remains well under $100 million each year through 2015. The ORS-1 optical satellite does not prove its worth until well after the long-delayed 2011 launch,[321][322] giving DigitalGlobe and GeoEye breathing room on continued support to the U.S. military.[323][324][325][326]

[309] Adam Keith, EO Operators Serving Defense Need to Add Commercial Customers, SpaceNews, 8 November 2010.
[310] DigitalGlobe, ImageConnect, 2010.
[311] Rick Tetzeli, Mapping for Dollars, Fortune, 18 October 1993.
[312] Euroconsult press release, Worldwide government spending on space to flatten over the next five years, 16 February 2011.
[313] Deloitte. Change your world or the world will change you, The future of collaborative government, 2010.
[314] Bob Weber, Resource Monitoring and the Earth Observation Industry, May 2010.
[315] World Economic Forum, Industry Partnership, www.weforum.org/en/about/IndustryPartnershipProgram, 2010.
[316] Ariane Cornell, Bringing Space Down to Earth: Space Applications to Grow Our Sector Today and Ensure Its Future Tomorrow, SpaceNews, 23 June 2010.
[317] John Bennett, USAF Surprised OSD by Putting Small Sats on Wish List, DefenseNews, 8 June 2009.
[318] Erik Schecter, Congressional Rescue, C4ISR Journal, 1 September 2009.
[319] Turner Brinton, Pentagon Seeks to Shift Money to Satellite Programs, SpaceNews, 13 July 2010.
[320] Samuel Black and Victoria Samson, Space Security Programs of Interest in the FY11 DoD Budget Proposal, 2010.
[321] ORS-1 Satellite Now Set for April Launch, SpaceNews, 10 December 2010.
[322] Turner Brinton, Taurus XL Failure Investigation Could Delay TacSat-4 Launch, SpaceNews, 18 March 2011.
[323] Amy Butler, ORS-1 On Track for 2010 Launch, Aviation Week's DTI, 8 December 2009.

Moreover, the original 2007 ORS plan of completing eight tactical satellite launches through Fiscal Year 2013, with a budget of $409 million, falls short of the goal.[327] The competition between Skybox and SSTL becomes a battle on a global scale beginning in 2013, but U.S. Government funds for DigitalGlobe and GeoEye dwarf the revenue available to competitors using small satellites.

DigitalGlobe and GeoEye do not lose sight of any potential U.S. Government funding opportunity. Moreover, GeoEye obtains money from the State of Virginia to assist in moving its corporate headquarters, contingent on adding at least 100 jobs.[328][329] Both companies seek a large role in NGA's Geospatial Data Readiness (GDR) and Foundation Data Change Detection (FDCD) activities.[330][331] They also chase opportunities provided by other Government entities such as the Department of Transportation's solicitation on use of remote sensing for infrastructure planning and operations.[332] The companies also seek revenue from potential interagency Federal projects, such as the Imagery for the Nation (IFTN) initiative, but are wary of the Government's hope that imagery data will be placed in the public domain, not licensed.[333]

Competition from non-U.S. satellites does not become a serious problem until at least 2015. France's two Pleiades satellites will not be fully operational until at least 2012,[334][335] giving DigitalGlobe and GeoEye time to market in advance the capabilities that EnhancedView will provide. Korea's sub-meter resolution Kompsat-3 satellite launches in 2011, but is not robust enough to pose a serious threat. Japan's first high-resolution commercial ASNARO satellite does not launch until at least 2013, and perhaps Germany's long-planned HiROS.[336] Moreover, Japan's plan to export communications and earth observation satellites is an uphill struggle.[337][338] India's long-running remote sensing satellite program continues to evolve, but it

[324] An ORS Bus Trip, www.satnews.com, 18 February 2010.
[325] ATK To Ship The Operationally Responsive Space-1 Bus, www.spacewar.com, 19 February 2010.
[326] Goodrich Begins Environmental Test of ORS-1 Satellite, www.spacedaily.com, 21 December 2010.
[327] Department of Defense, Plan for Operationally Responsive Space, 17 April 2007.
[328] Marjorie Censer, GeoEye to relocate within Virginia, The Washington Post, 12 October 2010.
[329] Gregg MacDonald, GeoEye, Inc. moving its headquarters to Herndon, Fairfax County Times, 14 October 2010.
[330] NGA Request for Information, GEOINT Data Readiness, 11 September 2009.
[331] NGA Request for Information, Foundation Data Change Detection, 18 June 2010.
[332] Department of Transportation, Commercial Remote Sensing & Spatial Information Technologies Program, 27 May 2010.
[333] U.S. Government, Request for Information on Imagery for the Nation, 15 July 2010.
[334] Peter B. deSelding, First Flight of European Soyuz Delayed Again, SpaceNews, 7 September 2010.
[335] Satellite Imaging Corporation, Pleiades Satellite Imagery and Sensor Specifications, 2010.
[336] Thomas Walati and Andreas Eckardt, Very High Resolution and 3D optical remote sensing solutions, 27-28 May 2008.
[337] Hiroyuki Inahata, Private sector efforts to nurture satellite business have their limits, www.asahi.com, 14 February 2011.
[338] Japan to fund Vietnam's satellite project, www.saigon-gpdaily.com, 3 January 2011.

is not a serious threat to U.S. companies because satellites built by India are designed to meet national socio-economic development needs, ahead of commercial interests.[339][340] Italy's ten-year development plan to field a range of satellites in collaboration with Israel, from optical to radar, is not a near-term commercial threat for U.S. high resolution imagery providers. [341]

By 2020, both DigitalGlobe and GeoEye focus heavily on providing analytic services because in 2010 a noted expert on remote sensing stated that "a nearly bewildering set of data sources at different scales and characteristics is already available for the information needs of potential customers."[342][343][344] The companies' value to customers increasingly hinges on quality product that is a blend of imagery and non-imagery sources. Collateral information adds context and precision to what is observed on imagery. The companies make money on change detection because providing spatio-temporal, location-based services is vital for business success.[345][346][347] Astrium's plan to acquire American earth observation firm(s) founders due to U.S. domestic interests.[348] French and German remote sensing interests fail to fully align under Astrium GEO-Information Services due to national aerospace objectives.[349][350][351] The result is vibrant, private sector American GEOINT.

2020 Future Two: A Slow Growth Business, Still a U.S. Government Appendage

In this alternative future, U.S. commercial imagery companies continue to rely on defense and intelligence clients for the largest share of their revenue, but funds from DoD increase marginally, if at all, forcing the companies to look elsewhere for clients, and inward for efficiencies more aggressively than in a setting where Government funds are not trimmed. In November 2010, DigitalGlobe warned investors about the future budget climate;[352] months, earlier, the company was aware of a zero-increase scenario with U.S. Government customers.[353] Between 2010 and 2020, DigitalGlobe and GeoEye are not able to make big gains

[339] Emily Wax, India's Space Ambitions Taking Off, The Washington Post, 4 November 2009.
[340] Timothy Puckorius, Indian Remote Sensing Satellite Program, 3 March 2010.
[341] Leopoldo Benacchio, Space Agencies: New Projects and Budget Obligations, Milan Il Sole Ore.com, 21 November 2010.
[342] Ray Williamson, From Reality 2010 to Vision 2020, Imaging Notes, Summer 2010.
[343] GeoEye Press Release, GeoEye to Acquire SPADAC, Inc., 8 December 2010.
[344] Peter B. deSelding, GeoEye to Purchase Spadac for $46 Million, SpaceNews, 8 December 2010.
[345] Bo Huang, Special Issue on Change Analysis, Photogrammetric Engineering and Remote Sensing, August 2009.
[346] Bob Weber, Monitoring Change to Know the Earth, December 2009.
[347] DigitalGlobe, 8-Band Multispectral Imagery, http://www.digitalglobe.com, 2010.
[348] Peter B. deSelding, Astrium Looking for U.S. Earth Observation Firms to Acquire, SpaceNews, 12 January 2011.
[349] Kenneth Timmerman, Secrets Among Friends, Insight Magazine, 23 July 2001.
[350] Tim Lister, Cables point to German-French battle over satellite technology, www.cnn.com, 4 January 2011.
[351] Peter B. deSelding, OHB Satellite Exec Fired Over Wikileaks Disclosure, SpaceNews, 18 January 2011.
[352] Peter B. deSelding, DigitalGlobe Warns on U.S. Budget Climate, SpaceNews, 3 November 2010.
[353] Peter B. deSelding, With U.S. Contracts Delayed, DigitalGlobe Looks Elsewhere for 2010 Growth, SpaceNews, 25 February 2010.

in revenue from commercial clients because U.S. defense-related requirements force the cost of space and ground segments to increase significantly.[354] GeoEye-2, planned for launch in 2013 could cost up to $850 million, at least 60 percent more than GeoEye-1.[355][356][357] DigitalGlobe's WorldView-3 satellite will cost over $300 million.[358] Moreover, GeoEye's Ikonos satellite is 11 years old, and would have 14 years in space if it lasts through 2013.[359] DoD is not able to entirely offset the burden on corporate infrastructure due to budget pressures, but still looks favorably on commercial imagery satellites as a backup for national satellites, and reduce the vulnerability of U.S. space systems.[360]

The DoD does not, over the next decade, abandon commercial imagery because major elements of U.S. forces for several years are still affected by operations in Iraq and Afghanistan.[361] An enduring role in Afghanistan and elsewhere to defeat terrorists drives continuing access to a range of imagery sources. Moreover, the military counts on the Director of National Intelligence to field and operate next-generation, national electro-optical satellites as agreed in 2009. The military insists on having its own satellites that are acquired primarily for support to on-going military operations.[362] This principle, articulated in 1998 by the Defense Science Board (DSB), remains intact. The responsibility of the Secretary of Defense and Director of National Intelligence to prevent redundancy in imaging systems remains in force at least through 2020, after the next-generation national satellites are launched and prove successful. The separate concerns of DoD and DNI, however, suggests that the resulting multiple ISR systems will not disappear, notwithstanding apparent duplication of effort.[363]

The DNI does not, over the next decade, abandon commercial imagery because ten years is needed to convince national leaders that complex and expensive reconnaissance satellite acquisition is again doable. The original contract for the failed Future Imagery Architecture (FIA) extended to 2010;[364] according to an intelligence official, because the industrial base is thin and narrow, the country now does not want to push for more than it can handle.[365][366] Keen observers will want proof that the Intelligence Community can regain and

[354] Peter B. deSelding, GeoEye-2 Price Tag Rises on Ground System Upgrades, SpaceNews, 12 November 2010.
[355] Ibid.
[356] Peter B. deSelding, NGA to Contribute $337 Million to GeoEye's Next Satellite, SpaceNews, 10 August 2010.
[357] Inflation hits GeoEye-2, http://geospatialworld.net, 15 November 2010.
[358] Peter B. deSelding, DigitalGlobe Awards $307M in Contracts for WorldView-3 Satellite, SpaceNews, 31 August 2010.
[359] Lockheed Martin + GeoEye…Eleven Image-Filled Years, Satnews Daily, October 2010.
[360] Department of Defense, Quadrennial Defense Review Report, February 2010.
[361] Ibid.
[362] Defense Science Board Task Force on Satellite Reconnaissance, January 1998.
[363] Richard Best, ISR Acquisition: Issues for Congress, 15 June 2010.
[364] Kenneth Silber, Spy Satellite Agency Awards Big Contract to Boeing, www.space.com, 8 September 1999.
[365] Colin Clark, President Approves New Spy Satellites, www.dodbuzz.com, 7 April 2009.
[366] Dwayne Day, Better the devil you know…., The Space Review, 10 August 2009.

apply critical program management skills.[367][368][369][370] As the DNI noted in 2009, commercial "less complex" satellites are especially useful as a "supplement and backup to the government's existing imagery architecture."[371]

National budget constraints by mid-decade, however, limit the availability of funds for commercial satellite imagery. Defense Secretary Gates stated in May 2010 that the post-9/11 "gusher" of defense spending has been turned off, "and will stay off for a good period of time."[372] This year, the Undersecretary of Defense outlined an initiative to better manage defense procurement and trim costs where possible, starting with $100 billion in savings.[373][374][375] Secretary Gates wants to instill a "culture of savings and restraint."[376][377] Some observers contend that the downward trend will reduce the Pentagon's share of the national budget from 19.4 percent in 2010 to 15.6 percent in 2015.[378]

The huge increase in the use of Unmanned Aerial Systems (UAS) for reconnaissance and other purposes continues from 2010 to 2020. Worldwide expenditures for such systems could total between $75-95 billion in the next ten years, half from the United States.[379][380] The 2010 QDR states that these systems are a priority; their use will "expand."[381] The Pentagon spent $284 million on such systems in FY2000, but wants to spend $4.1 billion on them in FY2011.[382] The number of deployed UAS has increased by thousands in the last few years, and their use for homeland security becomes increasingly viable.[383] Nonetheless, commercial satellite imagery hangs on in this alternative future because both the DoD and DNI vouch for its utility and

[367] Philip Taubman, In Death of Spy Satellite Program, Lofty Plans and Unrealistic Bids, The New York Times, 11 November 2007.
[368] Bill Gertz, Exquisite Spy Satellite, The Washington Times, 10 September 2009.
[369] Ben Iannotta, Spy-Sat Rescue, C4ISR Journal, 2 June 2009.
[370] Edmund Nowinski and Robert Kohler, The Lost Art of Program Management in the Intelligence Community, Studies in Intelligence, Vol. 50, No. 2, 2006.
[371] ODNI News Release No. 12-09, DNI Blair Announces Plan for the Next Generation of Electro-Optical Satellites, 7 April 2009.
[372] Robert M. Gates, Speech on Defense Spending by Secretary of Defense, www.defense.gov/speeches, 8 May 2010.
[373] Ashton Carter, Better Buying Power: Mandate for Restoring Affordability and Productivity in Defense Spending, 28 June 2010.
[374] John Bennett, Gates Taps Carter to Lead Procurement, Services Efficiency Effort, DefenseNews, 28 June 2010.
[375] Dana Hedgpeth, Pentagon Looks for 100 Billion in Cost Savings, The Washington Post, 29 June 2010.
[376] Craig Whitlock, Pentagon to Cut Thousands of Jobs, Defense Secretary Says, The Washington Post, 10 August 2010.
[377] Colin Clark, Culture of Savings and Restraint, www.dodbuzz.com, 9 August 2010.
[378] Thomas Donnelly and Gary Schmitt, The Big Squeeze, The Weekly Standard, 7 June 2010.
[379] Jeff Specht, Drones, Earth Imaging Journal, September / October 2010.
[380] Global UAV Market to Total $94 Billion in Next Decade, http://info.intelligencecareers.com, 18 March 2011.
[381] Department of Defense, Quadrennial Defense Review Report, February 2010.
[382] Department of Defense, Quadrennial Roles and Missions Review Report, January 2009.
[383] Christopher Bolkcom, Blas Nunez-Neto, Homeland Security: Unmanned Aerial Vehicles and Border Surveillance, CRS Report for Congress, 13 May 2008.

pressure mounts to consolidate UAS expenditures across the military Services.[384] Moreover, the track record for ORS has not yet given military commanders enough confidence that they can give up one of the forms of satellite imaging (national, tactical and commercial), not until Defense budget cuts force choices.

- The 2011 presumed success of ORS-1 gives renewed vigor to the program, but its 0.42 meter diameter aperture only allows the satellite to collect 1 meter resolution imagery, not as sharp as commercial satellites by DigitalGlobe and GeoEye.[385]

- ORS proves successful from 2010 to 2020 because it meets the 2007 objective to develop, acquire, and field space capabilities more quickly and in more affordable ways.[386][387][388] The cost for commercial imagery goes in the other direction because national and military needs for 0.25 meter resolution satellite imagery drive up the cost, increasing risk for the industry.

In this future, sub-meter commercial satellite imagery is a commodity available from several international sources. Astrium's 2010 positive claims regarding company health and growth reflect an upward path.[389][390] Well before 2020, France installs at many of SPOT's 44-partner sites receiving equipment for Pleiades imagery. SPOT does well pressing its view on being the "trusted" source for geo-spatial information and services.[391][392] Although the launch of Pleaides satellites is delayed by problems constructing the Soyuz launch site in French Guyana[393], both satellites are in space and operating before GeoEye-2 or Worldview-3 are launched. Moreover, Astrium's SPOT 6 and 7 satellites, although lacking resolution, become viable alternative for some users.[394] Japan is successful with a sub-meter resolution commercial satellite, and South Korea makes a serious run at commercial market share due to its experience with German-provided optics for the Kompsat-3 satellite.[395] South Korea and Germany become ongoing partners, giving Germany's HiROS project global reach. Skybox

[384] Walter Pincus, Military services should consider common course in chase for updated unmanned aircraft, The Washington Post, 11 January 2011.
[385] Stanley Kishner, David Flynn, Charles Cox, Goodrich Optical and Space Systems Division, Reconnaissance Payloads for Responsive Space, April 2006.
[386] Department of Defense, Plan for Operationally Responsive Space, 17 April 2007.
[387] United States Congress. Senate Report 111-201, Operationally Reponsive Space, 2010.
[388] Harris Corp. Press Release, Harris Corporation Awarded $42 Million Contract to Provide All-Weather Imaging Payload Onboard New Military Spacecraft, 16 December 2010.
[389] Reinhold Lutz, Astrium – A Global Player in the Earth Observation Business, March 2010.
[390] Peter B. deSelding, Astrium Reports Steady Sales, Good Prospects, SpaceNews, 12 November 2010.
[391] Rhett Caltrider, The Trusted Source for Geo-Spatial Information, Briefing to NGA, 20 March 2009.
[392] SPOT Image: From 3D to Services, www.asmmag.com, 30 May 2010.
[393] Peter B. deSelding, Hurdles to European Soyuz Were Higher than Expected, SpaceNews, 8 October 2010.
[394] AstroTerra puts itself on the map, www.astrium.eads.net, 25 January 2011.
[395] Andreas Eckardt, High Resolution Instruments for Air and Spaceborne Application, 20 November 2006.

Imaging and SSTL drive down the cost of satellites and imagery, placing serious pressure on DigitalGlobe and GeoEye.

Alternative imagery sources, other than high-resolution optical from DigitalGlobe and GeoEye, become important for NGA, causing difficult funding decisions regarding GEOINT data. Germany's commercial TanDEM-X satellite mission, costing about $200 million,[396] by 2015 produces an elevation map of the world more detailed and precise than available to NGA from the Shuttle Radar Topography Mission (SRTM) flown in 2000 at a cost of $142 million.[397][398][399] Lacking commercial radar satellites, there is no American alternative for the dataset. In 2005, a German company believed that the commercial radar data market at the time was $60 million, about 15 percent of the optical market.[400] The value of TanDEM-X data may turn out to be many times greater, and NGA may have to buy a good bit of it for mission reasons. Moreover, a German idea to partner with the United States on a future mission called TanDEM-L could draw funds away from U.S. commercial imagery suppliers.[401]

U.S. Government interest also increases in alternative sources that could be gained via asymmetric trade such as launch of a satellite in exchange for data. This approach was used with Canada's Radarsat-1 and could be used for the future Radarsat Constellation Mission.[402] Canada's forthcoming review of aerospace policy may result in opportunities for government-to-government collaboration with the United States.[403] In addition, the U.S. apparently would have access to imagery from a future Australian-owned imagery satellite.[404]

The insatiable U.S. defense and intelligence need for high-resolution optical satellite imagery in this period continues to stymie hope for a U.S. moderate resolution multispectral system. DigitalGlobe had a license in 2000 to operate a 5 meter resolution multispectral imaging system as a complement for high-resolution data.[405][406] The military applications reportedly were "growing in popularity", including signature and terrain analysis.[407] The

[396] Satnews Daily, Spatial Injection for TanDEM-X, www.satnews.com, 21 June 2010.
[397] Peter B. deSelding, Dnepr Rocket Launches German Radar Satellite, SpaceNews, 21 June 2010.
[398] TanDEM-X Adds More Elevation Data, www.asmmag.com, 24 June 2010.
[399] Satnews Daily, Firsts for TanDEM-X, www.satnews.com, 28 June 2010.
[400] Bob Weber, European Satellite Imagery Continuity, March 2010.
[401] Peter B. deSelding, Germany Envisions Tandem Radar Mission with U.S., SpaceNews, 9 December 2010.
[402] Peter B. deSelding, Canadian Radarsat Constellation to Get $374 Million Cash Infusion, SpaceNews, 26 August 2010.
[403] Marc Boucher, Harper Government to Review Aerospace Policy and Programs, http://spaceref.ca, 22 March 2011.
[404] Philip Dorling, Australia and US sign secret spy deal, http://theage.com.au, 7 February 2011.
[405] Department of Commerce, M-5 Private Remote Sensing System License Summary, www.licensing.noaa.gov, 29 June 2010.
[406] DigitalGlobe News Room, M5 System to Image the Earth's Land Surface Every Four Days, 30 May 2002.
[407] USAF Air University, Maxwell AFB, Multispectral Imagery, AU Space Primer, www.space.au.af.mil, August 2002.

Pentagon's Joint Requirements Oversight Council (JROC) wanted such a capability, but to date it has not been fielded.[408]

- As with commercial radar imagery, Germany filled this gap in remote sensing leadership by fielding a 5-satellite multispectral system called RapidEye.[409] The system has a higher spatial resolution than Landsat (6.5 meters vis-à-vis 30), and more frequent revisit. Each Landsat image covers more area, but RapidEye is able to cover large areas more quickly. RapidEye imaged 80 percent of China within six months for land management and change detection purposes.[410][411][412]

2020 Future Three: Business Failure as U.S. Government Funds Erode and Competition Grows

This outcome is not out of the question, as U.S. Federal spending takes a sharp downturn, including for defense and intelligence.[413] Over $80 billion was spent on intelligence in Fiscal Year 2010, more than double the 2001 amount, causing Congressional leaders to call for restraint.[414] The Director of National Intelligence noted in November 2010 that "we had the same thing happen" in the early 1990s when the intelligence budget was reduced by 22.5 percent.[415] At the time, a media opinion claimed that the Director of Central Intelligence was wrong in trying to add money for new spy satellites, and that Congress should continue to cut the intelligence community "down to appropriate size".[416] After spending over $2 trillion more for defense from 2000-2010 than anticipated in 1999, the incentive to reduce outlays is clear.[417][418]

Regarding purchase of commercial imagery, there is precedent for the Department of Defense to reduce funding. In 1994, less than four months after the highly publicized rollout of new national policy on commercial imagery, the Vice Chairman of the Joint Chiefs of Staff wrote to the Defense Mapping Agency directing use of imagery from the government's national satellites in lieu of commercial sources.[419] Although the guidance was not specific, it would

[408] The Joint Staff, National Security Space Architect Integrated Spectral Architecture, 14 November 2002.
[409] Kim Douglas, Markus Heynen, RapidEye: Delivering the World, Imaging Notes, Fall 2010.
[410] RapidEye Newsletter, China Imaging Campaign, July 2010.
[411] RapidEye, RapidEye Standard Image Product Specifications, May 2010.
[412] RapidEye, RapidEye Images the Entire Country of China, 2010.
[413] Lori Montgomery, A renewed focus on spending, The Washington Post, 27 October 2010.
[414] Walter Pincus, Intelligence spending at record $80.1 billion overall, The Washington Post, 29 October 2010.
[415] Turner Brinton, Clapper Seeks to Phase in Intelligence Spending Cuts, SpaceNews, 3 November 2010.
[416] Ever More Money for Intelligence, The New York Times, 19 April 1993.
[417] Winslow Wheeler, $1 Trillion Bought Older, Smaller Forces: Fix it, Mr. Gates, http://www.dodbuzz.com. 30 August 2010.
[418] Top GOP Congressman: DoD Not Spared From Cuts, Agence France-Presse, 4 January 2011.
[419] W.A. Owens to Director, Defense Mapping Agency, CM-856-95, 27 June 1994.

have included Russian commercial imagery that DMA found could meet or augment DoD requirements in some cases.[420]

Even if only a portion of the $1 trillion in defense cuts from 2011 - 2020 suggested in a June 2010 task force study are taken, satellite programs would not be immune.[421] A separate bipartisan debt reduction panel in November 2010 called for a transition to less expensive satellite imagery.[422] According to the Director, Congressional Budget Office, solving the national debt problem would take action such as a 25 percent increase in taxes, a 20 percent reduction in Federal spending, or some combination.[423] This is one reason why The National Commission on Fiscal Responsibility and Reform recommends a cap on discretionary spending, including for defense, through 2020.[424] Further calls to cut back on defense, including for the war in Afghanistan,[425] emerge in 2011 on the 50th anniversary of former President Eisenhower's farewell address concern about the power of the military-industrial complex and need for balance in national programs.[426427428]

By 2020, it is too late for DigitalGlobe and GeoEye to diversify their business base from two decades of dependency on defense and intelligence. The availability of their commercial imagery for the public is de facto restricted due to heavy use by defense and intelligence.[429] The scale of the restriction in 2020 dwarfs the first "assured access", less than $10 million payment by NGA from October to December 2001 to Space Imaging for access to IKONOS imagery of Afghanistan.[430] Moreover, the Pentagon cannot afford to spend billions of dollars for commercial satellite imagery as costs explode for other satellite services.[431] Government spending on space-related projects flattens.[432]

High-resolution commercial satellites based on defense and intelligence needs for image detail are generally not optimal for global scale monitoring of resource issues. In 1968, Vice

[420] Defense Mapping Agency. Report on the Evaluation and Procurement of Former Soviet Union Imagery and Materials, 10 March 1994.
[421] Report of the Sustainable Defense Task Force titled Debt, Deficits, & Defense, 11 June 2010.
[422] Turner Brinton, Domenici-Rivlin Panel Targets Missile Defense, Satellite Imagery for Cuts, SpaceNews, 17 November 2010.
[423] Minutes of the Third Meeting of the National Commission on Fiscal Responsibility and Reform, 30 June 2010.
[424] Report of The National Commission on Fiscal Responsibility and Reform, The Moment of Truth, December 2010.
[425] Rajiv Chandrasekaran, Battle looms over pace of Afghanistan pullout, The Washington Post, 31 March 2011.
[426] Wikipedia, Military Industrial Complex, December 2010.
[427] Wikisource, Eisenhower's farewell address, 17 January 1961, December 2010.
[428] Walter Pincus, Eisenhower's words worth listening to today, The Washington Post, 14 December 2010.
[429] Clarence Robinson, Combat Units Drive Imagery, The Year in Defense, 2006.
[430] Joe Francica, Executive Interview with Robert Cardillo of NGA, Directions Magazine, 29 July 2004.
[431] Turner Brinton, Pentagon Seeing Sharp Price Increases for Commercial Satcom, SpaceNews, 18 March 2011.
[432] Euroconsult News Release, Worldwide government spending on space to flatten over the next five years, 16 February 2011.

President Humphrey argued, to no avail, with budget cutters for a civilian "Sky Spy".[433] He argued that study of the Earth would be a big payoff from the space program. Earth scientists thought that earth monitoring satellites could pay for themselves, partly on grounds that cameras on military satellites could provide a wealth of information for industry and government planners worldwide. Werner Von Braun thought a technical spinoff from the U.S. Apollo program could be satellites to monitor global agriculture.[434]

- Landsat satellites were a success, but remote sensing experts worried in 2006 that the U.S. was yielding leadership in moderate resolution land imaging data.[435] Even if Landsat 8 succeeds after launch in December 2012 and extends its 40-year continuity[436], Federal deficit issues could derail plans for Landsat 9 service in 2017 and beyond.[437][438]

- France's SPOT 6 and 7 satellites, beginning in 2012, largely eliminate a U.S. role in moderate resolution space-based imaging. SPOT sales exceeded $150 million in 2008, up from $40 million in 2002.[439] By 2020, SPOT proves that it can reliably offer multi-satellite, multi-sensor, multi-resolution service.[440]

In this alternative future, the U.S. commercial satellite imagery industry does not recover ground lost piecemeal after 2000 to Europe, Canada, and Asia. France, Germany, India, Japan, and South Korea all have mature commercial sales programs for sub-meter optical imagery. Competition and more satellites increase the industry's capacity, causing depressed prices.[441] SPOT's objective to win back high-resolution market share with Pleiades satellites succeeds due to the scope and distribution of its 44 ground stations, and constellation concept whereby Pleiades 1 and 2, and SPOT 6 and 7 are spaced equidistant in the same orbit to maximize high and moderate resolution collection.[442] France's plan to double its space budget by 2020 results in marked advances in classified and commercial satellite imaging capacity.[443][444] This keeps Astrium busy making imaging satellites and marketing services, including "smart

[433] The Washington Post. Civilian Sky Spy Is a Budget Victim. 10 January 1968.
[434] U.S. News and World Report, 12 December 1966.
[435] ASPRS, Remote Sensing Survey on the Future of Land Imaging, 6 November 2006.
[436] Landsat 8 Launch Goal is December 2012, http://eureka-geo.com/wordpress, 2010.
[437] Deanna Archuleta, Department of Interior's Role in Earth Observation, 16 March 2010.
[438] Barbara Ryan and Bruce Quirk, Landsat Program on Track for 2011, ACSM Bulletin, December 2007.
[439] Peter B. deSelding, SPOT Commits to New Satellites, But Funding Questions Remain, SpaceNews, 15 June 2009.
[440] Jeff Thurston, SPOT Image: From 3D to Services, www.asmmag.com, 28 June 2010.
[441] Northern Sky Research, White Paper on The Changing Face of Earth Observation, December 2008.
[442] Reinventing the Constellation Concept, SPOT Magazine, First Semester 2010.
[443] Christian Lardier, Soon a Military Command for Space, Paris Air & Cosmos, 11 December 2009.
[444] Peter B. deSelding, France Orders Two Recon Satellites, SpaceNews, 2 December 2010.

mapping solutions" according to a company banner.[445][446] Increased investment in the European Space Agency has a positive effect on the European industrial base.[447] India's remote sensing satellites continue to succeed[448]; Korea flies a 3rd generation optical Kompsat; Germany flies for itself or exports the HiROS system[449][450]; and Japan makes this sector a commercial winner ten years after Tokyo's 2009 plan to make its space industry competitive, not just use it for R&D.[451] The negative impact on the health of DigitalGlobe and GeoEye is unmistakable.

From 2010 to 2020, little or nothing is done by the U.S. Government to counter the erosion of U.S. leadership in commercial imagery.[452] There are few options because satellite imaging technology is widespread, and access to "free" or low-cost data from government-operated satellites conflicts with commercial industry objectives.[453] Advances in technology outpace the Government's ability to deal with it, such as the quandary on providing imagery to foreign governments for targeting support.[454] The U.S. focus remains narrow, greatly emphasizing spatial resolution. Moreover, the "exquisite" classified satellites referred to in 2010 as a "multibillions" program for Lockheed turn out to be successful, and operate from 2015 onward, thereby reducing the need for commercial satellite imagery that once served as a temporary supplement or backup. In a sign of change, the NRO's so-called Next Generation Optical system includes a different optics supplier than the one chosen for the failed FIA project. [455] The Director, NRO follows through on his plan to increase funding for science and technology efforts for developing future satellites.[456]

The nation cannot afford commercial satellites, costing nearly one billion dollars each, which some officials reportedly say provide much of the same capabilities as NRO's satellites.[457] National leaders decide that in-orbit NRO satellites take priority over commercial alternatives.[458][459] The ranking member of the House Intelligence Committee noted in March 2011 that the NRO recently launched an imaging satellite and will launch another in two

[445] France getting EADS spy satellites, http://www.spacedaily.com, 7 December 2010.
[446] Astrium News Release, Infoterra and Spot Image are now Astrium GEO-Information Services, 1 December 2010.
[447] Peter B. deSelding, ESA Budget Rises to $4B as 14 Nations Boost Contributions, 21 January 2011.
[448] K.S. Jayaraman, Indian PSLV Rocket Puts Cartosat-2B into Orbit, SpaceNews, 12 July 2010.
[449] Peter B. deSelding, Germany Eyes High-Resolution Optical Imaging Satellites, SpaceNews, 10 June 2010.
[450] Thomas Walati and Andreas Eckhardt, Very High Resolution and 3D Optical Remote Sensing Solutions, May 2008.
[451] The Yomiuri Shimbun, Space Industry Funding to Double in Next Ten Years, 27 May 2010.
[452] Center for Strategic and International Studies, Health of the U.S. Industrial Base and the Impact of Export Controls, February 2008.
[453] Northern Sky Research, Free Market Economy the Bane of the EO Industry, 25 February 2010.
[454] David Ignatius, New rules for new weapons, The Washington Post, 11 November 2010.
[455] Turner Brinton, Goodrich Chosen to Build Spy Sat Optics, SpaceNews, 29 October 2010.
[456] Amy Butler, NRO to Declassify Some Program Data, Aviation Week and Space Technology, 15 September 2010.
[457] Marc Ambinder, Why McCain is Holding Up Clapper's Nomination, The Atlantic, 2 August 2010.
[458] Justin Ray, Delta 4-Heavy's hush-hush payload found and identified, Spaceflight Now, 23 January 2011.
[459] Turner Brinton, Air Force Launches NRO Satellite Aboard Delta 4 Heavy, SpaceNews, 20 January 2011.

years.[460] Moreover, the Director, NRO claimed in November 2010 that his agency had already cut all the [budget] corners possible, noting that legacy spy satellites may be de-orbited.[461]

- ORS also becomes a cost-effective imagery solution for DoD due to acquisition reform pressures,[462] and more responsive to commanders' needs than commercial imagery.[463] Defense acquisition reform results in stark choices for the military from 2010 – 2020, such as recapitalizing equipment. Low-cost ORS approaches become more valued assets than DigitalGlobe and GeoEye commercial satellites, which more or less become an unclassified version of national classified satellites.

- ORS becomes more important as the Pentagon seeks alternative imagery sources less costly than classified and unclassified satellites made by Lockheed. Raytheon's "Responder" modular satellite, built in months vice years, for example, proves viable for providing satellite imagery to field commanders.[464][465]

- Small commercial satellites made and operated by Skybox and SSTL become a staple for defense and non-defense users because their low cost results in a marked reduction in the cost of data and services.

In this future, the end state is driven by a reduction in U.S. Government funding, rapid increase in foreign competition and advances in low cost small satellite capability. Astrium follows up on high expectations,[466] and gains traction with its GEO-Information Services division.[467] Military and intelligence support continue as the basis for licensed commercial satellite imagery in the United States. Use for commercial purposes remains secondary. As a result in 2020, the U.S. is less able to image and monitor with diverse means global problems such as food and water availability, natural resource depletion, and changes caused by explosive demographics. This ground is largely ceded to Europe and Asia because U.S. military and intelligence use of high-resolution optical commercial imagery remains paramount.

This future begins in 2020, twenty years after the successful launch of NASA's Earth Observing-1 mission, including its hyperspectral sensor called Hyperion.[468] Such sensors include

[460] Turner Brinton, Congress Still Weighing Options for New Imaging Satellites, SpaceNews, 15 March 2011.
[461] Turner Brinton, Clapper Seeks to Phase in Intelligence Spending Cuts, SpaceNews, 3 November 2010.
[462] Gary Payton, Military Space Programs in FY2011 and the Future Years Defense Program, 21 April 2010.
[463] Goodrich…Sensing Success with ORS, Satnews Daily, 25 October 2010.
[464] Stew Magnuson, Military Looks to Small Satellites as Costs for Large Spacecraft Grow, National Defense, July 201.
[465] Raytheon product brochure, Responder: Responsive Space Solutions, 2010.
[466] Peter B. deSelding, Astrium's 2010 Results Surpass Expectations, SpaceNews, 9 March 2011.
[467] Astrium News Release, Infoterra and Spot Image are now Astrium GEO-Information Services, 1 December 2010.
[468] NASA Fact Sheet, Earth Observing-1, The Advanced Land Imager, 1999.

hundreds of spectral bands for improved Earth surface characterization. By 2010, over 40,000 images had been collected, resulting in over 400 technical papers.[469] A workshop in Iceland on hyper-spectral image processing in June 2010 covered a range of applications, including defense and security.[470]

The utility of hyperspectral imaging for the U.S. military is proven on an ORS satellite called TacSat-3, launched in May 2009, capable of detecting about six times more of the electromagnetic spectrum than the human eye.[471][472] Before launch, an author suggested that it could revolutionize space-based intelligence collection.[473] One year later, media reports indicated that it had demonstrated utility to U.S. military forces.[474][475][476] The transition of the system from experimental to operational took place on 18 June 2010.[477]

For various reasons, in this alternative future there is no U.S. commercial hyperspectral imaging satellite, while Germany goes ahead with a plan to field a system called EnMAP. Although TacSat-3 has much better spatial and spectral performance than EnMAP, it is restricted for military use because DoD considers hyperspectral sensing to have significant military utility.[478] Whereas ten years ago it was apparent that United States regulators wanted limits on sale of commercial hyperspectral data and products,[479] German experts now write that EnMAP data policy should give room to encourage value adding companies to enter this field in earth observation.[480] This aligns with Germany's November 2010 national space strategy which features technological independence and opening up new markets.[481]

The 15-year U.S. lead with Hyperion over EnMAP, both designed as scientific missions with similar performance, becomes irrelevant as Germany uses EnMAP for commercial gain, just as TerraSAR / TanDEM-X surged ahead of the United States in commercial radar imaging. A Japanese hyperspectral approach, studied initially in 2006, becomes real in 2014 / 2015 as a

[469] NASA, http://eo1.gsfc.nasa.gov/technology/hyperion, Hyperion Instrument, 2001.
[470] WHISPERS, 2nd Workshop on Hyperspectral Image and Signal Processing, June 2010.
[471] Wikipedia, TacSat-3, 2010.
[472] William Matthews, Putting Image Analysis in Space, DefenseNews, 15 June 2009.
[473] Taylor Dinerman, TacSat-3, The Space Review, 25 June 2007.
[474] Todd Neff, Tall Order, C4ISR Journal, 1 April 2010.
[475] Rebecca Boyle, Prototype Hyperspectral Satellite Fast-Tracked to Begin Official Spy Work for Military, www.popsci.com/technology, 11 June 2010.
[476] Lewis Page, New Prototype US Spy Satellite Rushed Into Active Use, www.theregister.co.uk, 11 June 2010.
[477] U.S. Air Force News Release, Space command officials embark on many firsts with tactical satellite, 28 June 2010.
[478] Mark Hewish, Cost cut for eyes in space, Jane's International Defence Review, December 2000.
[479] Charles Robb to William Cohen, 22 June 1998.
[480] Gunter Schreier, Fundamentals of Earth Observation Policy, Examples of German and European Missions, 23 March 2010.
[481] The German Federal Government adopts a new space strategy, www.satnews.com, 8 December 2010.

hosted payload on ALOS-3.[482][483] U.S. restrictions on commercial hyperspectral imaging imposed in 2000 for a satellite that failed on launch are reinforced by the TacSat-3 success.[484]

2020 Reference Point: The Purpose of Commercial Satellite Imagery

The balance in use of U.S. commercial satellites for military and non-military needs is the point to watch in 2020. Experts agree that the main purpose of the geospatial industry is to track changes on the planet and changes in physical resources, such as food, water, and minerals. [485] Use of imagery for military and intelligence concerns will continue to be the top priority for the United States -- at this point 60 years beyond fielding its first spy satellite. Nonetheless, if analysts are correct that the international system as we know it will be almost unrecognizable in 2025, imagery satellites by 2020 should make a much greater contribution than today for monitoring non-military activity.[486][487] This potential contribution was deemed enormous in an intelligence report published in 1971, noting that the roughly 2-meter resolution Corona satellite system was a breakthrough for resources exploitation.[488] The report found that the economic and political impact of this type of monitoring could not be overstated.

The 2010 drought and fire impact on Russian agriculture illustrates the importance of food production and export.[489] The CIA thought in 1967 that aerial photography could be used to identify agricultural trouble spots.[490] By the 1970s, CIA used meteorological data, agronomic expertise, and satellite images to monitor the Russian grain crop.[491] Although climate change may improve growing conditions for Russian crops, experts noted in 2009 that over the past 10-20 years climate change in Russia has been linked to extreme events such as heat waves and fires.[492] Monitoring these problems has a direct relationship to American exports, especially in states like Minnesota whose farmers anticipated a bumper 2010 crop.[493] Wheat prices rose 70 percent due to heat and fire in Russia, causing experts to express concern over global food supply challenges.[494][495][496]

Industries associated with the World Economic Forum are aware of future pressures on available water, agriculture, minerals and so on. China's aggressive pursuit of minerals from Australia, for example, has caused Australian national security concerns.[497][498] Commercial imagery satellites can make a contribution in these areas.[499][500][501][502] Much depends on the extent that future U.S. commercial imagery satellites are designed and used for non-military tasks.

[482] Itochu Corporation Press Release, Commercial Hyperspectral System Hyper-X, 18 April 2006.
[483] Duke TAKAHASHI, Hyper-X provides answers versus images, Itochu Corporation, March 2010.
[484] Bryan Bender, USA to Limit Sale of Satellite Imagery on Security Grounds, Jane's Defense Weekly, 8 March 2000.
[485] Craig Bachmann and Natasha Lager, The 4th Dimension: Time, Imaging Notes, Fall 2009.
[486] National Intelligence Council, Global Trends 2025: A Transformed World, NIC 2008-003, November 2008.
[487] National Intelligence Council, Global Trends 2015, NIC 2000-02, December 2000.

In an attempt to preserve military and intelligence superiority, there is no EnMAP-comparable American commercial hyperspectral imaging system in space before 2020, if at all. Although a U.S. firm obtained in September 2010 a license from the Department of Commerce for hyperspectral satellites in geosynchronous orbit, the best panchromatic resolution would be 300 meters, and the best hyperspectral resolution would be 2 kilometers.[503][504]

Role of the Department of Commerce

Knowing the history of remote sensing regulation is important to enable the Department of Commerce (DoC) "to prepare for the future of environmental observations, develop a next generation strategic plan, and position itself to be the world's most comprehensive source and recognized authority for satellite products, environmental information, and official assessments of the environment in support of societal and economic decisions…"[505]

The role of the DoC is central to current Government process in commercial remote sensing licensing,[506] but the priority of this work seems to have declined over the past 25 years. NOAA activities such as maintaining effective environmental monitoring using DoC-owned, operated, and funded capabilities appear to be more important. On the other hand, commercial remote sensing is very important to DoD due to massive investment. Ironically, in 1870, President Grant authorized the Secretary of War to create a national weather service because it was believed that military discipline would result in prompt and accurate

[488] CORONA, America's First Satellite Program, 1995.
[489] Lauren Goodrich, Drought, Fire, and Grain in Russia, www.stratfor.com/weekly, 10 August 2010.
[490] William R. Gasser, Aerial Photography for Agriculture, Studies in Intelligence, Volume 11, Fall 1967.
[491] James Noren, CIA's Analysis of the Soviet Economy, Watching the Bear, Chapter II, 16 March 2007.
[492] National Intelligence Council, Russia: Impact of Climate Change to 2030, NIC 2009-04D, April 2009.
[493] Mike Hughlett, Big Crop Could Pay Off for Minnesota's Farmers, Minneapolis StarTribune, 12 August 2010.
[494] Neil MacFarquhar, UN Raises Concerns as Global Food Prices Jump, The New York Times, 3 September 2010.
[495] Javier Blas, Fears grow over food supply, Financial Times, 3 September 2010.
[496] Rudy Ruitenberg, Speculation, Price Swings Threaten Security of Food Supply, Bloomberg, 23 January 2011.
[497] Malcolm Knox, The deal is simple. Australia gets money, China gets Australia, Bloomberg Businessweek, 6 September 2010.
[498] Keith Bradsher, China Still Bans Rare Earth to Japan, The New York Times, 10 November 2010.
[499] Water, Our Thirsty World, National Geographic, April 2010.
[500] World Economic Forum Water Initiative, January 2009.
[501] World Economic Forum, A New Vision for Agriculture, www.weforum.org/en/initiatives/, 2010.
[502] World Economic Forum, Mining and Metals Scenarios to 2030, 2010.
[503] GeoMetWatch…Showing A Great Deal of Sense, SatNews Daily, 27 October 2010.
[504] GeoMetWatch, Inc., Private Remote Sensing License Public Summary, 2010.
[505] Department of Commerce, Request for Quotation SS133E-10-RQ-1275, 19 August 2010.
[506] The 1984 Land Remote Sensing Commercialization Act, repealed and replaced in 1992 by the Land Remote Sensing Policy Act, require Commerce to license the operations of commercial remote sensing satellites.

observations.[507] The function was transferred to the Department of Agriculture in 1890, then to Commerce in 1940.

The National Environmental Satellite, Data, and, Information Service (NESDIS) evolved as a management and data base function for national environmental data, originally tied to weather information included in the 1950 formation of a data center for climate. The environmental data base function became increasingly important with the 1970 formation of NOAA.[508] NESDIS was created in 1982 to consolidate NOAA's satellite and data management activities.[509] By 2004, according to NOAA Strategic Direction, forming an Information Service Enterprise (ISE) would be the "lifeblood" of NOAA, i.e., the environmental information provided by the enterprise to NOAA users.[510] The Strategic Direction was silent, however, on commercial remote sensing systems. This silence is also evident in a June 2010 draft of NOAA's next-generation strategic plan.[511]

In 1988, the Secretary of Commerce formed the Office of Space Commercialization within the Department of the Secretary.[512] The office was positioned in the 1980s to be DoC's advocate for commercial remote sensing, but by this time NESDIS was the DoC focal point for remote sensing issues. Nonetheless, the purpose of the space commercialization unit was to foster conditions for the economic growth and technological advancement of the U.S. commercial space industry. This function was moved to DoC's Technology Administration in 1996.[513] The Technology Administration was formed, in part, to "conduct technology policy analyses to improve United States industrial productivity, technology, and innovation, and cooperate with United States industry in the improvement of its productivity, technology, and ability to compete successfully in world markets."[514]

Legislation was enacted in 1998 to realign the Office of Space Commercialization to DoC's National Institute for Standards and Technology.[515] In 2005, the office was again realigned to NOAA, and now resides in NESDIS.[516] In 2007, the Technology Administration was abolished by the American COMPETES Act.[517] As a result, a point of advocacy for commercial

[507] National Weather Service, http://srh.noaa.gov/mob/?n=history, 2010.
[508] Department of Commerce, Reorganization Plan No. 4 of 1970, effective 3 October 1970.
[509] Department of Commerce, A History of NOAA, 2010.
[510] Department of Commerce, Strategic Direction for NOAA's Integrated Global Environmental Observation and Data Management System, July 2004.
[511] Department of Commerce, NOAA's Next-Generation Strategic Plan, Version 4.0, Draft dated 23 June 2010.
[512] Department of Commerce, Department Organizational Order 15-19, 2 December 1988.
[513] Department of Commerce, Department Organizational Order 10-17, 1996.
[514] 15 USC 3704 – Sec 3704, Commerce and technological innovation.
[515] 105th Congress, Public Law 105-309, An Act to Authorize Appropriations for the National Institute of Standards and Technology, 1998.
[516] Department of Commerce, Department Organizational Order 25-5, 2005.
[517] H.R. 2272, America COMPETES Act, 9 August 2007.

remote sensing has shifted over 20 years from being a direct report to the Secretary of Commerce, to an advocacy support function in NESDIS. NESDIS is, in effect, the Government's advocate and regulator for commercial remote sensing. This balancing act becomes more complex as spatial technologies fuse.

U.S. firms in the remote sensing business do not believe that the Government promotes national leadership in this field.[518] The DoC is in a bind, however, because it is the USG's advocate and regulator for commercial remote sensing, a champion for unfettered ("free") access to remote sensing data as part of GEOSS, and a consumer of commercial environmental data to support the national interest. It may become even more difficult for DoC to regulate commercial remote sensing as fusion of data sources overtakes the intended effect of regulating each one. Moreover, the DoC would find it hard to object to access to environmental data via GEOSS from future civil systems such as Japan's ALOS-3 in expected to collect 1-meter resolution data beginning in 2014. Dual-use 1-meter systems such as South Korea's operational Kompsat-2 are already planned for use in Sentinel Asia, a multi-national project where data are shared for disaster monitoring purposes.[519][520] For this reason, changes may be needed in 15 CFR 960, such as not requiring full interagency review of license applications for 1-meter imagery satellites intended for mass market use.

In the United States, commercial remote sensing is not part of the nation's civil-sector earth observation infrastructure. Although Congress requested a plan for sustainable national Earth observation activities in the 2010 Consolidated Appropriations Act, there is no specific role for commercial satellite imagery identified in a September 2010 Office of Science and Technology Policy report.[521] Vast amounts of commercial imagery are procured by DoD, but these data are largely separate from infrastructure that manages the capture of Landsat imagery. NOAA's FY2009 - 2014 Strategic Plan states that an objective is to increase government procurement of NOAA-licensed remote sensing systems, but does not specify what this means regarding purchase of commercial satellite imagery.[522] NOAA's focus is management of environmental satellite operations.[523]

NESDIS has over $1 billion out of the DoC's roughly $8 billion annual budget, and is responsible for the operation of 15 satellites, none of which are commercial remote sensing satellites.[524][525][526] NOAA's focus ranges from climate and weather to ocean and coastal

[518] J. Christian Kessler, Leadership in the Remote Sensing Satellite Industry, October 2008.
[519] JeongHeon SONG, Contribution of KARI to Sentinel Asia, Korea Aerospace Research Institute, 6 July 2010.
[520] Sentinel Asia website, https://sentinel.tksc.jaxa.jp/sentinel2/topControl.action, 2010.
[521] The White House. Office of Science and Technology Policy. Achieving and Sustaining Earth
[522] Department of Commerce, NOAA Strategic Plan, FY2009-2014,
[523] Department of Commerce, http://www.nesdis.noaa.gov/SatInformation.html, 2010.
[524] Department of Commerce, NESDIS FY2011 Budget Highlights.
[525] The White House. Fact Sheet on Department of Commerce FY2011 Budget.

stewardship. NOAA has a keen interest and responsibility regarding the international Group on Earth Observations (GEO) formed in July 2003, and a potential Global Earth Observation Systems of Systems (GEOSS) that could include over 100 systems monitoring over 500 environmental parameters.[527][528] NOAA's work on an Integrated Data Environment (IDE) for GEO, in effect, broadens the ISE's importance.[529] In contrast, none of NOAA's 31 performance measures in 2009 to comply with the Government Performance & Results Act (GPRA) touched on commercial remote sensing.[530] This reflects a bright line between policies and issues associated with unclassified U.S. Government owned and operated vis-à-vis commercial satellites, even though a common use is for environmental monitoring.

There are options on what NOAA / NESDIS might say or do about commercial remote sensing in a future strategic plan.

- Retain status quo, taking into account any meaningful suggestions industry may have made in response to DoC's call for input on ways to "protect national security that does not place the U.S. commercial remote sensing industry at a competitive disadvantage with respect to foreign competitors."[531] It may be difficult, however, to be the global leader on environmental data management if commercial imagery is largely or entirely outside of the ISE. At a minimum, establish a GPRA criterion for NOAA for commercial remote sensing, such as granting licenses for innovative concepts as quickly as licenses for routine or proven solutions.

- Increase the stature of Office of Space Commercialization. Chair and guide a revised ACCRES, in cooperation with the National Coordination Office for Space-Based Positioning, Navigation, and Timing on grounds that both provide location-based services.[532] The minutes of ACCRES meetings since 2002 do not indicate that the Committee has dealt with or promoted the value of fused, location information (see text box below).

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[526] FY2011 Department of Commerce Appropriations, www.agiweb.org, 21 June 2010.
[527] Carrie McDougall, Atziri Ibanez, Susan White, Achieving Environmental Literacy with NOAA's Observing Systems Data, Marine Technology Society Journal, Winter 2006.
[528] The Global Earth Observation System of Systems 10-Year Implementation Plan, www.earthobservation.org, 16 February 2005.
[529] Department of Commerce, NOAA Global Earth Observation Integrated Data Environment Concept of Operations, 13 September 2006.
[530] Department of Commerce, 2009 NOAA Accomplishments and Performance Results.
[531] Department of Commerce, Request for Information – Privately Operated Commercial Remote Sensing Satellites, 15 June 2009.
[532] http://www.pnt.gov/orgchart.pdf, 2010.

- Place the commercial remote sensing licensing function inside DoC's Bureau of Industry and Security because BIS is responsible for export administration and enforcement, including items of national security concern such as commercial encryption products.[533] Have NESDIS manage satellite operations for civil environmental purposes only. This means DoC would review the record that led to President Clinton's 1996 determination that all encryption products no longer needed regulation as defense articles on the U.S. Munitions List, and take a similar approach with commercial imagery.[534][535][536][537][538][539][540][541][542] Because 1-meter resolution satellite imagery has become a commodity since 2000, easement in licensing may make sense, similar to the way that "publicly available" commercial encryption products with a specified key length are exportable with notification to BIS, but not further review. Aligning the licensing activity for remote sensing and encryption within BIS would give industry a single focal point in DoC for commercial imagery and encryption. This would separate within Commerce the advocacy and regulatory functions for licensing, and not allow a single management structure in the Office of Space Commercialization to be both advocate and regulator for remote sensing. Time for such action may be fleeting, however, due to ongoing challenges regarding export control reform.[543]

- Shift commercial remote sensing oversight to DoD for better than one-meter resolution systems. Retain within Commerce licensing for lesser performing systems designed for land use monitoring and environmental observation purposes. DoD wanted strict alignment between 1984 law and NOAA-issued regulation pertinent to commercial remote sensing licenses, including 15 CFR 960 when first issued on 15 July 1987. DoD's view, in response to a 1986 NESDIS request for coordination on draft regulatory text was that "…the discretion to determine the licensing conditions necessary to meet national security concerns afforded the Secretary of Defense by

[533] Department of Commerce, Bureau of Industry and Security, Annual Report to Congress, 2008.
[534] Wikipedia, Export of cryptography in the United States, November 2010.
[535] David E. Sanger, Clinton Ready for Exports of Data Codes, The New York Times, 1 October 1996.
[536] The White House, Statement of the Vice President on Clipper 4, 1 October 1996.
[537] The White House, Encryption Export Policy, 15 November 1996.
[538] Clinton administration issues new rules on computer encryption technology, The Washington Post, 28 December 1996.
[539] Even stronger encryption systems can be exported, The Baltimore Sun, 1 February 1997.
[540] Congressional Research Service, Encryption Export Controls, 11 January 2001.
[541] Department of Commerce, Guidance on Commercial Encryption Export Controls, November 2010.
[542] Department of Commerce, Notification Requirements for Publicly Available Encryption Source Code, November 2010.
[543] Jeff Foust, A fading opportunity for export control reform?, The Space Review, 11 October 2010.

the Act should not be limited by NOAA's rulemaking."[544] There is no reason to believe that DoD's role is less important today. DoD has a huge vested interest in support to military operations, not necessarily the success of commercial ventures.

- Change the 1992 Act, and allow "U.S. land remote sensing systems to provide whatever level of spatial resolution or other technical specifications may be of interest for civilian or commercial applications", as recommended in 1992 by the House of Representatives Committee on Science, Space, and Technology.[545] For example, licensing of 1 meter optical systems could be done by Commerce without interagency review because such systems are commonplace. Foreign competition is much stronger now than when the Committee stated that "These [foreign] systems operate within a commercial marketplace in which [U.S.] national security constraints can cause significant competitive disadvantages."

- Be bold. Change the 1992 Act and transfer the entire satellite arm of NOAA to the private sector, completely, or in stages, as suggested 20 years ago in a think tank report.[546] This may make more sense now because commercial GPS, commercial remote sensing, and commercial encryption products in a cyber-savvy world are more likely to be marketed in packaged applications instead of separately.

[544] Craig Alderman, Jr. to Thomas Pyke, 22 January 1987.
[545] House of Representatives, National Landsat Policy Act of 1992, HR 102-539, 28 May 1992.
[546] A More Effective Civil Space Program, The Final Report of the CSIS Study of Civil Space Policy, Center for Strategic and International Studies, May 1989.

Highlights of ACCRES Meetings, 2002 - 2010

30 September 2002: The Committee was briefed on a 10-year remote sensing industry analysis by the American Society for Photogrammetry and Remote Sensing (ASPRS). The study was initiated through a 1999 agreement with NASA.

14 January 2003: The Committee was briefed again on the findings of ASPRS study which found that Government influence is pervasive, with legislation and policies restricting U.S. remote sensing sales. The number one user concern is cost of data.

16 May 2003: Government policy supports the industry by directing agencies to purchase commercial data, and to use government satellite data to meet only those requirements that cannot be serviced by the commercial sector.

27 August 2004: NOAA focuses on timeliness performance measures for license applications. In the future, NOAA will expand these measures to include foreign agreements and license amendments. U.S. government remains in a risk aversion mode. The focus is on protection of intelligence sources and methods.

2 February 2005: The Committee was updated on NOAA's effort to revise its regulations. As part of an effort to respond to the new commercial remote sensing space policy, NOAA is in the final stages of coordinating within the Department of Commerce.

10 March 2006: The Government hopes to transition the Landsat program from a series of independently planned missions to a sustained operational program funded and managed by a U.S. Government operational agency or agencies, an international consortium, and/or a commercial partnership. The economic benefits of the system were questioned.

15 March 2007: The recommendation by ACCRES to eliminate the 24-hour restriction on distribution of certain types of remote sensing data is under consideration within the U.S. Government and a final decision is expected by next month.

27 March 2008: According to a 10-year industry forecast, data currency is continuing to increase in relative importance.

7 October 2008: A briefer pointed to an increasing preference towards smaller, lighter, faster missions for environmental monitoring, with climate change at the top of the earth observation agenda. The future of the industry will be characterized by further consolidation and integration as companies look to tap into the large but fragmented service sector.

8 October 2009: NOAA issued a license for a synthetic aperture radar (SAR) satellite capable of producing 1-meter imagery for commercial sale. About ten percent of NOAA's spending is on commercial remote sensing data.

Appendix A

Key Points in the Land Remote Sensing Policy Act of 1992

This section contains extracts of text from the current United States law that governs operation of commercial earth observation systems.

1. **Section 2 (3).** "The national interest of the United States lies in maintaining international leadership in satellite land remote sensing and in broadly promoting the beneficial use of remote sensing data."

   What it means: U.S. companies can argue that it is a legal requirement to have better system performance than any non-U.S. system.

   2020 version: No change needed.

2. **Section 2 (15):** "Development of the remote sensing market and the provision of commercial value-added services based on remote sensing data should remain exclusively the function of the private sector."

   What it means: After the failed 1980s attempt to privatize Landsat, the Congress did not support government help for commercial remote sensing companies.

   2020 version: The text should be revised to cover formal public private partnerships, when it is in the national interest, because absent radical change in the industry it is wrong to presume that this sector could sustain itself without Government funds.

3. **Section 201(a)(2).** "In the case of a private space system that is used for remote sensing and other purposes, the authority of the Secretary [of Commerce] shall be limited only to the remote sensing operations of such space system."

   What it means: This is generally understood to mean that licensing applies to safely managing a spacecraft in orbit. The law does not say that licensing also relates to the ability of a company to operate a ground processing system or data distribution network, but data handling is a factor in 15 CFR 960. A company can obtain a license if it can prove that it has the ability to fly a satellite and maintain its health and safety.

   2020 version: The ability of the Government to control or regulate the flow of commercial data needs clarification. Otherwise, the term "operations" is open to interpretation.

4. **Section 201(c).** "The Secretary [of Commerce] shall review any application and make a determination thereon within 120 days of such application."

   What it means: This is a specific rule. Companies complain that U.S. Government agencies take longer than this. License requests considered precedent setting, such as for a 1 meter resolution SAR system, usually take longer than 120 days to process.

   2020 version: Shorten the timeframe to 60-90 days change to demonstrate U.S. Government action to help make industry more competitive in the global marketplace.

5. **Section 202(b)(6).** "Any license issued pursuant to this title shall specify that the licensee shall comply with all requirements of this Act and shall notify the Secretary [of Commerce] of any agreement the licensee intends to enter with a foreign nation, entity, or consortium involving foreign nations or entities."

   What it means: The U.S. Government wants to know how U.S. companies are involved with foreign entities, especially if it involves foreign ownership. The U.S. Government in general does not want to give a foreign entity rights to operate a satellite via a U.S. company's license.

   2020 version: This should focus exclusively on foreign ownership and potential sales to entities banned from purchasing U.S. goods. Regulating data flows in this highly globalized sector inhibits commerce.

6. **Section 204.** "The Secretary [of Commerce] may issue regulations to carry out this title. Such regulations shall be promulgated only after public notice and comment in accordance with the provisions of section 553 of title 5, United States Code.

   What it means: This is the reason why 15 Consolidated Federal Regulation 960 is so important. The public, not just companies seeking licenses to operate remote sensing systems, has a right to review and comment on any regulations that implement the law.

   2020 version: The regulation should be significantly streamlined, mindful that at this point Google will be almost 25 years old. Simply stating that the Government has a right to procure data pertinent for national security use, and retain it in a non-public archive, may be one way to allow for public and non-public archives.

7. **Section 507(a).** "The Secretary [of Commerce] shall consult with the Secretary of Defense on all matters under this Act affecting national security. The Secretary of Defense shall be responsible for determining those conditions, consistent with this Act, necessary to meet national security concerns of the United States and for notifying the Secretary [of Commerce] promptly of such conditions."

What it means: DoD has a major role in deciding what commercial remote sensing systems are licensed to operate. In fact, DoD's view is arguably more important than the Department of Commerce. This is why commercial systems that can also service DoD needs, as well as DoD's foreign military partners, get much attention in the license review process.

2020 version: No change. DoD would retain this authority in light of the vast amount of defense and intelligence funds invested in commercial systems.

8. **Section 507(b).** "The Secretary [of Commerce] shall consult with the Secretary of State on all matters under this Act affecting international obligations. The Secretary of State shall be responsible for determining those conditions, consistent with this Act, necessary to meet international obligations and policies of the United States and for notifying promptly the Secretary [of Commerce] of such conditions."

   What it means: The Department of State has a major role in deciding what commercial remote sensing systems are licensed to operate. The power granted in law is significant, especially for requests that involve potential sale of space or ground systems to foreign entities, or placement of parts of the licensee's infrastructure in foreign territory.

   2020 version: No change. DoS would retain this authority because the United States will always have international obligations. Since resource and environmental issues could become a much more important factor for diplomacy in 2020 and beyond, the DoS role in commercial imagery licensing would not be altered.

Key Points in 15 CFR Part 960, Final Rule, Dated 25 April 2006

This section contains extracts of text from the current United States regulation that governs operation of commercial earth observation systems.

9. **Subpart A:** "Of particular interest is the fact that the Act and these regulations apply to any person subject to the jurisdiction and control of the United States who operates or proposes to operate a private remote sensing space system, either directly or through an affiliate or subsidiary….a person is an individual who is a United States citizen, or a foreign person subject to the jurisdiction and control of the United States…or any other private remote sensing space system operator having substantial connections with the United States or deriving substantial benefits from the United States that support its international remote sensing operations sufficient to assert U.S. jurisdiction.

   What it means: A license is needed if it involves processing the data and/or marketing it from facilities within the United States. U.S. Government reviewers of license

requests tend to consider operating a remote sensing system to include both the space and ground segments.

2020 version: Some adjustment to this rule may be necessary because this already globalized industry will increasingly rely on web services. Anyone inside the United States would be able to market data or services, and not be an "operator" of a remote sensing space system.

10. **Subpart B, Section 960.11.** "In furtherance of these obligations, the license contains rigorous conditions on the operation of a system, including the requirement that the licensee maintain operational control of its system from a U.S. territory at all times and incorporate safeguards to ensure the integrity of system operations. In particular, it is important to note that the license requirement imposed on the licensee that it maintain operational control is an implementation of U.S. obligations under the United Nations Outer Space Treaty of 1967."

    What it means: The reason why licensing was originally linked to operation of a space system was potential U.S. Government liability for actions of a person or entity in the private sector. The Department of Commerce has a requirement that operational control of the system must be based within the territorial jurisdiction of the United States. This is also the reason why the U.S. Government pays close attention to the level of foreign investment in a U.S. company before granting a license to operate the system.

    2020 version: This rule may need adjustment to align with increased U.S. Government activity regarding Space Situational Awareness, space debris mitigation and international collaboration in these areas.

11. **Section I – Annual Compliance Audit.** "An on-site audit shall be conducted at least annually, following issuance of a license, to confirm the licensee's compliance with the national security, foreign policy, and international obligations of the United States and compliance with all other license conditions."

    What it means: Department of Commerce officials visit companies to review their files and facilities for compliance with U.S. law and regulation.

    2020 version: No change likely because U.S. Government funds remain vital for success of the industry, and it is a condition of the license regardless of who is funding the system. Verification is required.

12. **Section II – Twelve Months Before Launch.** "Submit operations plan for restricting collection and/or dissemination of Israeli territory to that which is no more detailed or precise than what will be available from non-U.S. commercial sources during the time of the licensee's planned operations."

    What it means: The Kyl-Bingaman amendment to the 1997 Defense Authorization Act imposed strict limits on space-based imaging of Israel. The best course of action for U.S.-licensed remote sensing system operators is to not image Israel.

    2020 version: No change because political factors would outweigh any substantive argument.

13. **Section III – No Later Than Six Months Prior to Launch.** "Submit a data flow diagram which graphically represents the data flow from the sensor to final product delivery locations."

    What it means: U.S. Government reviewers are just as interested in details about data flow on the ground as they are about satellite operations.

    2020 version: Change is needed because delivery via the Internet means the companies probably could not diagram their data flow to "final" locations, other than to www.

14. **Licensing of New or Advanced Systems.** "As a general matter, the license covers the end-to-end operational capability of a remote sensing space system's ability to quantify information that includes, but is not limited to spatial, spectral, temporal, coherence, and polarization properties of reflected, transmitted, or emitted electromagnetic radiation."

    What it means: U.S. Government reviewers pay close attention to technical attributes of the satellite system and its sensor(s). Performance limits may be imposed. Licenses may be issued so that it can be operated at one level for all users, while reserving the full operational capability for the U.S. Government.

    2020 version: No change because huge increase in defense funding for commercial systems from 2010 to 2020 arguably gives the Pentagon a stronger voice regarding license conditions.

15. **Licensing of New or Advanced Systems.** "In issuing licenses for synthetic aperture radar and hyperspectral systems, conditions or specific limitations may be placed, as necessary, on operational parameters, design characteristics, and data throughput due to national security, foreign policy, or international obligations."

What it means: U.S. Government reviewers can fundamentally affect the design and use of a remote sensing system. The impacts may range from minor to major. For SAR systems, geo-location accuracy is listed as a factor to be considered, as well as how the phase history data are protected from unauthorized use.

2020 version: No change. The experience with TacSat-3 vis-à-vis Hyperion should give the Government enough information to determine what to license for commercial use. To adhere to a policy of U.S. leadership, however, comparison also needs to be made with EnMAP's performance which should be similar to Hyperion's. The body of papers and presentations on Hyperion applications should be reviewed as a baseline for considering whether any proposed system with better spatial or spectral fidelity would pose national security concerns.

Appendix B

Europe's Evolving Approach

Assessment

In the 1980s, SPOT was successful in the United States because it was technically better than Landsat in terms of performance. Moreover, SPOT gained initial attention because it was considered a threat to reveal secrets only detectable on classified American satellite imagery. It spurred policy debates on what to do about high-quality images taken from space. Aggressive marketing and publicity pushed by SPOT Image Corporation further advanced knowledge about the system and its products.

In the 1990s, SPOT was initially successful because it was the best space-based system that could provide unclassified imagery to the U.S. military and coalition allies prior to and during the Gulf War. The sale of a direct receipt capability to the U.S. Air Force also enabled SPOT to sell timely imagery to interested commanders. By 2000, however, SPOT lost traction in the U.S. market because U.S. defense users had new access to commercial imagery from American sensors, specifically Ikonos that was launched in 1999.

The greatest advantage for the newly formed Astrium GEO-Information Services will accrue from a marketing strategy based on the principle that the "sum of the optical and radar space-based and ground processing parts is greater than the whole." Promoting Pleiades, for example, in isolation as an optical alternative is not likely to gain traction, unless it guarantees a significant price break from other offerings.

The period 2010-2020 could be a rebirth for Astrium GEO-Information Services after ten years of competition from high-resolution U.S. commercial providers. Success hinges on (a) successful launch of Pleiades 1 and 2; (b) successful capture of DEM customers from TanDEM-X; (c) successful launch of SPOT 6 and 7; (d) convincing the Astrium worldwide user community that multi-sensor service is key to their needs; and (e) maximum effort to further advance Pixel Factory capabilities.

- The earth observation community is in a decade of data overload. Customers will want to spend their money on solutions that are not skewed to collecting more information they are unable to use.

- Because Astrium GEO-Information Services arguably will have the most accurate commercial earth observation data on the market for users requiring dynamic service, the company can do very well with a goal of providing quality knowledge in a timely manner, not perfection.

Specific steps that might illustrate the path of Astrium GEO-Information Services in this decade include:

- Fulfill the 2005 pledge of the SPOT CEO to carve out a substantial share of the commercial high-resolution market that is a virtual monopoly of the United States.

- Issue all promotional material to reflect the Astrium GEO-Information Services brand, including material that blends what users need to know about SPOT 6 and 7, Pleiades 1 and 2, TanDEM-X, and the Pixel Factory.

- Ensure planning crossover in France and Germany for the successor systems to Helios 2 and SAR Lupe. Both the optical and radar components of MUSIS may have commonality with Pleiades and the SAR Lupe / TerraSAR successors.

- Deliver on all promises made regarding the global elevation data service, for both military and commercial users. Protect gains made in obtaining market share for high-resolution optical imagery.

- Morph the Pixel Factory so that it is known worldwide as the "geographic time and place" machine that provides ready-to-use data for any GIS. Celebrate this moment 20 years after the 1995 Franco-German aerospace merger.

- Ensure that the Astrium GEO-Information Services Reference 3D archive has a complete DTED Level 3+ elevation layer, and orthoimagery to provide a world-class locational basis for all satellite imagery sources that lack ground control.

- In 2011, celebrate the 25thth anniversary of SPOT. Make it a joint effort of the French and German embassies in Washington so that it also celebrates German X-SAR / SRTM / TerraSAR / TanDEM success going back to 1994.

- Ensure that the Astrium GEO-Information product and service line is clear and understood, especially if products and services from Europe's Global Monitoring for

Environment and Security (GMES) project are provided to the public at little or no cost, especially from the SENTINEL satellites.

The Path to Success

1990 was a defining year for Europe in this field because arms control monitoring concern caused decision makers to chart a course they believed could be supported by advances in satellite technology. On 1 January 1990, the SPOT-1 satellite was only European imaging satellite in space. It was joined within weeks by SPOT-2, and the first European Earth Resources Satellite (ERS-1) with a radar imagery sensor was planned for launch within one year. Nonetheless, the WEU set forth a vision that gave rise to what has become a broad, multi-national, politically-supported European effort with diverse space-based capabilities. The collapse of the Warsaw Pact did not dash European momentum toward a future in space independent of the United States, even though partnering projects were established in the civil space area, and were considered for national security purposes. The need for an indigenous European means of treaty verification was driven by the sheer land area of the Warsaw Pact, and a political view that Europe had the technical ability to field satellites that support various users.

Pre-1990 Impact of the SPOT Satellite

For decades, France has held a leading role developing Europe's presence in space. Steps were taken in internal French channels, and internationally as part of a major contribution to the European Space Agency (ESA) formed in 1975. Dr. Pasco wrote in 2000 that "Commercialization of capabilities appeared very early in the planning process as the most convenient way to achieve a French or European space observation capability." The 1970s U.S. experience with Landsat civil program was positive, but what to do about the future of the program was uncertain.

In September 1983, ***The Wall Street Journal*** called SPOT Image Corp. an "invader". With aggressive marketing tactics, "SPOT is encroaching on the very homeland of a global monopoly enjoyed by the U.S. Government's pace-setting Landsat satellites."[547] SPOT Image Corp., however, was not affected by the criticism, and used an ad with a simulated SPOT picture of Washington, D.C., noting that "…we're launching a better way to look at your business."[548]

[547] Arlen J. Large, French Company to Offer Satellite Images of Earth as U.S. Monopoly in Field Unravels, The Wall Street Journal, 9 September 1983.
[548] SPOT Image Corporation, In October 1985, We're Launching a Better Way to Look at Your Business, 1985.

Before launch it was called "the ultimate skycam" and the "next logical frontier for journalism."[549]

Even before the first SPOT satellite was launched, the French space agency approved production of SPOT 3 and 4.[550] Agreements with distributors in 32 countries had already been struck, and a preliminary data evaluation program was organized to evaluate the data. 315 responses from 48 countries were received to a data call. Meanwhile, the SPOT Image Corp. workforce in the United States was eight, with an increase to 15 expected by the end of the year. According to pre-launch price list information, a color print from SPOT at 1:100,000 scale was $515.00.[551] Computer compatible tapes were priced at about three times more than prints. In 1986, no fee was charged for programming the satellite. Prices were listed as "subject to change."

SPOT had luck on its side when launched in February 1986. The Ariane rocket was not yet reliable and failed four times in 18 tries since its first launch in 1979, including the launch prior to SPOT's.[552][553] The Chernobyl reactor in the USSR exploded two months after SPOT's launch, giving news organizations worldwide their best overhead view of the scene.[554][555] CIA Director William Casey commented on SPOT at a meeting of newspaper executives: "Oh, I don't think there's anything we can do about it. Anybody can go out and get whatever information they can get, the press and anybody else in any other country…"[556][557] A former CIA official reportedly said he was "…not used to seeing pictures like that outside the agency."[558] In 2011, twenty five years after the accident, a satellite view of Chernobyl will be less relevant because Ukraine plans to open up for visitors the sealed zone around the site.[559]

The SPOT project had positive publicity after launch.[560][561][562][563] Pictures taken by SPOT of the Soviet space shuttle and naval facilities gave an indication of potential use of the system

[549] Tony Mauro, Space Camera Raises Privacy, Security Issues, USA Today, March 1986.
[550] Jeffrey Lenorovitz, France to Fund Two Additional SPOT Remote Sensing Satellites, Aviation Week and Space Technology, 5 August 1995.
[551] SPOT Image Corporation, SPOTLIGHT, Volume 1, Number 1, 1986; How to Obtain SPOT Data, Fee Schedule, 1986.
[552] The Washington Post, Ariane 2 Blown Up in Flight, 31 May 1986.
[553] Aviation Week and Space Technology, Ariane Experiences Fourth Failure in 18 Missions, 9 June 1986.
[554] Leonard David, Satellites for the Fourth Estate, OMNI Magazine, December 1986.
[555] Tony Mauro, The Puzzling Problems of Pictures from Space, Washington Journalism Review, June 1986.
[556] Nell Henderson, Civilian Satellites Penetrate Soviet Secrecy, Photograph Plant, The Washington Post, 2 May 1986.
[557] Warren Strobel, Photo Satellites for Media Worry Intelligence Brass, The Washington Times, 11 August 1986.
[558] Ibid.
[559] Ukraine plans Chernobyl tourism, The Washington Post, 14 December 2010.
[560] France's SPOT Satellite Transmits Multispectral Images Following Launch by Ariane, Aviation Week and Space Technology, 3 March 1986.

for military monitoring purposes.[564][565][566][567] SPOT marketing literature was graphic, including the SPOT Image Corporation's quarterly newsletter, and other handouts such as "A New Era in Remote Sensing." French satellite builder MATRA ran an advertisement describing the satellite as "an image harvester…a new tool as yet unequalled in the world." SPOT photos were described as important in a full-page newspaper article.[568]

- "In releasing these new, more precise views of the Earth, France whetted the news media's appetite for imagery of this kind and also poached on the surveillance turf of the great powers."

- "The photos from SPOT are sharp…At times they reveal new strategic information…"

- "SPOT photos have sex appeal because they disclose things that interest the casual observer: factories, houses, boats, sometimes even planes and trucks."

The ability to see planes and trucks was important because in November 1988 the WEU debated whether to have an arms verification agency.[569] This made sense because the Intermediate Range Nuclear Forces (INF) Treaty was realized in 1987. The WEU Assembly considered a roadmap that by 1990 would include "a modest SPOT buying center in the region of [$15 million US dollars], but in terms of political investment would prove invaluable as a demonstration of European will."

The WEU paper used as a basis for considering a verification agency noted that imagery of different resolutions could be used for different verification tasks. The paper included an "Example of imagery possible with SPOT-type satellites", and an "Example of imagery from reconnaissance satellites." The comparative imagery was of Nikolayev, USSR. The magazine ***Jane's Defence Weekly*** claimed that it had "three exclusive pictures, taken by a satellite only

[561] SPOT-1 Earth Resources Satellite Provides High-Resolution Images, Aviation Week and Space Technology, 10 March 1986.
[562] Spy Satellites Come In From The Cold, U.S. News and World Report, 8 September 1986.
[563] SPOT Earth Resources Satellite Beginning Commercial Operations, Aviation Week and Space Technology, 5 May 1986.
[564] William J. Broad, Satellite Photos Appear to Show Construction of Soviet Space Shuttle Base, The New York Times, 25 August 1986.
[565] Soviet Space Shuttle Facilities At Tyuratam Imaged by French SPOT, Aviation Week and Space Technology, 1 September 1986.
[566] French SPOT Satellite Shows Soviet Northern Fleet Facilities, Aviation Week and Space Technology, 2 March 1987.
[567] William Broad, Civilians Use Satellite Photos for Spying on Soviet Military, The New York Times, 7 April 1986.
[568] Eliot Marshall, The New Spy in the Sky Race, The Washington Post, 27 December 1987.
[569] Assembly of Western European Union, Verification: a future European satellite agency, Document 1159, 3 November 1988.

last month."[570] The source of the imagery was not stated. Almost as a prelude to the 1988 WEU paper, another image of the aircraft carrier was used as an insert on a SPOT image of a Soviet nuclear test site with an article by a Massachusetts Institute of Technology physicist who argued that arms control agreements can be verified.[571]

The WEU debate championed the prospect of a joint European satellite verification system, noting that it "…could have great political significance." By setting up a European satellite monitoring agency, the WEU "…would be offering all its partners a coherent system of monitoring from space." Moreover, ties with the United States would not be weakened, but strengthened: "Independent European analysis could well help, rather than hinder, transatlantic cooperation."

While Europe charted its own path on earth observation, a new U.S. National Space Policy was also released in 1988, near the end of President Reagan's administration.[572] The fundamental objective was space leadership, but the policy stated that "Leadership in an increasingly competitive international environment does not require United States preeminence in all areas and disciplines of space enterprise." This may have signaled that the United States was open-minded regarding space-related advances in Europe and elsewhere.

March to May 1990 in Europe

In the United States, the term "continuity" became a major focus in the earth observation lexicon due to debate on preserving Landsat after the 1980s failed attempt to privatize operation of the system. Continuity was a tenet in Europe because earth observation could contribute to global transparency, and SPOT-2 had just been launched in January 1990. WEU officials gathered in Rome in March to discuss the use of satellites for monitoring disarmament associated with an evolving NATO-Warsaw Pact agreement on Conventional Forces in Europe (CFE; November 1990). They set an enduring course on need for satellites. Having indigenous European assets was a central theme.[573]

- **WEU Assembly President Mr. Charles Goerens**: "If Europe wishes to retain control of its own security, it must certainly not move away from the Atlantic Alliance, but, as the United States Secretary of State called on it to do, it must be able to behave as a true partner. It must have its own means of monitoring the deployment of armaments and forces in Europe and throughout the world."

[570] Satellite pictures show Soviet CVN towering above Nikolaiev shipyard, Jane's Defence Weekly, Volume 2, No. 5, 11 August 1984.
[571] Kosta Tsipis, Arms Control Pacts Can Be Verified, Discover, April 1987.
[572] The White House, Fact Sheet on Presidential Directive on National Space Policy, 11 February 1988.
[573] Western European Union Assembly, Observation Satellites, A European Means of Verifying Disarmament, 27-28 March 1990.

- **Netherlands Minister of Defence A.L. ter Beek:** "At present the United States shares information obtained by its satellites in a number of cases. For the last few years, however, it has become clear that the US intends to make greater use of its satellite surveillance capability for its own purposes. Pleas in the US Congress to increase the number of satellites, each costing more than two billion dollars, are not welcomed with enthusiasm, given the budgetary problems in the US."

- **Dr. Hans Eschelbacher, German Chancellory Office:** "The countries of Western Europe – and in particular the Federal Republic of Germany as an important member state of NATO, the EC, and the WEU – will be more dependent than ever in the future on having a secure and up-to-date information base of their own if they are to safeguard their politico-strategic, security, and economic interests as partners. Space-based observation may be a decisive prerequisite for this."

- **P. Goldsmith, Director of Earth Observation at ESA:** "ESA, as the sole agency responsible for space activities at the European level, could be the natural framework to provide assistance and support to a European verification satellite program, should such a program be decided."

The WEU's May 1990 publication of guidelines based on the symposium was a clear statement that European observation satellites would be central to European security.[574]

- "It should not be forgotten that the antagonism of the East and West during the cold war…nevertheless had relative advantage of bipolar stability. With this no longer being the case, the world will be a less orderly and sometimes even less secure place."

- "…Islamic fundamentalism, a declared enemy of the western industrialized and secularized world, is gaining importance among all nations along Europe's southern border. This fundamentalism, combined with ethnic and nationalistic ambitions and a still increasing arsenal of armaments, is beginning to constitute a serious threat."

- "While maintaining the alliance with the United States, Europe will have to pull together and respond to the new challenges. Only then will it be able to play its part and guarantee its security in a changing world."

[574] Western European Union Assembly, Observation Satellites, A European Means of Verifying Disarmament, Document 1230, 25 May 1990.

- "With an apparently growing need for monitoring by satellite, for a number of reasons, Europe, notwithstanding the existing capability in the United States, should have its own observation satellite system."

- "Observation by satellite on a world-wide scale will be one of the key elements in future security measures because it allows the development of threats to be followed autonomously. Europe cannot rely only on the means of verification written into arms control treaties."

- "Opponents of an autonomous European observation satellite capability always refer to the existing American means which, it is said, will always provide the European allies with the information they require. Without blaming the Americans, it should be observed here that they only provide their satellite data up to a certain point."

- "The United States is understandably reluctant to share with its allies extensive information obtained from its satellites so as to not compromise its capabilities in this field. This has been demonstrated time and again. Whenever the United States has wished to denounce important events or developments in unfriendly territory which no doubt had been observed in detail by their own satellites, it has always made use of SPOT images…"

- "The complete European dependency on United States satellite data was quite embarrassing for some European governments during the INF crisis. The fact that information obtained from satellite data was provided by the United States, considered to be a biased party in the debate, did not help to calm down heated emotions. There can be no doubt that in this case an autonomous European observation satellite would have facilitated a rational debate."

- "For Europe, equal partnership with its American allies requires an autonomous observation satellite capability in order to enable it to co-operate on equal terms with the United States."

The technical capabilities needed to address the WEU aspirations were described as a full-scale system with day-night, all-weather capability, including optical, multispectral, and radar sensors. Fielding an optical system was not deemed a barrier because the forthcoming French Helios satellite had an "alleged" resolution of about one meter. Fielding a radar system

suitable for verification purposes would be more difficult, but UK official noted that studies in ESA pointed to using a steerable phased array antenna to provide "spotlight" mode imagery with much higher quality than expected from ERS.

1990: Possible Partnership with U.S. Companies

The National Security Strategy of the United States in March 1990 called for greater sharing of global leadership and responsibilities, and support for economic, political, and defense integration in Western Europe. Against this backdrop, U.S. companies eyed possible partnerships in Europe.

- A U.S. company gave a briefing to WEU officials including comments on the WEU's May 1990 guidelines based on the Rome symposium.[575] The U.S. firm estimated that the cost for a complete earth observation system with one-meter optical, and five-meter SAR satellites would roughly cost about $1 billion US dollars per year over 15 years. One of the company's main points was that "An all European system will be significantly more expensive than a joint European-U.S. program." Whether this assertion was correct is a moot point because a joint program was not realized.

- Another U.S. company was approached by a German company about a possible joint effort to build an optical satellite imaging system.[576] The idea could have led to joint work to field a 1-2 meter resolution system. The cooperation was not realized.

- Meanwhile, German industry continued to work on optical satellite technology. German technology has now advanced to the point where a system called Hi-ROS is now possible, with a resolution of 0.5 meters.[577] The German government would decide whether to go ahead with the project.

1991: The Persian Gulf War

The 1991 Persian Gulf War gave SPOT imagery a chance to be relevant in planning for, and execution of military conflict. United States Air Force Lt. General Charles A. Horner said that "the accuracy of the SPOT satellite imagery was an invaluable asset to the offensive air campaign."[578] According to a 2001 book on commercial observation satellites, between 1986

[575] Lockheed Missiles and Space Co., European Plans for an Observation Satellite Program, 25 October 1990.
[576] Eastman Kodak, Candidate Imaging System, Early 1990.
[577] Peter B. deSelding, Germany Eyes Teaming with Industry for Its Own Optical Satellite System, SpaceNews, 16 October 2009.
[578] Craig Covault, USAF Urges Greater Use of SPOT Based on Gulf War Experience, Aviation Week and Space Technology, 13 July 1992.

and 1991 SPOT reported average annual revenue growth of 42 percent.[579] An author who worked on long-range planning issues noted in October 1991 noted that "new sources of imagery will emerge over the next twenty years. The European Space Agency's earth resources satellites will be able to produce high resolution imagery, and will be able to image at night and through cloud cover, a capability not possessed by most current satellites."[580]

The Gulf War also gave impetus to France's national reconnaissance efforts. Defense Minister Pierre Joxe bemoaned the reliance on American intelligence during the war: "What is the point of carrying a big stick if you are blind?"[581] One year later on French television, Joxe said that France would not have capabilities comparable to America for a long time, but "we must not forget that during the Gulf war the Americans and allies used SPOT pictures." Developing a military satellite was necessary because modifications to SPOT would not suffice.[582][583] Moreover, France was not alone in thinking about indigenous satellites.

- Italian industry considered radar satellites for civil and defense applications, resulting in 1996 government funding for a national earth observation program, and later the COSMO-Skymed system as a core element.[584][585][586][587][588][589]

The Gulf War and Warsaw Pact collapse also altered the American intelligence enterprise.[590] According to a statement by Director of Central Intelligence Robert M. Gates, "…the world has turned upside down."[591] He noted that "One of the most difficult areas for us to address was that of imagery…It is a critical capability but one that has been identified repeatedly in post-mortems of Operation Desert Storm…I appointed a task force [which] concluded that we needed a National Imagery Agency." This led to the 1996 creation of what is now the National Geospatial-Intelligence Agency.

[579] John Baker, Kevin O'Connell, Ray Williamson, Commercial Observation Satellites, January 2001.
[580] Thomas Mahnken, Why Third World Space Systems Matter, Orbis, Fall 1991.
[581] Alan Riding, France Concedes Its Faults in War, The New York Times, 8 May 1991.
[582] Michael Mecham, Gulf War Rekindles European Interest in Developing Military Satellites, Aviation Week and Space Technology, 8 April 1991.
[583] Craig Covault, Ambitious Decade Ahead for Europe's Space Effort, Aviation Week and Space Technology, 15 March 1993.
[584] G. Perrotta, SAR Sensors On Board Small Satellites, International Conference on Radar, October 1991.
[585] G. Perotta, SAR Sensors On TACSATs: A Feasibility Assessment.
[586] Wikipedia, COSMO-Skymed, 2010.
[587] Italian Space Agency, Skymed-COSMO, 29 September 1998.
[588] Alenia, SAR Technology, 21 July 2003.
[589] www.eoportal.org, COSMO-Skymed, 2010.
[590] Warsaw Pact Formally Ends, The Washington Post, 2 July 1991.
[591] Robert Gates, Statement on Change in the CIA and the Intelligence Community, 1 April 1992.

1991-1993: The European Union Satellite Centre

European aspiration for a space-based monitoring capability led to the June 1991 creation of the European Union Satellite Centre near Madrid, Spain.[592] The Council of the European Union terms the EUSC "…essential for strengthening early warning and crisis monitoring functions".[593] The Centre's mission is to provide "material resulting from the analysis of satellite imagery and collateral data." Article 21 made provision for non-EU European NATO members to submit requests for imagery analysis, but there was no provision for cooperation with the United States. When inaugurated in April 1993, however, WEU Secretary General Willem van Eekelen left room for cooperation because European autonomy would increase the odds for a balanced partnership.[594]

- "The activities of this new body must be seen as the first stages of a much bolder project to be carried out in the next century. Indeed, the planned establishment of an independent European space-based observation system is consistent with the strengthening of the European pillar of the Atlantic Alliance, as foreseen in the WEU Maastricht Declaration. It is intended to develop a new autonomous system for the benefit of all concerned. The possibilities for future cooperation between the Centre and other corresponding bodies, particularly in Europe and in the US, on the basis of a balanced partnership, will remain high on our agenda."

Part of the cooperation was established in a 27 April 1993 Memorandum of Understanding between the Helios partner countries and the WEU that enabled the Centre to gain access to Helios imagery on 3 May 1996, according to WEU summary on the Centre's history.

1994: Possible Partnership with the United States…and a Russian Overture

The U.S. military did not forget SPOT's value. The first transportable SPOT ground station was delivered to the U.S. Air Force just weeks after the U.S. Government released a new policy on commercial remote sensing.[595] Within a month, the Deputy Secretary of Defense wrote to the chairman of the President's Foreign Intelligence Advisory Board recommending cooperation with allies in space-based reconnaissance, noting the possible advantage of cost sharing.[596]

- "…the Intelligence Community has been much too cautious in giving our NATO allies, Japan, and others access to and a role in space based surveillance, reconnaissance,

[592] Frank Asbeck, Geospatial Intelligence in Support of European Foreign and Security Policy, 8 December 2005.
[593] Council of the European Union, Joint Action Statement on the European Union Satellite Centre, 20 July 2001.
[594] Willem van Eekelen, Inauguration of the WEU Satellite Centre, 28 April 1993.
[595] Peter B. deSelding, U.S. Military to Receive First Mobile SPOT Station, SpaceNews, 2 May 1994.
[596] John Deutch to Les Aspin, 6 July 1994.

and SIGINT. Initiatives in these areas will strengthen the alliance, spread the cost of these expensive systems, and most importantly, avoid the risk that other countries, notably France and Germany will develop their own satellite technology and systems."

The general idea for collaboration had merit because at the time neither France nor Germany had a reconnaissance satellite. SPOT had proven its utility, but by the end of 1994 it was still a separate program from the classified French Helios satellite project. French Defense Minister Leotard announced that Helios 2 was in the definition phase with a projected launch for 2001, but a media report suggested it could be "doomed" for budget reasons, especially since space promoter Pierre Joxe was no longer leading French defense.[597] Leotard kept Helios alive, and projected that a new Franco-German agency would one day manage a joint satellite program; "…what is Franco-German today will be European in the future." France's Prime Minister Balladur stressed on 30 November 1994 to the WEU Assembly the importance of such cooperation.

- "This is an operational, technological, and industrial project which will emancipate Europe in some measure in the matter of space reconnaissance. I say emancipate deliberately. I discussed this subject yesterday evening and as late as this morning with Chancellor Kohl at the Franco-German summit just held in Bonn. I have every hope that the determination of our two countries will enable Europe towards equipping itself with the operational resources that it lacks."[598]

Prospects for cooperation with the United States were unclear, and Helios was well along in development. Moreover, a German newspaper argued that the country needed an independent capability to provide unfiltered information.[599] The author claimed this was the intent of a 1994 White Book on defense in Germany.

- "For the early recognition of regional crises…and to defend its interests in developing joint action plans within alliances and the United Nations, the federal government requires an accurate, up-to-date view of the situation."

Russia also seemed interested in an imagery partnership with Europe. Russian Foreign Minister Kozyrev offered to provide satellite intelligence to the WEU.[600] His proposal was to "provide on a commercial basis the WEU Satellite Centre with photo information from our satellites." The landscape for a European future in space reconnaissance was complicated, but

[597] JAC Lewis, Key projects threatened as France weighs up its options, Jane's Defence Weekly, 24 July 1993.
[598] Western European Union Assembly, Towards A European Space-Based Observation System, Document 1454, 2 May 1995.
[599] Ruediger Moniac, Europe Will Get Eyes in Space if Germany Pays, Hamburg Die Welt, 19 March 1994.
[600] Paul Taylor, Russia Proposes Far-Reaching Cooperation with WEU, 1 December 1994.

momentum for an autonomous capability was clearly established as French funding for SPOT and Helios increased.[601]

European Aerospace Merger; U.S. Cooperation Attempt Fails

1995 was a pivotal year for French earth observation projects, and transition to Franco-German cooperation in this field in lieu of cooperation with the United States.[602][603] In May, a U.S. official conveyed to the WEU Assembly the "…readiness and eagerness to increase the level of cooperation between the United States, WEU, and all of our Atlantic partners with regard to space systems."[604] Nonetheless, there were many subsequent press articles on prospects for Franco-German satellite cooperation. The French press claimed that Aerospatiale wanted an alliance with Germany's Deutsche Aerospace (DASA) to win back some ground lost to the United States. Helios 1A launched successfully in July. Technology Minister Francois Fillon said "…we are putting in place the machinery that will enable Europe one day to have a true European security policy, so it is a considerable development."[605]

In July, French press indicated that an Aerospatiale-DASA merger was subject to a pledge by Germany to join the Helios 2 project. But, it was a complicated political decision.

- "Diplomats said Bonn is more interested in an advanced 24-hour, all-weather radar satellite, tentatively dubbed Osiris or Horus, which would be launched around 2005." Moreover, "Paris has been pressing the Germans to choose the European project over an offer from the U.S. firm Lockheed Martin to buy its own spy satellite for $500 million, less than half the cost of Helios."[606]

- "When it comes to observation from space, Germany is the standard partner with a view to European defense, and area in which it could play a more active role. However, this partnership is no easy matter. First, because the United States is inviting Bonn to join forces with it by offering it a rival system that is up and ready to run."[607]

- "…There will be money for Helios only if French participation in Horus is assured." Moreover, "The alleged commercial success of the French SPOT program is probably

[601] French Satellite Decisions Affirm Space Policy, Aviation Week and Space Technology, 17 October 1994.
[602] EUCOSAT Symposium, Satellite System for Security: a European Multi-User System, 20 September 1995.
[603] Forschunginstitut der Deutschen Gesellschaft fur Auswartige Politik, Franco-German Discussion Group on European Space Policy, June 1995.
[604] Assembly of the Western European Union, A European space-based observation system, 24-25 March 1995.
[605] Paris France-Inter Radio Network, 8 July 1995.
[606] Alexander Miles, France to Launch First European Spy Satellite, Reuters, 6 July 1995.
[607] Space – Europe's Opportunity, Le Monde, 10 Jul 1995.

also based on a bookkeeping trick. Neither the acquisition cost nor the high expenditures for development are taken into account. The revenues for SPOT pictures just about cover current costs. The development expenditures for the civilian SPOT satellites can hardly be separated from those for the military Helios series."[608]

- "If the Paris government has its way, Bonn will soon have to participate in the French photographic satellite Helios 2."[609]

- "Germany is considering buying a Lockheed Martin optical spy satellite, and later joining France in a future radar-equipped spy satellite, German officials said. The Lockheed Martin proposal is less expensive for us, but we want to establish long-term relations with France in a radar satellite."[610]

- There was little chance the United Kingdom would work with France on Helios 2 because "…the British government feels that Helios is very expensive and not particularly advanced. In addition, intelligence officials believe that the relationship with America and its vast spy network is much more important than forging new links with Europe."[611]

Discussions continued for months about possible Franco-German aerospace cooperation. Expectations were that Germany would join the Helios 2 project, with German leadership retained on the Horus project as a quid pro quo.[612] A second U.S. company offered two optical satellites for about $300-350 million.[613] On 7 December, after a summit with President Chirac of France, Chancellor Kohl of Germany told the press that "There has hardly been any other summit at which we have reached as many decisions as we have here in Baden-Baden." Claimed achievements included a deal on the Helios satellite project, and a satellite industry merger.

- Aerospatiale's president stated that the joint decision was very important for the structure of the European defense industry.[614] The DASA chairman said the decision provided "…the conditions for progressive integration of the aeronautical, space, and defense industries in Europe." He thought it was an important step toward an

[608] Eric Chauvistre, Ruehe's Expensive Look Through the Clouds, Berlin Die Tageszeitung, 10 Jul 1995.
[609] We Will Realize That, Hamburg Der Spiegel, 10 July 1995.
[610] Germany Weighs Buy of U.S. Spy Satellite, DefenseNews, 11 September 1995.
[611] James Adams, Britain in Spy Satellite Talks, The Sunday Times, 14 January 1996.
[612] Carol Reed, Hopes High for Satellite Summit, Jane's Defence Weekly, 1 July 1995.
[613] Terry Straeter to Heinrich Rosenlehner, 25 September 1995.
[614] Craig Covault, Recon Pact to Give Europe More Clout, Aviation Week and Space Technology, 18 December 1995.

autonomous European security structure. ***Aviation Week*** wrote that the "Franco-German deal heralds an autonomous security structure for Europe and bolstering of the continent's crisis-ridden aerospace industry." Germany's ***Soldat and Technik*** magazine said that pooling was necessary to be competitive in the marketplace.

1995 was also pivotal for SPOT in the United States because it began to lose momentum. Sales to the Department of Defense generally declined and flattened after the 1994 U.S. Government decision to encourage the growth of a commercial imaging industry.[615] A media report stated that "The new technology will make for publicly accessible pictures at least 10 times clearer than those from today's best-resolution private system, the French SPOT satellites."[616] The positive 1980s press reporting on SPOT as new technology was gone due to prospects for new U.S. commercial satellite systems.[617]

The Franco-German aerospace merger had bumps along the way.[618] In 1997, Germany did not have funds for Helios 2, so France went ahead with the system alone.[619] Similarly, due to budget concerns, France abandoned plans to help Germany to build the Horus radar satellite.[620][621] A spokesman for DASA in Friederichshafen, Germany, noted that "…everyone agrees the future commercial competition in satellites is not between the Europeans, but between Europeans and the Americans."[622]

The imagery competition entered a new phase with the successful 1999 launch of the commercial IKONOS satellite by the U.S. firm Space Imaging. The competition, however, was limited to optical sensing, not radar imaging systems. Canada's first radar satellite was launched in 1995 on a U.S. rocket, in a partnership that provided data to the U.S. at no cost. A copy of the first Radarsat-1 image was published on 1 January 1996.[623] U.S. firms wanted to operate SAR systems for commercial purposes at least as capable as a future Canadian satellite called Radarsat-2, but were barred from doing so because DoD recommended a 5 meter best-resolution limit.[624] There was little apparent reason for concern by U.S. companies, however,

[615] Clark Nelson, SPOT Image: U.S. Partner, September 2002.
[616] Jeff Cole, New Satellite Imaging Could Transform the Face of the Earth, The Wall Street Journal, 30 November 1995.
[617] Terrey Hatcher Quindlen, SPOT Image's U.S. Arm Cuts Prices for Archived, New Imagery by 50%, SpaceNews, 20 April 1998.
[618] Peter B. deSelding, Spy Satellite Effort on Hold Until June, SpaceNews, 20 May 1996.
[619] France Plans to Start Work on Helios-2 Alone, Jane's Defence Weekly, 6 November 1997.
[620] France to Shoulder Burden of Helios II, Jane's International Defense Review, March 1998.
[621] Peter B. deSelding, France Abandons German Horus Satellite Effort, SpaceNews, 13 April 1998.
[622] Peter B. deSelding, French Move to Merge Space Divisions May Boost European Satellite Industry, DefenseNews, 20 October 1997.
[623] David Hughes, Radarsat Delivers First SAR Image, Aviation Week and Space Technology, 1 January 1996.
[624] Warren Ferster, U.S. Firms Demand Parity to Radarsat-2, SpaceNews, 9 March 1998.

because the Government of Canada decided in June 1999 that legislation was needed to control imaging satellites.[625]

- "As modern remote sensing satellites can produce imagery whose quality approaches that obtained from specialized intelligence satellites, we must ensure that the data produced by Canadian satellites cannot be used to the detriment of our national security and that of our allies."

Canadian sentiment soured within weeks, however, because it seemed that American rules would determine the capabilities of Radarsat-2, and how it could be launched, resulting in increased cost and reduced performance. Industry Minister John Manley ordered the makers of Radarsat-2 to take their business for satellite parts to Europe.[626][627] He accused the U.S. Government of illegally applying U.S. rules to Canada --"We're going to work on a European solution." Meanwhile, the Canadian military was reportedly investing in a way to receive "vital" information from secret U.S. satellites.[628][629] This showed that cooperation and competition in earth observation takes place at the same time.

The dispute between the United States and Canada had no apparent impact on plans in Italy to field the Cosmo-Skymed system comprised of four radar satellites. According to a 1997 brochure by Alenia Aerospazio, the future Cosmo radar satellites would have a 3 meter resolution, similar to Radarsat-2, and better than DoD's preferred 5 meter limit.[630]

2000 – 2004: Franco-German Imagery Advances, and EU Security Strategy

Against a backdrop of emerging U.S.-European commercial imagery competition, the successful February 2000 Shuttle Radar Topography Mission (SRTM), flown jointly by NASA and the National Imagery and Mapping Agency (NIMA), was a good example of U.S. teamwork with German aerospace.[631][632] But, another attempt at Franco-German cooperation emerged from a June 2000 summit in Mainz, Germany.[633] According to ***Reuters***, the countries "…agreed to cooperate on a spy satellite system that would cut Europe's reliance on U.S. military intelligence and revives an idea previously shelved as being too expensive…This bilateral

[625] Government of Canada News Release, Canada to Control Imaging Satellites, No. 134, 9 June 1999.
[626] Heather Scoffield, Ottawa to cut U.S. out of satellite project, The Globe and Mail, 11 August 1999.
[627] Shawn McCarthy and Heather Scoffield, Satellite industry could be grounded, The Globe and Mail, 22 April 1999.
[628] David Pugilese, DND's $50M secret, The Ottawa Citizen, 13 May 2000.
[629] David Pugilese, Spy satellites, The Ottawa Citizen, 25 January 2001.
[630] Alenia, Constellation of Small Satellites for Mediterranean Basin Observation, May 1997.
[631] NIMA, NIMA / NASA Space Shuttle Mission, EDGE, July 1998.
[632] Craig Covault, Radar Flight Meets Mapping Goals, Aviation Week and Space Technology, 21 February 2000.
[633] Franco-German boost for EU Reform, BBC News, http://news.bbc.co.uk, 9 June 2000.

initiative creates the basis for a European reconnaissance system that is open to other European partners."

The SRTM mission used a technique called Interferometric SAR to take images simultaneously from two antennas, thereby creating an elevation map of the world.[634][635][636] The technique was based on two Shuttle Imaging Radar (SIR-C) missions flown in 1994, also known as X-SAR, because the missions involved both C-Band and X-Band collection. German aerospace was involved in the X-SAR portion. German officials planned to use the X-Band success as a "springboard toward a commercial imaging system called TerraSAR."[637]

The SRTM mission cost $142 million, according to NASA.[638] The X-SAR portion cost $40 million. A post-mission paper co-authored by NASA, the German Space Agency (DLR), and university experts called the dataset "revolutionary."[639] They stated that "SRTM was an example of engineering at its best; it marked a milestone in the field of remote sensing." What the paper did not say is that it gave German engineers more confidence that the future TerraSAR-X commercial satellite system would be viable.

- In 1997, well before the SRTM mission, an article in a German magazine claimed that a third flight of X-SAR was a priority because Germany holds a leading position in the field of radar technology that entails exceptional civil and commercial prospects.[640]

- According to DLR, TerraSAR-X was begun in September 2001, about 18 months after the SRTM mission, which was also roughly the end of the data processing period, according to NASA.[641]

- TerraSAR-X was described by DLR as "A national, operational science satellite with commercial potential." And as "…the scientific / technological continuation of the highly successful national missions X-SAR (1994) and SRTM (2000)." A headline in

[634] Craig Covault, Shuttle Maps the World, Aviation Week and Space Technology, 21 February 2000.
[635] NIMA, SRTM DTED Fulfills Key Requirement of DoD and IC, EDGE, August 2002.
[636] US Geological Survey, Shuttle Radar Topography Mission, 25 September 2003.
[637] Peter B. deSelding, Germany Plans to Use X-Band Technology for Commercial Imaging, SpaceNews, 6 March 2000.
[638] NASA Jet Propulsion Laboratory, SRTM Mission Statistics, 14 March 2000.
[639] JPL, DLR, and university authors, The Shuttle Radar Topography Mission, 2006.
[640] Rolf-Peter Oesberga, Germany's International Space Commitment, Bonn Luft Und Rahmfahrt, October 1997.
[641] DLR, TerraSAR-X Mission, undated.

2002 termed the system a test of public-private satellite partnerships.[642][643] Radar imaging was a high priority in Germany.[644][645]

On 10 April 2001, according to a newspaper, the United States was on a path to spend $25 billion on a new generation of spy satellites called the future imagery architecture.[646] ***The Daily Telegraph*** in London reported that the United Kingdom wanted to be part of the project, noting that participation would ensure that some "jobs come to Britain." With regard to commercial imagery, ***The Economist*** reported that "High launch costs, and the fact that the biggest customers for high-resolution imagery are governments, are likely to sustain the cozy relationship between commercial satellite operators and the military."[647] Nonetheless, according to French defense analyst Francois Heisbourg, the pooling of information from Helios 2 and SAR Lupe would be "enough to keep the Americans honest" in telling other governments what satellites see in a crisis. France also considered lowering security restrictions on Helios 1 imagery, and adjusting the price to reflect the availability of high-resolution data from the commercial Ikonos satellite.[648]

Franco-German national earth observation programs moved ahead against a backdrop of rising EU interest in a more coherent approach. A December 2001 report from the European Commission to the Council and European Parliament concluded that due to "…competitive pressure coming from other regions of the world, the European space actors cannot afford to address issues in a dispersed and fragmented way." The report stated that "a major challenge lies in the coordination of the various emerging national, intergovernmental or international initiatives and their resulting capabilities." One such initiative is the EU's Global Monitoring for Environment and Security (GMES) project. According to the 2001-2003 EC Action Plan for GMES, "by mobilizing scientists, industrialists, and politicians and the full range of satellite and terrestrial observation technologies…Europe will have its own genuinely autonomous surveillance capability."[649][650] The future satellites in this project are named Sentinel. According to ESA summary information on the Sentinels, they will complement, not replace or duplicate national satellite initiatives.[651] The first two satellites will have imaging payloads.

[642] Peter B. deSelding, TerraSAR-X Will Test Public-Private Partnerships, SpaceNews, 15 April 2002.
[643] Peter B. deSelding, Germany Agrees to Finance Commercial Radar Satellite, SpaceNews, 25 March 2002.
[644] Christian Lardier, Germany is Relying on Radar Satellites, Air & Cosmos, 10 May 2002.
[645] Peter B. deSelding, German Military Prepares for 2005 SAR Lupe Deployment, SpaceNews, 24 May 2004.
[646] Joseph Fitchett, Spying from Space: U.S. to Sharpen the Focus, International Herald Tribune, 10 April 2001.
[647] Private Eyes in the Sky, The Economist, 6 May 2000.
[648] Peter B. deSelding, France Seeks to Boost Use of Helios, SpaceNews, 18 February 2002.
[649] European Commission, Global Monitoring for Environment and Security (GMES), EC Action Plan 2001-2003.
[650] European Commission, Towards A European Space Policy, 7 December 2001.
[651] ESA, Sentinels Overview, www.esa.int, 2010.

The SPOT 5 commercial satellite was launched on 2 May 2002, just two months after ESA launched ENVISAT as the successor to ERS-type satellites. SPOT Chairman and CEO Jean-Marc Nasr said that SPOT would, by mid-2003, be able to produce geo-referenced ortho-images "automatically, quickly, and cheaply."[652] He also stated that "we are working with InfoTerra…to leverage our respective offerings and create commercial synergies." This was an indication that combinations of optical and radar imagery can service an array of applications.

SPOT 5 was not designed as a direct competitor for American one-meter resolution commercial satellites, but it provided a 2.5 meter resolution capability, with a 60km wide swath, and stereoscopy. The French Institut Geographique National called SPOT 5 "a perfect tool for mapping."[653] Before SPOT 5 was launched, the U.S. company DigitalGlobe agreed to pay SPOT Image Corp. $50 million over six and one-half years for exclusive rights to distribute SPOT products and services to the U.S. agriculture and defense markets.[654]

- DigitalGlobe's CEO said "…we must be able to partner with market leaders to provide product options for our customers."[655] Within one year after launch, SPOT 5 caused a 48 percent increase in revenue for the SPOT company.[656]

Within weeks after the SPOT 5 launch, France and Germany agreed at a summit in Schwerin on a common military satellite-supported optical and radar reconnaissance system; "The combination of the two systems should contribute to the creation of a satellite reconnaissance system for the EU, independent of the United States."[657] The Franco-German bilateral deal did not, however, foreclose the possibility of including NATO states in light of a Spring 2002 idea to explore multinational satellite cooperation that could be considered at a November 2002 NATO Summit in Prague. This fleeting opportunity came about because European satellite monitoring of CFE treaty limited equipment east of the Urals would be possible with Helios 2 and SAR Lupe. Although France was in the vanguard of European observation satellite efforts, Germany needed a radar satellite due to lack of U.S. support during the Kosovo conflict, but "privileged" UK access to imagery from U.S. spy satellites made the British reluctant to develop national or European observation satellites.[658][659]

[652] SPOT Image, SPOT 5 Global Coverage, Accuracy, and 3D Vision, SPOT Magazine, no. 34, 1st Semester 2002.
[653] Dominique Lasselin, SPOT 5 Thematic Potential for Planimetric Cartographic Applications, 2002.
[654] DigitalGlobe to Pay SPOT Image $50 Million for Imagery Rights, SpaceNews, 8 April 2002.
[655] Joint DigitalGlobe and SPOT Press Release, 25 January 2002.
[656] Peter B. deSelding, SPOT 5 Sales Increase Company Revenue 48% in 2002, SpaceNews, 28 July 2003.
[657] Thomas Gutschker, Germany and France Want to Strengthen the EU Militarily, Frankfurter Allegemeine, 31 July 2002.
[658] Charles Grant, Europe Needs More Space, New Statesman, 20 May 2002.
[659] Germany to Receive Own Satellite Reconnaissance System, Berliner Zeitung, 31 July 2004.

Although Helios 2 and SAR Lupe were not factors in NATO's Capabilities Commitment discussed in Prague, the line of the EU toward the United States was clearly stated in the European Security Strategy published in December 2003.[660] The key premise is that U.S.-European ties benefit from a capable Europe.

- "The transatlantic relationship is irreplaceable. Acting together, the European Union and the United States can be a formidable force for good in the world. Our aim should be an effective and balanced partnership with the USA. This is a reason for the EU to build up further its capabilities and increase its coherence."

By the end of 2004, the SPOT CEO said that "…we will continue to increase resolution while maintaining the largest possible scene size, and we will still give the fastest response for users. The high resolution Pleiades constellation will gather top quality images at 0.5m resolution, comparable to any on the market today or in this decade, and we will provide unrivaled access to imagery and the information contained within."[661][662] This projection was only months after the integration phase for TerraSAR-X began at Friederichshafen, Germany.[663] According to the magazine, in early 2004 InfoTerra chose SPOT "…as the sole agent for the sale of all products and services derived from TerraSAR, particularly in countries where SPOT Image has channel partnership agreements."

- Satellite experts at the German Space Agency (DLR), in a 2004 perspective on earth observation satellites and services for the next decade, wrote that InfoTerra GmbH was "…in negotiation with several international customers for direct data reception in their respective countries. Experiences with marketing partners such as SPOT Image contribute to the globalization of such national missions."

DLR was correct that globalization in earth observation was well under way. An easy way for the public to use satellite imagery was near at hand. In October 2004, as consolidation of the SPOT InfoTerra product line took shape, the company Google in the United States acquired a company called Keyhole. Keyhole owned a huge library of satellite imagery and developed 3D imagery display services.[664] By Spring 2005, Google offered a new service called Google Maps. Using Google, users can view either images or maps. Google's products became part of the geospatial technologies market, estimated in 2005 by the United States Department of Labor to have annual revenues of $30 billion.

[660] European Union, A Secure Europe in a Better World, European Security Strategy, 12 December 2003.
[661] Joe Francica, Executive Interview with Jean-Marc Nasr, SPOT Image's CEO, 14 December 2004.
[662] Jon Fairall, Interview with Jean-Marc Nasr, Asian Surveying and Mapping, 20 December 2004.
[663] TerraSAR-X Satellite Integration Underway, SPOT Magazine, no. 38, 2nd Semester 2004.
[664] Google and CIA Connection, www.intelligenceonline.com, No. 498, 15 April 2005.

Germany's TerraSAR-X and Italy's Cosmo-Skymed radar satellite projects were well underway when the first European Space Council meeting took place on 25 November 2004. According to ESA's website, the then chairman of the EU Competitiveness Council stated that "Space technologies and applications will help Europe to reach its common goals in the field, i.e., competitiveness, environment, and security." The EU Commissioner for Enterprise and Industry noted that "The industrial dimension of space is key to increasing the competitiveness of European industry."[665][666] According to an article by DLR with a ten-year perspective on earth observation, resources for preparatory studies for GMES were released in September 2004, and future hyper-spectral imaging satellite called EnMAP would be studied.[667] Such studies took place against the reality that satellites called Pleaides, RapidEye, TerraSAR-X, and Cosmo-Skymed would be launched. The authors noted that the political focus of GMES, and the European Defense and Security Policy, would "drive and amplify" demand for earth observation data of various types. With the political framework in place, the authors argued that "…the European [earth observation] market becomes very attractive for both service suppliers and customers."

2005 - 2009: The Rate of Change Accelerates

European earth observation satellite efforts gained quick success when Helios-2A became operational in April 2005. Images from flight acceptance testing had "stunning clarity", including images of Las Vegas, Nevada.[668] A magazine claimed to have access to the images, but could not show them to readers because they were classified.[669] Some weeks later, it was reported that the high resolution thermal infrared sensor had provided operational images.[670] The satellite produced optical images claimed by the French Defense Ministry to be several tens of centimeters in resolution.[671] The French Joint Defense Staff later confirmed that the satellite was also producing better-than-expected infrared imagery.[672] According to Colonel Christophe Morand, "The infrared feature has been a real success…we have been able to evaluate many industries that make extensive use of cooling systems." The news about Helios 2 was good news for SPOT because the post-Helios 2 satellite system to be deployed by 2015 "…will bear

[665] European Space Agency, First ever Space Council pave the way for a European space programme, www.esa.int, 25 November 2004.
[666] Wikipedia, European Space Agency, www.wikipedia.org.
[667] Gunter Schreier, Stefan Dech, High Resolution Earth Observation Satellites and Services in the Next Decade, October 2004.
[668] Jean Dupont, Helios-2 Soon in the Military's Hands, Air & Cosmos, 25 March 2005.
[669] Ibid.
[670] Helios-2 Acquires Night Sensing Capability, www.intelligenceonline.com, 1 July 2005.
[671] Peter B. deSelding, France's Helios 2A Recon Satellite Produces First Images, SpaceNews, 31 January 2005.
[672] Peter B. deSelding, Helios-2A Sheds Light on Refineries, SpaceNews, 24 September 2007.

strong resemblance to the civil-military Pleiades satellites to be launched in 2010 and 2011, but will have a sharper ground resolution."[673]

As the new Helios-2A settled into service, the SPOT company gained the rights to market South Korea's Kompsat-2 data outside of Korea, the Middle East, and the United States. SPOT Chairman and CEO Herve Buchwalter projected that gaining a foothold in the very high resolution market would be a major challenge, but that there is "…huge potential for combining optical and radar data in many application areas. The TerraSAR-X satellite will give us the chance to offer customers a really comprehensive range of products and services. This unique capability will further consolidate our market position."[674]

- InfoTerra Germany projected in March 2005 that the SAR earth observation market was about $60 million, roughly about 15 percent of the overall spaceborne earth observation market.

- Combining datasets seemed to be the wave of the future. In November 2005, the EU Commission's spokesman for industrial policy, in announcing the pilot state for GMES, stated that the project is intended to exploit assets belonging to individual nations.[675] Nations would retain control of their satellites, but collected data would be shared.

SPOT's corporate mission as of 2006 was "To deliver satellite imagery and geographic information solutions to private and public sector worldwide." The transition would take the company from providing products to the scientific community in the 1980s, to providing imagery to governments and the commercial market over 20 years later. Whereas 19 percent of the company's 2005 revenue was gained in North America (70 percent of this from defense and intelligence), 39 percent was gained in the Asia-Pacific region. This strategy was presented just before the May 2006 announcement that DLR and Astrium would cooperate on the TanDEM-X satellite, according to German press reporting. The mission would be to generate a "…worldwide, consistent and homogeneous terrain model with no discontinuity at regional or national borders, and no inconsistencies resulting from different measurement protocols or measurement efforts staggered in time." The satellite would cost $110 million, only three times more than X-SAR flown on the Space Shuttle in 2000.

- TerraSAR-X was launched into space in June 2007, and the TanDEM-X project was well underway. The first of five successful SAR Lupe German military radar imaging satellites was launched in December 2006 (the final satellite was orbited in July

[673] Peter B. deSelding, France Begins Work on New Reconnaissance System, SpaceNews, 16 June 2009.
[674] SPOT, 2005 – A Year of Consolidation, SPOT Magazine, No. 40, 2nd Semester 2005.
[675] David Rennie, EU to Build Network of Spy Satellites, London Daily Telegraph, 15 November 2005.

2008). Moreover, the first Cosmo-Skymed satellite was also in space. According to German media reporting, Colonel Reinhard Pfaff said SAR Lupe was a "quantum leap in the acquisition of information."[676][677]

The variety and number of satellites launched by French, German, and Italian industry went from virtually none between 2000 and 2005, to several in the last five years.[678] This rapid expansion was one of the reasons that six European nations began work in mid-2007 on ways to coordinate future space-based reconnaissance systems, such as sharing imagery from multiple satellites, in a project called Multi-national Satellite Imaging System (MUSIS).[679] This meant that data sharing paradigms were being examined within both the GMES and MUSIS projects. The capability to process and share imagery among several nations would be core to MUSIS. [680][681]

2008 was a significant year regarding earth observation programs in Europe as a whole. The Germany firm RapidEye AG launched a fleet of five, innovative small commercial satellites designed to quickly monitor change to vegetation, especially crops.[682] Dr. Ray Williamson wrote that the approach "…could well revolutionize the business of remote sensing."[683] ESA signed contracts for two Sentinel observation satellites for GMES.[684] Atrium Services decided to take over the 41 percent share of SPOT held by CNES.[685][686] This would give Astrium Services an ability "…to develop an integrated strategy for the full range of earth observation services and applications, along the entire geo-information value chain, according to Astrium CEO Eric Beranger. This move aligned with a White Paper on defense produced in June 2008 that recommended giving "great prominence" to space intelligence.[687][688] Prime Minister Francois Fillon said that the White Paper "…gives a central role to capacities of reconnaissance and

[676] Friedich Kuhn, Look at Every Corner of the Earth, Berlin ddp, 27 July 2008.
[677] Nicholas Fiorenza, Fast Intel With SAR Lupe, Defense Technology International by Aviation Week, November 1998.
[678] Michael Hales, Foreign SAR Satellites on the Rise, Earth Imaging Journal, January / February 2008.
[679] Peter B. deSelding, Six European Nations Eye Space-Based Reconnaissance Systems, SpaceNews, 11 June 2007.
[680] Henry Kenyon, European Nations Focus Space-Based Observation Capabilities, SIGNAL Magazine, October 2007.
[681] Jean Guisnel, MUSIS, The Future of European Space Espionage, www.lepoint.fr, 21 November 2008.
[682] F. Jung-Rothenhausler, RapidEye – Small Satellites Gone Operational, 31 March 2009.
[683] Dr. Ray Williamson, The Game Continues to Change…and Ever More Quickly, Imaging Notes Magazine, Fall 2008.
[684] ESA Signs Contracts for Two Observation Satellites, SpaceNews, 18 April 2008.
[685] Michael Taverna, Astrium's Takeover of SPOT Image Positions it to Lead in Space Imagery, Aviation Week and Space Technology, 21 July 2008.
[686] EADS Astrium Press Release, Astrium purchases majority share in SPOT Image, 15 July 2008.
[687] Space to get boost in French defense review, Reuters, 6 June 2008.
[688] Pierre Tran, France Readies Satellite Launches, DefenseNews, 6 November 2008.

anticipation." This would result in a budget for space of about $500 million in 2008, increasing to $1 billion in 2020.[689]

The EUSC reported in 2008 that acquisition of satellite imagery is a prerequisite of the Centre's work. The Centre claimed that it "greatly improved" its access to imagery from commercial and governmental sources. Although commercial sources comprised the largest share of imagery used by the Centre, "…governmental imagery is very important to EUSC…and guarantees European autonomy."

The importance of coordination across civil and defense earth observation programs and ground-processing gained increasing prominence in 2008. According to a vision statement on European Space Policy by the EU Council's Competitiveness Council on 26 September, the vision called for improving synergy between civil and defense space programs.

- Consolidation requires much attention to processing data from multiple sensors in an efficient, timely manner. A product called Pixel Factory by InfoTerra France is a solution for the problem of too much imagery.[690][691][692] The Pixel Factory is a product to process data from many sensors. This digital geo-production processing capability is described in marketing literature as "The Next Generation Solution for Industrial Geo-Production".

- Recommendation 830, adopted by the EU Assembly on 3 December 2008, stated that 40 percent of the MUSIS budget is devoted to the ground segment because "…even the best-performing satellite architecture is useless without an equally efficient ground segment to receive the images."[693]

- The MUSIS plan was ratified on 5 March 2009, and would involve the European systems to succeed Helios 2, SAR Lupe, Italy's Cosmo-Skymed, and Pleiades in about the 2015-2017 timeframe.[694] MUSIS is consistent with the EU's December 2008 report on implementation of the 2003 European Security Strategy, i.e., "…to be still *more capable, more coherent, and more active*."

[689] Defense: France is Going to Launch its Space Spies, www.francesoir.fr, 15 November 2008.
[690] InfoTerra brochure, Pixel Factory – The power of an industrial solution in your hands.
[691] Peter B. deSelding, Pixel Factory Provides Increasingly Popular Cheap and Easy Imaging, SpaceNews, 24 November 2008.
[692] Rolta to Use InfoTerra's Pixel Factory Image Processing Technology, www.itnewsonline.com, 9 December 2009.
[693] EU Assembly, Recommendation 830 on the Multinational Space-based Imaging System (MUSIS), 3 December 2008.
[694] Julian Hale, 6 EU Nations to Develop Satellite System by 2015, DefenseNews, 6 March 2009.

- Strengthening space capabilities for military missions was mentioned in the December 2008 report on Strategy implementation.[695] This task is assigned to the European Defense Agency (EDA). According to EDA, one of the tasks in MUSIS is to seek synergies with civilian earth observation programs, in particular with GMES.[696]

In the past year, the rate of change continued to accelerate. The future SPOT 6 and 7 satellites, along with Pleiades, and TanDEM-X "…will give Astrium a fleet of imagers and a portfolio of geo-information services unparalleled in the industry."[697] The challenge for the future is to align a major increase in collection capacity with processing output to service high, medium, and low-resolution needs. In 2008, revenue at SPOT was about $150 million, an increase of almost $100 million since 2002. The upside potential is significant because sensor diversity provides alternative data sources and solutions.

- Increased product accuracy and timely delivery of solutions will be expected by commercial and military users. Because a Pleiades replacement will be needed by about 2015 or soon thereafter, commonality between the replacement system and Helios 3 seems likely. Helios 3 may be comprised of three satellites, including one in a lower orbit to maximize resolution.[698]

- In June 2009, TerraSAR-X marked two successful years in orbit, according to an Astrium press release.[699][700][701] "What has been particularly impressive is the outstanding geo-location accuracy of better than 0.5 meters. This allows fully automatic, pixel-accurate superposition of two images of a scene acquired at different times."

- French military space spending is on path to increase about 8 percent per year, and ESA signed more contracts for GMES-related earth observation satellites.[702][703][704][705]

[695] European Union, Report on the Implementation of the European Security Strategy, 11 December 2008.
[696] European Defence Agency Press Release, New EDA Project on Space-Based Earth Surveillance System, 5 March 2009.
[697] Michael Taverna, Going Private, Aviation Week and Space Technology, 15 June 2009.
[698] A Third Satellite Considered for French Helios System, SpaceNews, 6 February 2009.
[699] Astrium Press Release, TerraSAR-X marks two successful years in orbit, 15 June 2009.
[700] InfoTerra Press Release, TerraSAR-X performance confirmed by US National Geospatial-Intelligence Agency, 12 March 2009.
[701] German TerraSAR-X remote sensing sat launched, Aerospace Daily & Defense Report, 19 June 2007.
[702] Peter B. deSelding, France Seeks Military Space Investment Partners, SpaceNews, 27 November 2009.
[703] Peter B. deSelding, ESA Signs New Contracts Worth Over 500 Million Euros, SpaceNews, 18 December 2009.
[704] ESA News Release, Strong support for GMES at space conference, www.esa.int, 20 October 2009.
[705] Peter B. deSelding, Europe's Ambitious Global Monitoring Program Taking Shape, SpaceNews, June 2009.

- In November 2009, ESA member states approved the Sentinel Data Policy that ensures free-of-charge access to all Sentinel data.[706][707] One year later, European ministers voiced support for GMES even though funds are lacking.[708]

2010 and Beyond

European nations individually and collectively have a bold range of commercial, civil and military earth observation satellite projects.[709] European political, industrial and commercial interests all know the importance of success. The satellites already in space and in development have spatial and spectral features that can service a wide variety of users, but the earth observation community is in a decade of data overload. Customers will want to spend their money on solutions that are not skewed to collecting more information they are unable to use. For this reason, advances made in ground processing and product line may be far more important than the satellites.

[706] ESA News Release, ESA Member States approve full and open Sentinel data policy principles, 27 November 2009.
[707] Peter B. deSelding, European Officials Embrace Open Data Policy for GMES Satellites, SpaceNews, 30 June 2010.
[708] Peter B. deSelding, European Ministers Voice Support for Galileo, GMES, SpaceNews, 26 November 2010.
[709] Peter B. deSelding, ESA Budget Rises to $4B as 14 Nations Boost Contributions, SpaceNews, 21 January 2011.

Appendix C

Japan's Evolving Approach

Assessment

The 1980 U.S. intelligence judgment that Japan would become a competitor in commercial imaging did not give a timeframe. In retrospect, the competitive threat was not imminent in the '80s and has still not become certain. This could begin to change by 2015, assuming that a future commercial optical satellite known as ASNARO by NEC is successful. Meanwhile, the Information Gathering Satellite (IGS) program focus of satellite imagery developments and expenditure in Japan likely will remain central to Japanese national security. Moreover, the Advanced Land Observing Satellite (ALOS) program will continue, but due to lower imagery resolution it is not a near-term serious threat to the defense and intelligence business core to DigitalGlobe and GeoEye success.

Japan's first Marine Observation Satellite (MOS-1) launched in 1987 was designed to monitor natural resources, even though an American magazine reported that the satellite could image airfield runways and taxiways.[710] Japan's first "spy" satellite in 2003 was also based on a system designed for earth resources monitoring, not intelligence tasks. Japan's 2008 Basic Law on Outer Space now, however, gives official latitude for Tokyo to use satellites for defense and security. Commercialization efforts, moribund for decades due to a focus on "R&D" satellites, are now sanctioned and could become vibrant.

Post-World War II Mapping of Japan

Japan's main reason for having the current Advanced Land Observing Satellite (ALOS) is to make maps, not analyze images for defense and security purposes. In fact, Japan's current need to monitor the Earth for defense and security purposes has evolved from a domestic mapping function based on the 1945 creation of the Geographical Survey Institute (GSI) in the Ministry of Construction. Within a few months after the 1951 Treaty of Peace between the Allied Powers and Japan, the U.S. Army Map Service agreed to map Japan.[711] This included providing copies of post-war aerial imagery taken of Japan which is available today in GSI archive.[712]

[710] Aviation Week and Space Technology, 23 March 1987.
[711] Memorandum of Agreement, U.S. Army Map Service and GSI, 13 April 1952.
[712] http://www.gsi.go.jp

The GSI now has a modern mapping capability based on aerial and ground surveys. Because it is difficult, however, to collect aerial photos in remote areas far from the Japanese mainland, GSI uses satellite images from ALOS launched in 2006. The ALOS imaging capability is similar to the French SPOT system with a 2.5m resolution sensor, and is the civil counterpart of Japan's Information Gathering Satellite (IGS) system first launched in 2003 for intelligence purposes (see graphics[713][714]). This approach roughly parallels the way France evolved its Helios intelligence satellite from SPOT first launched in 1986.

1986: Japanese Latitude for Flexible Imaging Future

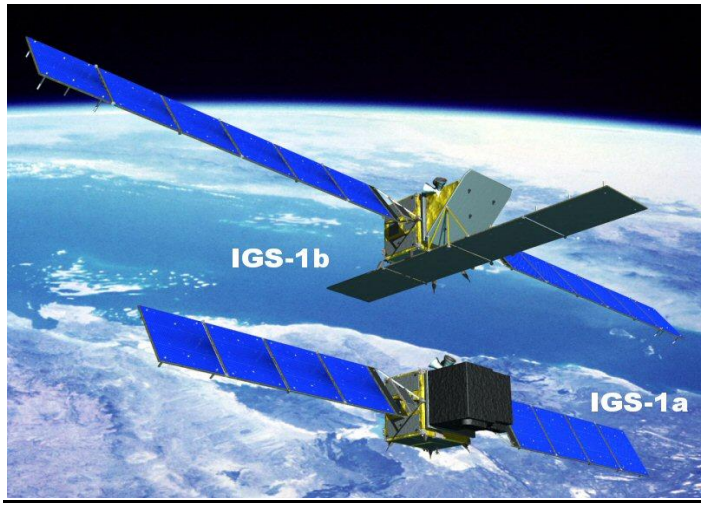
In December 1986, the United Nations adopted principles relating to remote sensing of the Earth from space. The United States and Japan did not consider the principles to be binding, and noted that creating a legal instrument such as a treaty was not necessary or desirable.[715][716] In retrospect, retaining latitude for the use of such systems helped Japan develop three successor satellite systems for MOS, ultimately leading to the IGS series. The design for the Japan's Earth Resources Satellite (JERS), for example, was completed in 1987. The satellite, which included both optical and radar sensors, was launched in February 1992 to monitor natural resources.[717]

1991 - 1997: Increased Focus on Japanese Satellite Effort

Officials in the United States were aware of and concerned about prospects for satellite imagery developments in Europe and Japan. In December 1991, a proliferation expert in the U.S. Department of Defense assessed that "How European and Japanese civil and military space programs are operated will be of serious military concern to DoD."[718] A law was signed in the United States in 1992 to re-establish Landsat as a Government program. [719] In a House of Representatives Report 102-539, foreign competition was cited by the House Committee on Science, Space, and Technology as a factor in the legislation. "These [foreign] systems operate within a commercial marketplace in which [U.S.] national security constraints can cause significant competitive disadvantages."

[713] http://forum.nasaspaceflight.com/index.php?topic=20242.0
[714] http://www.jaxa.jp/projects/sat/alos/index_e.html
[715] United Nations, Principles relating to remote sensing of the Earth from space, A/RES/41/65, 3 December 1986.
[716] Daphne Lincoff, Annual Review of United Nations Affairs, Oceana Publications, Inc., 1986, p. 96.
[717] http://jaxa.jp/projects/sat/jers1/index_e.html
[718] DoD / ISA Memorandum, Military Implications of Commercial Space Technology, 30 December 1991.
[719] U.S. Congress, "Land Remote Sensing Act of 1992", Public Law 102-555, 28 October 1992.

Information Gathering Satellites (IGS), 2003-Present



Japan's spy satellite program relates to two other satellites begun in the 1990s. Mitsubishi Electric (MELCO) was awarded a design contract for the IGS in March 1999 (Steven Berner, Japan's Space Program, RAND, 2005. p. 17). The timing was good for MELCO because it had a new, multi-purpose satellite bus in design called the Service Module (SEM).

Service Module (SEM); Flew in 2002 as part of USERS

*According to MELCO, the SEM's mass of 800kg can be augmented with 800kg of payload. The SEM can be operated in an earth-facing mode to support earth observation missions. MELCO's goal was to build satellites more quickly with lower recurring costs (see MELCO **ADVANCE** Magazine, Vol. 86, June 1999, p. 5-7.)*

The SEM first flew in 2002 as part of the Unmanned Space Experiment Recovery System mission, months before the first IGS launch on 28 March 2003. [Note the similar appearance of SEM's box-like structure on USERS and IGS (see www.spacetoday.org)]. USERS flew in a 500km altitude orbit, about the same as IGS (see www.spaceandtech.com). This would result in better quality imagery than from ALOS at 700km.

Advanced Land Observing Satellite (ALOS), 2006-Present

The bus for ALOS was built by NEC. The decision to use MELCO's SEM for the IGS -- resulting in a less than 2,000kg IGS versus 4,000kg for ALOS -- may have been made in part to gain lifespan in space. Sensors for IGS, however, were probably based sensors designed for ALOS due to available technology. The optical imagery would be about 1-meter resolution. (Steven Berner, Japan's Space Program, RAND, 2005. p. 19). North Korea's August 1998 TaepoDong-1 missile launch occurred as the SEM and ALOS were in development.

On 10 March 1994, the Department of Commerce hailed President Clinton's "New Policy on Remote Sensing Space Capabilities."[720] This was described as an effort to increase global market access for American business, and help create jobs. Six weeks after the Department of Commerce announcement, a license was granted to Lockheed Missiles and Space Company to operate a private remote sensing system.[721] The timing of the license was almost concurrent with an idea in the U.S. Department of Defense to do more with allies regarding space cooperation. The Deputy Secretary of Defense wrote to the chairman of the President's Foreign Intelligence Advisory Board recommending cooperation with allies in space-based reconnaissance, noting the possible advantage of cost sharing.[722]

- "…the Intelligence Community has been much too cautious in giving our NATO allies, Japan, and others access to and a role in space based surveillance, reconnaissance, and SIGINT. Initiatives in these areas will strengthen the alliance, spread the cost of these expensive systems, and most importantly, avoid the risk that other countries…will develop their own satellite technology and systems."

Experts in the United States knew in 1995 that Japan did not have a military imaging satellite, but noted that unilateral control of subsystems and components for such satellites would not be a viable policy option to prevent this development.[723] Companies such as NEC, MELCO, Fujitsu, Ohara Glass, Tokyo Opto-Electronics, Hitachi, Fujitsu, Oki, IHI, and Sharp had a range of technical capabilities. Japan's Advanced Earth Observation System (ADEOS), launched in August 1996, had an 8 meter resolution sensor, better than SPOT or Landsat.[724] ADEOS-I failed after one year in space, but for a brief period Japan seemed on par with Europe in satellite imaging capability. Moreover, the 1995 formation of the Defense Intelligence Headquarters (DIH), with a 50-member Satellite Image Analysis Division pointed to military interest in a satellite.[725] That was consistent with the JFY1996 National Defense Program Outline that called on JDA to be "capable of high-level intelligence gathering and analysis, including strategic intelligence, through possession of diversified intelligence gathering means and mechanisms."[726]

In 1996, it was clear that Japan would be able to build and deploy a 2.5 meter resolution imagery satellite. There was little apparent competitive threat from Japan, however, because expected U.S. commercial satellites would be superior. Prime Minister Hashimoto told the

[720] The White House, Presidential Decision Directive 23, 10 March 1994.
[721] Robert S. Winokur to Albert E. Smith, 22 April 1994.
[722] John Deutch to Les Aspin, 6 July 1994.
[723] Berner, Lanphier and Associates, Inc., Proliferation of Imagery Satellite Capabilities, February 1995.
[724] http://landportal.gsfc.nasa.gov/sensor_detail.php?sid=23
[725] http://www.fas.org/irp/world/japan/dih.htm
[726] http://www.mofa.go.jp/policy/security/defense96/contents.html

Asahi Shimbun newspaper that Japan might develop a reconnaissance satellite for security purposes, if necessary.[727] Liberal Democratic Party (LDP) leaders discussed the need for this satellite.[728] Because this was not technically possible in a short time, JDA sought agreements with U.S. companies Space Imaging and Earthwatch for access to future high quality commercial satellite images.

The Ministry of Foreign Affairs (MOFA) engaged in a 1997 effort to find a way to obtain satellite imagery for intelligence purposes. MOFA asked the Diet for the equivalent of $40,000 to study having an international intelligence gathering satellite.[729] Hearings were held in March on this subject. NEC estimated the cost to be about $2.4 billion USD, but funds were not available. As a result, momentum to build an intelligence satellite was not enough to drive a program. Meanwhile, Japan's National Space Development Agency (NASDA) pursued ALOS for mapping and environmental monitoring purposes.

1998 - 2000: Japan Decides on Intelligence Satellite

MOFA again sought funding for JFY1998, beginning 1 April 1998, to study having an intelligence satellite.[730] This was opposed by the United States because the U.S.-Japan alliance involved supplementing respective capabilities, not duplicating. After the 31 August 1998 launch by North Korea of the Taepo Dong 1 missile over Japan, however, LDP officials quickly proposed that Japan should launch four satellites (two optical and two radar), to obtain images with resolution as good as 1 meter.[731] The satellites would orbit at about 500km above the Earth. Mitsubishi Electric Company (MELCO) informed the LDP that it could launch a satellite by 2002 / 2003.[732] JDA Administrative Vice Minister Akiyama focused on the importance of having an independent capability.

- "Japan and the U.S. must cooperate in information gathering under the Japan-U.S. Security arrangements…However, if we do not have our own methods to collect information, the cooperation would remain inconsistent and defective."

By mid-1999, a U.S. defense official stated that Japan's decision to build its own intelligence satellite had merit, but that Japan should first buy a complete satellite from the United States, and use it as a stop gap until Japanese industry could produce a system.[733] The official said reports that the United States did not provide intelligence information to Japan

[727] EarlyBird Tweaks the Law, http://www.spacedaily.com/spacenet/text/spy-97a.html, 1997.
[728] Kazuto Suzuki, Japanese Remote Sensing Policy at Crossroads, 1999.
[729] Asia Eye's Japan's New Military Intelligence Unit, The Christian Science Monitor, 21 March 1997.
[730] Kyodo News, 6 January 1998.
[731] Intelligence Satellites Urgent for Defense, Japan Times, 30 October 1998.
[732] Mitsubishi Recce Plan Gains Ground in Diet, Aviation Week and Space Technology, November 1998.
[733] Asahi News, 23 July 1999.

were untrue. That was no reason for Japan to build an intelligence satellite. On 29 September, U.S. and Japanese officials signed an agreement on parts and components for the project.[734] Nearly $800 million USD was requested by Japan's Cabinet Office for JFY2000 to execute a program that could eventually cost up to $3 billion. The U.S. Deputy Secretary of Defense said that collaboration on satellites was a good example of the U.S. philosophy on industrial and military cooperation, to ensure interoperability whether or not the specific hardware is the same.[735] Some months later, a bipartisan, independent group of U.S. experts on Asia stated that the United States should support Japan's "reasonable" desire to have independent intelligence capabilities, including satellites.[736]

2001 – 2004: Technical Risk, Operational Success, and Performance Reality

Developing the intelligence satellite was an urgent priority for Japan. Chief Cabinet Secretary Fukuda said the project will be of "great significance in the nation's history" when he opened the Cabinet Satellite Information Center (CSICE) in April 2001.[737] He made a point about independent access to information that is often made in Europe about intelligence satellites.

- "The new system will enable our nation to establish ways to gather information independently, leading us to have plural sources of information. This will significantly reinforce the information gathering capability of not only the Cabinet, but the entire government."

Fukuda made his point weeks ahead of a critical test launch of the H-IIA rocket that had failed in two previous launches. Without the H-IIA, Japan could not launch the planned intelligence satellites. On 29 August, the launch was successful, giving Japan renewed hope for success in space-related activities.[738][739][740][741] Arrangements for satellite tracking stations in Australia were announced in October, giving the intelligence satellite project an international cooperation aspect other than with the United States.[742] According to a JDA official, the satellite project was important because "The United States wouldn't share information if Japanese national interests conflicted with U.S. national interests."[743]

[734] U.S. Gains Foothold in Japanese Contest, Defense News, 11 October 1999.
[735] John J. Hamre, U.S.-Japan Defense Industry Cooperation, Speech in Tokyo, 26 November 1999.
[736] The United States and Japan: Advancing Toward a Mature Partnership, INSS Special Report, 11 October 2000.
[737] Spy Satellite Office Set Up by Cabinet, Japan Times, 3 April 2001.
[738] One Last Try for Japanese Rocket, The Washington Post, 26 August 2001.
[739] Launch Success of the H-IIA Launch Vehicle No. 1, NASDA Press Release, 29 August 2001.
[740] Japan's New Rocket Soars on Maiden Flight, CNN.com, 29 August 2001.
[741] Japan's Ailing Space Program Boosted by Rocket Launch, The Washington Post, 30 August 2001.
[742] Australia to Help Japan Launch Four Spy Satellites, Japan Times, 17 October 2001.
[743] Government Preparing for Launching of 1st Spy Satellites, The Daily Yomiuri, 13 August 2002.

The Japanese government announced in early January 2003 that the first intelligence satellites would be ready for launch by the end of March.[744][745] There were concerns, however, that the satellites would not be able to take pictures as good as American commercial satellites, mainly due to inferior sensor and satellite performance.[746] The reported reason that Japan did not buy a satellite from Lockheed Martin was to try to "boost Japanese industry."

The use of ALOS-type technology for the Information Gathering Satellites suggests that Japan did not have either the time or skill to quickly develop and launch a high-resolution intelligence satellite. ALOS was well along in design by 1998 on a path toward a launch in 2002.[747][748] By March 2001, however, the lead engineer's status report on ALOS stated that launch would not be until "2003/6", even though NASDA's website as of October 2001 still listed the 2002 launch date.[749] The priority for IGS may have been much higher than for ALOS. The main difference between the programs is that IGS satellites have much less mass, and orbit at a lower altitude than ALOS (500km vs. 700km).[750] Moreover, the optical and radar sensors for IGS are mounted on separate satellites.

The two ALOS-type sensors pertinent for use on the IGS are the Panchromatic Remote Sensing Instrument for Stereo Mapping (PRISM) and the Phased Array L-Band Synthetic Aperture Radar (PALSAR). According an Australian partner of Japan's Aerospace Exploration Agency (JAXA), the PRISM can collect 2.5 meter resolution imagery, and PALSAR can collect 6.25 meter resolution radar imagery in the azimuth direction.[751] The data quality would be better for IGS satellites flown at lower altitude.

The launch of the first two IGS satellites on 28 March 2003 was successful. Having their own satellites was important to Japanese officials.

- **Chief Cabinet Secretary Fukuda:** "We can use the satellites not only for gathering intelligence information, but also for monitoring damage from a natural disaster. We will make the fullest use of them possible. Other countries are doing it."[752]

- **JDA Director General Ishiba:** "It is meaningful for us to obtain by ourselves information to ensure the peace, safety, and independence of our country."[753]

[744] Government Commission OKs Launch of Reconnaissance Satellites, Tokyo Jiji Press, 8 January 2003.
[745] Spy Satellites to Watch N. Korea, The Daily Yomiuri, 4 March 2003.
[746] Japan's Spy Satellites Inferior to U.S. Commercial Ones, Japan Economic Newswire, 28 December 2002.
[747] Takashi Hamazaki, Overview of the Land Observing Satellite, 1998.
[748] http://alos.jaxa.jp/topics/news-e.html
[749] Takashi Hamazaki, Overview of the ALOS Satellite System, 27 March 2001.
[750] http://www.jaxa.jp/projects/sat/alos/index_e.html
[751] http://www.ga.gov.au/remote-sensing/satellites-sensors/alos.jsp
[752] Rocket Carrying Japan's First Spy Satellite Launched, Tokyo AFP, 28 March 2003.

Within weeks, however, the quality of the imagery was reported to be 2-3 meters in resolution, not 1 meter as was hoped.[754] Investigation was in progress to see how this might be improved. Meanwhile, the JDA bought commercial one-meter imagery from a United States supplier. The second pair of IGS satellites was launched on 29 November 2003, but the H-IIA rocket failed to put them in orbit.[755][756] Even so, the IGS program was not abandoned.

Abandoning the IGS project in 2004 was not possible, in part, because Japan began to extend the international use of its military forces, including up to 1,000 troops for a role in southern Iraq. The first group of Japanese soldiers deployed to Iraq on 16 January, crossed into the country from Kuwait on the 19th.[757][758] 2004 was also an important milestone for U.S.-Japan relations, 150 years after the first bilateral treaty.[759] Meanwhile, RESTEC's involvement with training for CSICE analysts continued, and the Japanese government decided to start research on an advanced spy satellite with 0.5 meter resolution for launch in 2010.[760][761]

2005 – 2010: Renewed Success and Problems for IGS and ALOS

The performance of the IGS system led to criticism that its development was inefficient.[762] The government gave three different ministries authority to distribute funds for the IGS. Moreover, an organization of "middlemen" in a chartered corporation called Japan Resources Observation System Organization (JAROS) took money that caused the contracting process to be inefficient and wasteful. Discussions took place on allowing the CSICE to contract directly with the IGS manufacturers.

The first ALOS satellite was launched on 24 January 2006, years after the initial plan. Plans to launch two more IGS satellites in 2007 were set.[763] Just as the initial technical performance of the IGS was suspect, ALOS was not able to fulfill the requirements of the Geographical Survey Institute to make maps. According to thermal distortion on the satellite, ALOS was not able, without ground control points, to provide the height accuracy needed to make 1:25,000 scale maps.[764][765]

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[753] No Sign of N. Korean Missiles as Japan Launches Spy Satellites, Japan Today, 29 March 2003.
[754] Doubts Raised About Capability of Reconnaissance Satellite, Asahi Shimbun, 7 June 2003.
[755] http://wapedia.mobi/en/Information_Gathering_Satellite.
[756] http://en.wikipedia.org/wiki/Information_Gathering_Satellite.
[757] Japanese Army Team Leaves for Iraq, The Washington Post, 17 January 2004.
[758] Japan in Historic Iraq Deployment, www.cnn.com, 19 January 2004.
[759] 150 Years of U.S.-Japan Relations, The Washington Post, 31 March 2004.
[760] Overview of CSICE Related Support Projects, RESTEC, 11 August 2004.
[761] Japan to Develop New Spy Satellite to Monitor North Korea, Kyodo World Service, 25 September 2004.
[762] Spy Satellites Waste Billions, Tokyo Asahi Shimbun, 28 March 2005.
[763] Japan to Launch Two More Spy Satellites by March 2007, Kyodo News, 6 January 2006.
[764] Japanese Satellite Flops at Mapmaking, Tokyo (AFP), 8 January 2008.
[765] Briefing on Utilization of Data Acquired by DAICHI for Maps, by GSI and JAXA, 16 January 2008.

Part of the reason for problems with IGS and ALOS related to the 1969 Diet resolution on use of space for non-military purposes only. This made it difficult to specify the performance requirements for a satellite that could perform intelligence and military tasks. In March 2006, a subcommittee in the Diet discussed creating a new law that would allow space to be used to support defense needs.[766] North Korea tried to launch a TaepoDong-2 rocket on 5 July, but the IGS was not able to monitor the situation due to low resolution of the satellites.[767] Nonetheless, Japanese government sources bragged that "It is more effective to see with our own eyes, even if the performance is inferior."[768]

Technical barriers regarding IGS did not slow down Japanese government interest in a higher performance satellite, or cooperation on mapping with the United States.[769] Research and development was underway for a satellite with a resolution of 0.4 meters and the ability to change camera angles for imaging.[770] This would reduce the number of satellites needed because satellites that look straight down are not flexible for intelligence purposes. Due to increasing challenges in the East Asia security environment, more capable satellites would be needed.

On 11 September 2006, Japan successfully launched the third IGS satellite. The satellite had an optical sensor. Someone who worked on ALOS told the Japanese media that the IGS was modeled on ALOS, but could not process a large volume of data at high speed that works in space.[771] For this reason, improving resolution would take time. An Australian space expert suspected that to improve performance Japan changed the sensor on IGS to a telescope instead of a scanner.[772]

Satellite performance problems did not reduce Japan's interest in the IGS. Two more satellites were launched on 24 February 2007, including one with a radar sensor and one with an experimental optical "apparatus" to test an improved resolution capability for future satellites.[773][774][775] Prime Minister Abe stated that he hoped "Japan's space program will mark results that are appropriate for a leading nation in space."[776] Within weeks after having a full

[766] Cabinet Post Likely for Strategic Space Exploitation, Asahi, 29 March 2006.
[767] TaepoDong-2 Failure; Japan Relied on US Data Due to Insufficient Satellites, Asahi, 1 September 2006.
[768] Third Spy Satellite Will Soon Be Launched, But Cost and Operation are Problems, Asahi, 10 September 2006.
[769] Japan, U.S. to Exchange Topographic Data, Kyodo News, 21 December 2006.
[770] Government to Develop High Performance Intelligence Satellite, Nihon Keizai, 9 September 2006.
[771] Japan Successfully Launches 3rd Intelligence Satellite, Asahi, 12 September 2006.
[772] http://www.spacewar.com/reports/Guessing_Games_For_Japan_Information_Gathering_Satellite.html, 11 October 2006.
[773] Tokyo Launches New Spy Satellite, BBC News, 24 February 2007.
[774] Japan Successfully Launches Satellites, Kyodo News, 24 February 2007.
[775] Japan Successfully Puts Final Spy Satellite Into Orbit, Jiji Press, 24 February 2007.
[776] Japan Unveils Spy Satellite Network, Associated Press, 27 February 2007.

set of four IGS satellites, however, one of the two radar satellites reportedly failed.[777] Moreover, the newest IGS optical satellite launched on 28 November 2009 also reportedly failed.[778] This was not the case, but in August 2010 the only remaining IGS radar satellite failed, making it impossible to image in darkness or cloudy weather.[779][780] The satellite was only three years old, two years short of life expectancy.

2008: New Japan Law on Outer Space

Japan's Basic Law on Outer Space was approved by the Diet on 21 May 2008 (Law No. 43 of 2008).[781] The Upper House approved it by a vote of 221-14.[782] This law now allows use of space for defensive purposes. The 1969 ban on non-military use was lifted. The new law is intended to promote space development that contributes to national security, including military use of "high-grade spy satellites".[783] Another objective is to strengthen the capability of domestic industry and international competitiveness. On 27 August 2008, a Headquarters for Space Policy was formed under the Cabinet Secretariat to lead the work on a comprehensive space plan, across all affected ministries. 21 staff members were assigned to this activity, including two from Defense.[784] Before the law, neither MOFA nor MOD was involved in forming space policy because it was not a national security activity. Inside Defense, a Maritime and Space Policy Office was formed to help clarify the use of space assets in the military.

Before the 2008 law, the Ministry of Defense indicated that it used commercial optical imagery from the U.S. satellites Ikonos, QuickBird, Worldview-1, and GeoEye-1.[785] The data are provided by U.S. firms to two Japanese distributors (Japan Space Imaging, and Hitachi Software Engineering Co.).[786][787] One of the U.S. firms specifically advertises that the imagery can be used for defense and intelligence, including monitoring of forces, military facilities, weapons development and storage, mapping, and 3D modeling. The MOD also receives commercial radar satellite imagery from Germany's TerraSAR-X and Canada's Radarsat-2. The imagery is

[777] http://www.strategypage.com, 1 April 2007.
[778] Japanese Highly Classified Information Gathering Satellite IGS-5 Has Failed. http://forum.nasaspaceflight.com/index.php?20242.0
[779] Japan's lone radar intelligence orbiter breaks down, The Yomiuri Shimbun, 29 August 2010.
[780] Japanese spy satellite over DPRK out of commission, The Voice of Russia, http://english.ruvr.ru, 29 August 2010; www.satnews.com, 30 August 2010.
[781] Briefing on Background Information on Basic Law of Outer Space, 2008.
[782] Japan Parliament OKs Space Defense Bill, Associated Press, 21 May 2008.
[783] Lawmakers to Submit Bill to Let Japan Use Own Spy Satellites, Asahi Shimbun, 9 May 2008.
[784] The Basics of Japan's Defense Policy and Build-up of Defense Capability, p. 123.
[785] Ministry of Defense Briefing, Space-Related Defense Policies and Future Topics for Consideration, November 2008.
[786] http://www.geoeye.mediaroom.coom/index.php?s=43&item=288
[787] http://www.digitalglobe.com/index.php/53/Providers?provider_id=15

usable by Defense because the Diet in 1998 allowed military use of publicly available data from imagery satellites. The MOD did not indicate any use of IGS imagery, however. Under the new law, one of the MOD's objectives in using space for national security is to "strengthen existing intelligence functions", including the intent to "improve the capability of image satellites."

Future Plans for IGS and ALOS

Japan's new law on outer space has caused planning to move ahead on future IGS satellites with improved resolution.[788] The future of IGS seems assured, as an independent means of intelligence collection for Japan. The CSICE plans to launch an optical satellite with 0.4 meter resolution capability in 2014, based on a demonstration satellite to launch in 2012.[789] On 2 June 2009, the Cabinet's new Space Policy office recommended that an unspecified number of IGS satellites be developed and flown over the next ten years.[790][791] In a 2009 Japanese space products catalog, NEC offers the Small Standard Bus that could conduct a 0.5 meter resolution imagery collection mission known as the Advanced Satellite with New Architecture for Observation (ASNARO) project.[792] This satellite is also known as the Small Advanced Satellite for Knowledge of Earth (SASKE).[793][794] The goal is to field a commercially competitive lightweight, high-resolution imaging satellite, including to possible customers in Southeast Asia, Africa, and South America.[795] NEC considers ASNARO to be part of a new generation of satellites based on the NEXTAR bus.[796]

The future of ALOS also seems assured. ALOS-2, planned for launch in 2013, will have a radar imaging payload capable of 1 meter resolution in the azimuth direction.[797][798] ALOS-3 would have a 1 meter resolution optical sensor, and be launched later on its own platform.[799][800][801] The apparent design and approach for ALOS 2 and 3 is similar to the desired capability of the IGS national security program when conceived over ten years ago. This

[788] Paul Kallender-Umezu, Japan Rebuilding Spy Satellite Capability, Inching Forward on Military Space Choices, SpaceNews, 14 February 2011.
[789] Japanese Government Plans Powerful Information Gathering Satellite, Yomiuri Shimbun, 2 February 2009.
[790] Missile Warning System at Forefront of Japan's New Space Policy, SpaceNews.com, 5 June 2009.
[791] Japan Space Plan Calls for Doubling Space Budget, Parabolic Arc, 11 May 2009.
[792] The Society of Japanese Aerospace Companies, Directory of Japanese Space Products & Services, 2009.
[793] Norihiko Saeki, Ministry of Economy, Trade, and Industry; Briefing on SASKE R&D Program, International Commercial Remote Sensing Symposium, 4 March 2010.
[794] Shuichi Kaneko, METI, Policies on Japanese Space Industry.
[795] Yu Toda, Hayabusa fires up space industry, Yomiuri Shimbun, 4 August 2010.
[796] NEC, Advanced small standard satellite system NEXTAR, http://www.nec.co.jp/solution/space,2010.
[797] Yukihiro Kankaku, JAXA, Overview of the L-Band SAR On ALOS-2, 18 August 2009.
[798] Briefing by JAXA, ALOS-2 and Its Follow-on Satellite, ALOS-2, 3 November 2009.
[799] http://www.space.skyrocket.de/doc_sdat/alos-3.html
[800] http://www.adsabs.harvard.edu/abs/2009SPIE.html
[801] Hiroki Imai et al, A Conceptual Design of the Optical Satellite for the Post-ALOS Program, JAXA, November 2009.

suggests that lessons learned from the performance of IGS satellites since 2003 may have influenced the design for the future ALOS-2 and ALOS-3.

The performance of both the IGS and ALOS systems may not have met technical expectations regardless of cost. For the IGS this was estimated to be about $600 million USD per year since 2003, not including the satellites which cost billions more.[802] Over the course of the past decade since the 1998 Taepo Dong 1 launch by North Korea, this suggests over $6 billion has been spent on the program. As of 2007, according to a study in the United States, Japan had invested over $4 billion in the IGS project.[803] This is a much greater expenditure than a rough estimate of $1 billion for two optical and two radar satellites provided in 1999 by Lockheed Martin for Japanese consideration.[804] Nonetheless, Japan learned about industrial and strengths and weaknesses by building and operating its own satellite imagery systems.

Former Prime Minister Hatoyama's call for more equal ties with the United States suggests that independent Japanese intelligence satellites would help balance the relationship, similar to the way Europeans value these capabilities.[805] The result is that both sides can bring intelligence evidence to the table when there are disagreements over whether a North Korean rocket shot is a missile test or a satellite launch, reportedly one of the main reasons why Japan sought its own satellites in 1998.[806]

Once imagery satellite programs become part of a nation's security fabric, the programs tend to become permanent "eyes" on the globe. Japan may need as many satellites as possible to monitor China, especially if a territorial dispute over islands in the East China Sea, and Japan's access to resources such as rare earth minerals mined in China remain unresolved.[807][808][09][810][811][812] Japan's National Defense Program Guidelines reflect the need to address the China threat.[813][814][815] An American author notes that "passivity encourages China's

[802] Maeda Sawako, Transformation of Japanese Space Policy: From Peaceful Use of Space to The Basic Law on Space, http:www.japanfocus.org/articles/print_article/3243
[803] Manuel Manriquez, Japan's Space Law Revision: the Next Step Toward Re-Militarization?, James Martin Center for Nonproliferation Studies at Monterey Institute of International Studies, January 2008.
[804] Lockheed Martin, Informational Presentation, SAR and EO Considerations, July 1999.
[805] Japan Leader Wants More Equal Ties with U.S., www.foxnews.com, 3 January 2010.
[806] Japanese to Create a Spy Satellite System, www.stratfor.com. 2 November 1998.
[807] Cara Anna, Chinese Protest Japan claim to islands, The Washington Post, 16 October 2010.
[808] Seima Oki, China calls off joint gas seabed talks / Move response to seizure of fishing vessel, Yomiuri Shimbun, 12 September 2010.
[809] China and Japan Meet Amid Dispute, The New York Times, 30 October 2010.
[810] Keith Bradsher, China Said to Widen Its Embargo of Minerals, The New York Times, 19 October 2010.
[811] Keith Bradsher, China Still Bans Rare Earth to Japan, The New York Times, 10 November 2010.
[812] China cuts export quotas for rare-earth minerals, Reuters and The Washington Post, 29 December 2010.
[813] Chico Harlan, New Japanese defense plan emphasizes China threat, The Washington Post, 13 December 2010.
[814] Government of Japan, National Defense Program Guidelines for FY 2011 and Beyond, 17 December 2010.

new world order, with fateful consequences for the United States and everyone else." This suggests that advancing the IGS system for national security, and setting up a geospatial intelligence system is a prudent course of action.[816]

[815] John Pomfret, Regional risks make U.S.-Japan ties even more key, Gates says, The Washington Post, 14 January 2011.

[816] Japan's Visions for Future Security and Defense Capabilities in the New Era, The Council on Security and Defense Capabilities, August 2010.