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July 16, 2007

Vice Admiral Robert B. Murrett, USN
Director, National Geospatial-Intelligence Agency
4600 Sangamore Road
Bethesda, MD 20816

Dr. Donald M. Kerr
Director, National Reconnaissance Office
14675 Lee Rd.
Chantilly, VA 20151

Dear Vice Admiral Murrett and Dr. Kerr

Enclosed is the final report entitled " Independent Study of the Roles of Commercial Remote Sensing in the Future National System for Geospatial-Intelligence (NSG)" that identifies and discusses viable business cases in support the US government's increased acquisition of commercial remote sensing satellites and ancillary support. The review panel had the full cooperation and invaluable support of Mr. Frank Calvelli (NRO), Mr. Jaan Loger (NGA), and Mr. David Svetz (ODNI).

Two key requirements drove the analysis and the recommendations:

- Data must be available when needed. The US government cannot rely on or be dependent on any external entity to responsively get needed data.
- Flexible, highly agile, and survivable remote sensing capabilities with sufficient capacity to respond to all needs in a timely manner. The capabilities must operate in a manner consistent with a defined architecture.

The panel believes that the US government can commercially acquire robust commercial remote sensing capabilities to meet minimal acceptable requirements through the adoption of acquisition strategies that "buy" proven, complex technologies but are modularly designed so as to maximize flexibility to meet dynamic mission needs. The modular design has the possibility, with the use of "commercial practices," to allow components such as buses and payloads to be acquired separately.

The panel concurs that the business case that mitigates the most risk is for the US government to competitively acquire satellites and supporting infrastructure to ensure maximum control and access to imagery data on demand. Business Case 3 or 4 are the optimum choices. In deference to the policy to support the CDPs when possible, recommended business case (Business Case 4) supports the US government offering the Commercial Data Providers (CDPs) the ability to buy satellites in a "block" with the US government absorbing the upfront costs in order to spread costs and increase the efficiency of the business model. However, the panel believes that regardless of whether the US government fully adopts the recommended business case that its other recommendations should be fully adopted. Some of the key recommendations are:

- Expand the definition of what constitutes “commercial to reflect market realities that every vendor and supplier operates in the commercial marketplace,
- Adopt “best practices” including Firm Fixed Price contracts”,
- Buy in “blocks” in order to apply “lean manufacturing” techniques as well as ensure maximum flexibility
- Commercially developed ground infrastructure can be managed to meet mission requirements. The panel recommends a highly distributed ground infrastructure to ensure survivability.
- Compete all contracts at some point in the cycle (as appropriate).

The panel fully supports the findings and recommendations contained in the report. Although I have shared our findings and recommendations with each of you, I am happy to further discuss the report in more detail at your convenience.

Sincerely,

Peter Marino
Chair, National Geospatial-Intelligence Agency
Advisory Group

INDEPENDENT STUDY OF THE ROLES OF COMMERCIAL REMOTE SENSING IN THE FUTURE NATIONAL SYSTEM FOR GEOSPATIAL-INTELLIGENCE (NSG)

FINAL REPORT

Chair
Mr. Peter Marino

Members
Mr. Evan Hineman
Dr. Edward McMahon

Assistant to the Chair
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Acronyms

CAIV	**Cost As an Independent Variable**
COCOMs	**Combatant Commanders**
CDP	**Commercial Data Provider**
COTS	**Commercial-Off-The-Shelf**
D/NGA	**Director, National Geospatial-Intelligence Agency**
DOD	**Department of Defense**
EELV	**Evolved Expendable Launch Vehicle**
EO	**Electro-Optical**
EVM	**Earn Value Management**
FFP	**Firm Fixed Price**
GSD	**Ground Sample Distance**
HSI	**Hyper-Spectral Imagery**
IC	**Intelligence Community**
ICA	**Integrated Collection Architecture**
ITAR	**International Traffic in Arms Regulations**
LIDAR	**Light Detection And Ranging**
MSI	**Multi-Spectral Imagery**
NAG	**National Geospatial-Intelligence Agency Advisory Group**
NGA	**National Geospatial-Intelligence Agency**
NIIRS	**National Imagery Interpretability Rating Scale**
NIMA	**National Imagery and Mapping Agency**
NOAA	**National Oceanic and Atmospheric Administration**
NRE	**Non-Recurring Engineering**
NRO	**National Reconnaissance Office**
NSG	**National System for Geospatial-Intelligence**
NSP	**National Security Policy**
NTM	**National Technical Means**
ODNI	**Office of the Director of National Intelligence**
PDD	**Presidential Decision Directive**
R & D	**Research and Development**

SAR	**Synthetic Aperture Radar**
SLAs	**Service Level Agreements**
TCPED	**Tasking, Collection, Processing, Exploitation and Dissemination**
TDL	**Theater Down Links**
US	**United States**
USSTRATCOM	**US Strategic Command**

EXECUTIVE SUMMARY

The Directors of the National Geospatial Intelligence Agency (NGA) and the National Reconnaissance Office (NRO) requested in mid-January 2007 that a small review team evaluate how commercial remote sensing capabilities might be incorporated into the National Technical Means (NTM).[1] Several previous government-sponsored studies evaluated the technological capabilities of commercial remote sensing and more recently, the Phase 1 of the Integrated Collection Architecture (ICA) addressed the future roles of commercial vendors. Therefore, the Directors requested that the panel define and evaluate viable business cases for how the U.S. government might formulate a commercial industry-government partnership to acquire commercial remote sensing capabilities to be incorporated into the NTM. Three time periods were to be examined now (2007-2009), mid-term (2010 – 2012), and beyond. The requested review was in response to concerns/criticisms by Congress of how NGA and NRO have under-utilized commercial remote sensing capabilities. A 2007 report from NGA and the NRO to Congress concluded that commercially acquired imagery data and products would continue in the near- to mid-term to provide augmentation to mission. The recent Senate Select Committee on Intelligence (SSCI) language argues for increased use of commercial capabilities. NGA's investments in the commercially acquired imagery data using the commercial data providers (CDPs) are coming to fruition in 2007 with the completion of the second-generation collection systems.

This is the panel's report. It contains general findings about the technical competency and business viability of commercial remote sensing vendors, suppliers, and CDPs in the United States. Four business cases were identified and assessed. Government representatives from NGA, NRO, and the Office, Director National Intelligence (ODNI)[2] supported the panel and often collaborated with the panel in the development of many of the report's findings and recommendations. The panel believes that all of its recommendations should be implemented to effectively integrate commercial remote sensing capabilities into the NTM. Should the government choose not to fully implement the business case that mitigates the most risk, the panel supports adoption of the other recommendations to ensure that the government leverages its ability to cost effectively acquire leading edge commercial capabilities in the near- to mid-term.

Given the breadth of the topic and its complexity the panel designed and followed a structured methodology. The government representatives provided an unclassified set of minimally acceptable requirements for remote sensing (See Appendix D) in order to focus the discussions on specific technical and mission needs. The panel requested that the various presenters discuss how they could meet or exceed the minimal acceptable requirements in their proposed business cases. The panel disaggregated the remote sensing mission into three mission layers based on the complexity of functions and

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[1] The analytic work of the NGA Advisory is supported under the auspices of a contract from NGA to the Defense Group, Inc. Research and administrative support was provided by Abigail Chapman (DGI).
[2] The government representatives are: Mr. Jaan Loger (NGA), Mr. Frank Calvelli (NRO), and Mr. David Svetz (ODNI).

technologies employed to meet mission demands to better understand the various business cases and their risks. The three mission layers are:

1. **Mission Layer 1** consists of leading edge, advanced, complex technology with long life spans. It produces very high-resolution multi-functional remote sensing capabilities. These capabilities meet requirements for agility, accuracy, and almost real-time access that are highly challenging. Broad area imagery in a single over flight and agile revisit capabilities are essential. The satellites in this layer cost upwards of $1 billion or more.
2. **Mission Layer 2** utilizes proven high technology with mid-to-high level resolution. The mission layer contains some new development focused on single functions to meet specific requirements in the architectural concept. The capabilities in this layer use Commercial-Off-The-Shelf (COTS) components and subsystems including hardware and software. The satellites in this layer are less agile then those in Mission Layer 1. The satellites are modular in design so as to maximize flexibility to meet mission needs. The modular design enables the use of
"commercial practices" so that components such as buses and payloads can be acquired separately. These satellites cost between $300 million and less than $500 million.
3. **Mission Layer 3** includes low mid-resolution that approaches medium. The satellites are designed to collect in narrow swath under limited conditions. The layer uses COTS extensively and is dependent on proven technologies. The developers of capabilities in this layer rely on "commercial practices" to sustain their business viability. The satellites cost between $50 million and $250 million depending on their complexity.

<u>The panel believes that there are two (2) overriding capabilities that must be achieved within the operational architecture. First, is the government's ability to acquire data when it needs it. The US government cannot rely on or be dependent on any external entity to responsively get needed data. Second, is the need for flexible, highly agile, and survivable remote sensing capabilities with sufficient capacity to respond to all needs in a timely manner. These capabilities must operate in a manner consistent with the defined architecture.</u> The needs are the key drivers in the study. Based on these needs the panel identified risk categories that included technical, mission, and business. From these analyses four (4) business cases were defined and evaluated in terms of what mitigated the most risk and achieved the needed capabilities for the U.S. government (see Chapter 2). The business cases were informed by several attributes that the commercial remote sensing industry representatives argued were key to a successful industry-U.S. government partnership – mission function specialization, adoption of acquisition strategies that used FFP contracts and well-defined schedule and performance metrics, and government oversight discipline. Each of the business cases incorporates some or all of the attributes. The four business cases are:

1. <u>**Multi-Year Data Buys**</u> **(Most risk)** in which the government commits to a predictable, multi-year data and products purchase using the CDPs.
2. <u>**Satellite Production - Service Level Agreements (SLAs)**</u> **(Most risk)** in which the CDPs (a minimum of two) operate as the middleman between the government

and satellite vendors and suppliers. The U.S. government commits to a predictable multi-year data and products purchase and partially funds development costs in exchange for priority and accommodation of specialized requirements. SLAs define the partnership and how the CDPs will provide value added.

3. **Multi-Year Satellite Buy – U.S. Government Manages (Minimum risk)** has the government procure medium satellites and ancillary support on a FFP basis drawing primarily from Mission Layer 2 technologies and "commodity" components (as appropriate) from Mission Layer 3. The government uses "commercial practices" to have qualified vendors provide 2 to 4 satellites in "blocks" in order to eventually achieve "lean manufacturing". Subsequent "blocks" incorporate proven technology upgrades on individual components such as buses and payloads. The government owns the design to ensure the option to compete future "blocks" in order to obtain the most capability at the lowest price. This business case insures that the U.S. government owns and manages its satellites to guarantee the timely and responsive delivery of imagery data and products. The business case provides the government the maximum flexibility to acquire needed satellites using a modular (e.g., "plug and play") approach. The business case and supporting acquisition strategy facilitates the US government's ability to choose the "payload" that meets mission needs "at the last minute".
4. **Hybrid of Business Cases 2 and 3 (Minimum risk)** incorporates the best aspects of Business Case 2 with Business Case 3. The government acquires the satellites, but grants access to two satellites worth of data, a minimum buy of four, or allows the CDPs to buy two satellites in a "block" with the government absorbing the non-recurring engineering (NRE) costs. The SLA defines how the CDP data will be managed, paid for, and sold on the global market. The government buys the first couple of systems in order to support moving to a "block" production. The business case drives down costs to the CDPs, mitigates the government's risk of depending on the CDPs, while increasing the efficiency of the business model.

Figure ES-1 summarizes the risks associated with each of the proposed business cases.

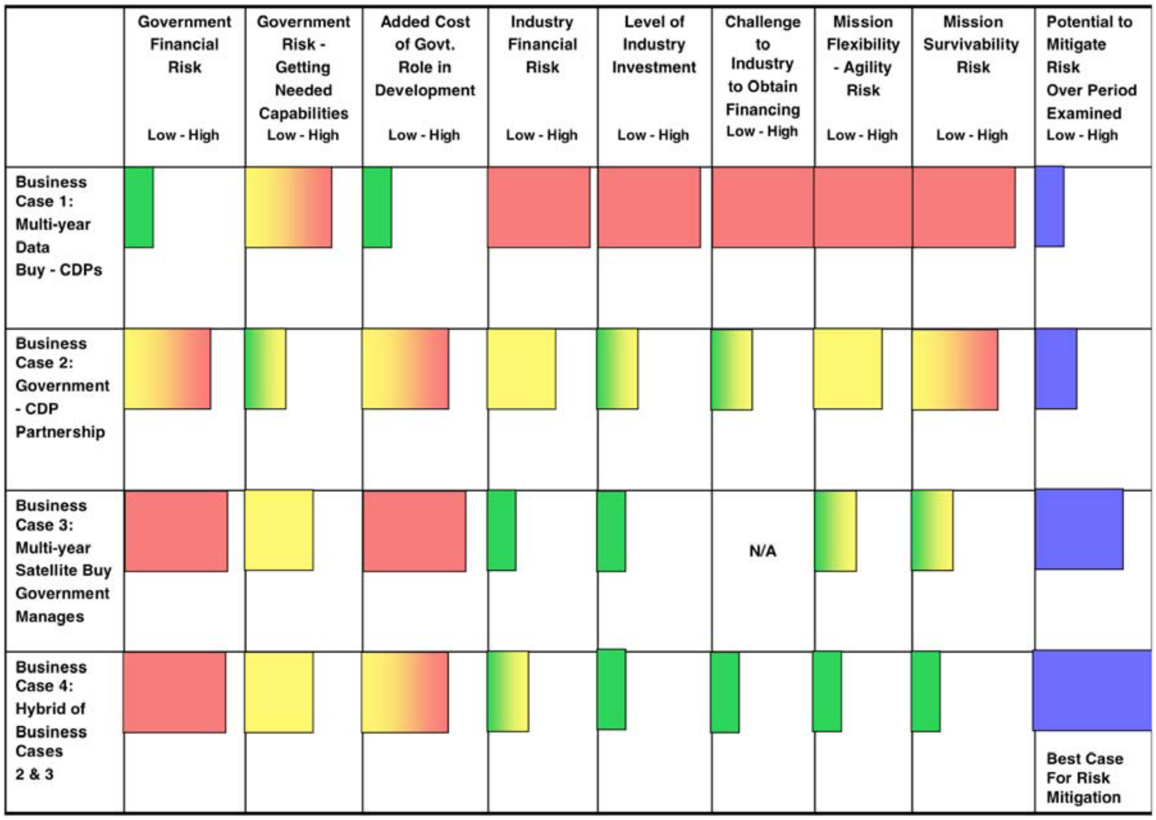

Figure ES-1: Summary of Business Case Risks

The panel has five general findings about commercial remote sensing and its integration into the NTM:

1. Current commercial remote sensing capabilities are sufficiently technically robust, modular, and available to meet the government's minimal acceptable requirements. Using appropriate acquisition strategies the U.S. government can acquire and field sufficient capabilities within 3 to 5 years (mid-term).
2. There is little potential for developing commercial competition for capabilities in Mission Layer 1.
3. The term "commercial" encompasses more than the CDPs. Everyone is commercial. "Commercial" are those goods and services developed or produced and delivered from industry or business from outside of the government. A government "buy" of a product or service would be termed a commercial development or procurement. The NRO and NGA by acquisition directive "buy" all their capabilities to support the mission performance and operate within the architectural approach.
4. The lack of common definitions across the DoD and IC hinders the ability of the government to discuss and decide at an enterprise level on how to proceed concerning the use of commercial imagery, its acquisition, and integration into the existing architecture. The lack of common and approved definitions for such terms as "commercial" imagery, "best commercial practices", "lean

manufacturing", and even "requirements" confuse the debate and inhibit the ability of the government to decide on courses of action and their execution.

- "Best commercial practices" (as used in this report) include core requirements defined upfront, standardized modular design, and firm fixed price contracts.
- Lean manufacturing (as used in this report) means a qualified vendor can develop and produce a standard design spacecraft and ancillary support at a competitive price point due to repetitive procurement, and optimized manufacturing processes and application of labor. The approach can also provide significant flexibility in what is acquired and how.

5. The U.S. commercial remote sensing market is at risk without significant U.S. government investments in imagery products and satellite development for Mission Layers 2 and 3. The panel's recommendations specifically focus on improving the viability of Mission Layer 2, the most seriously threatened, and to a lesser degree in Mission Layer 3.

The panel's specific findings and recommendations are discussed below. There are eight (8) findings:

1. Define a minimal acceptable set of requirements;
2. Expand the concept of what constitutes "commercial" to reflect market realities;
3. Adopt "best commercial practices", including FFP contracts;
4. Buy in "blocks" in order to apply "lean manufacturing" techniques as well as flexibility;
5. Business Case 4 provides the most flexibility, agility and survivability, and mitigates the most risk;
6. Ground infrastructure can be managed to meet mission needs;
7. Compete all contracts (as appropriate); and
8. ITAR policies and regulations inhibit the global competitiveness of U.S. vendors.

FINDINGS AND RECOMMENDATIONS

1. Define a minimal acceptable set of requirements.

- **Recommendation #1**: Reassess the current requirements deck to delineate the requirements among the three mission layers based on the concept of sufficiency.
- **Recommendation #2**: Ensure that the requirements analysis defines outcomes rather than focus solely on technical improvements to NTM.
- **Recommendation #3:** Determine first what commercial capabilities can sufficiently fill the mission gaps and architectural approach.

2. Expand the definition of what constitutes "commercial" to reflect market realities.

- **Recommendation #1:** Leverage on the commercially available technologies and the "commoditization" of many components available in Mission Layers 2 and 3 to acquire needed capabilities.
- **Recommendation #2**: Update NSPD 23 and PDD 27 to reflect the changes in the commercial remote sensing industry**.**

3. Adopt "best commercial practices," including FFP contracts.

- **Recommendation #1**:Develop commercial satellites that are single function in order to manage technical and business risks.
- **Recommendation #2**: Adopt an acquisition strategy using FFP contracts with well-defined requirements and cost, schedule, and performance metrics.
- **Recommendation #3:** Ensure that the government program manager is held accountable for executing the agreed to acquisition strategy through his performance appraisal.

4. Buy in "blocks" in order to apply "lean manufacturing" techniques, as well as ensure maximum flexibility.

- **Recommendation #1:** Ensure that the acquisition strategy for commercial satellite buys incorporate a "block" approach that drives to "lean manufacturing".
- **Recommendation #2:** Develop multi-year procurement strategies and packages whose goal is the creation of a "warm base" production pipeline to develop and sustain a proficient workforce.
- **Recommendation #3:** Ensure that the U.S. government owns the drawings and technical data to ensure that "blocks" can be competed (as appropriate) so that systems are acquired at a competitive FFP.

5. Business Case 4 mitigates the most government risk.

- **Recommendation #1:** Adopt Business Case 4 because it provides flexibility and agility through the acquisition of "plug and play" remote sensing capabilities, while consistent with the architectural philosophy.
- **Recommendation #2:** Use SLA's to define the CDPs roles and responsibilities. The incorporation of the CDPs allows the government to spread costs across the U.S. government and CDPs, while it leverages on the CDPs contacts with foreign governments and foreign-subsidized industries.
- **Recommendation #3**: Compete the contract (as appropriate) and subsequent "blocks" in order to foster technical and cost competition among vendors and suppliers and enhance the market.

Figure ES-2 summarizes how risk is mitigated if Business Case 4 is adopted.

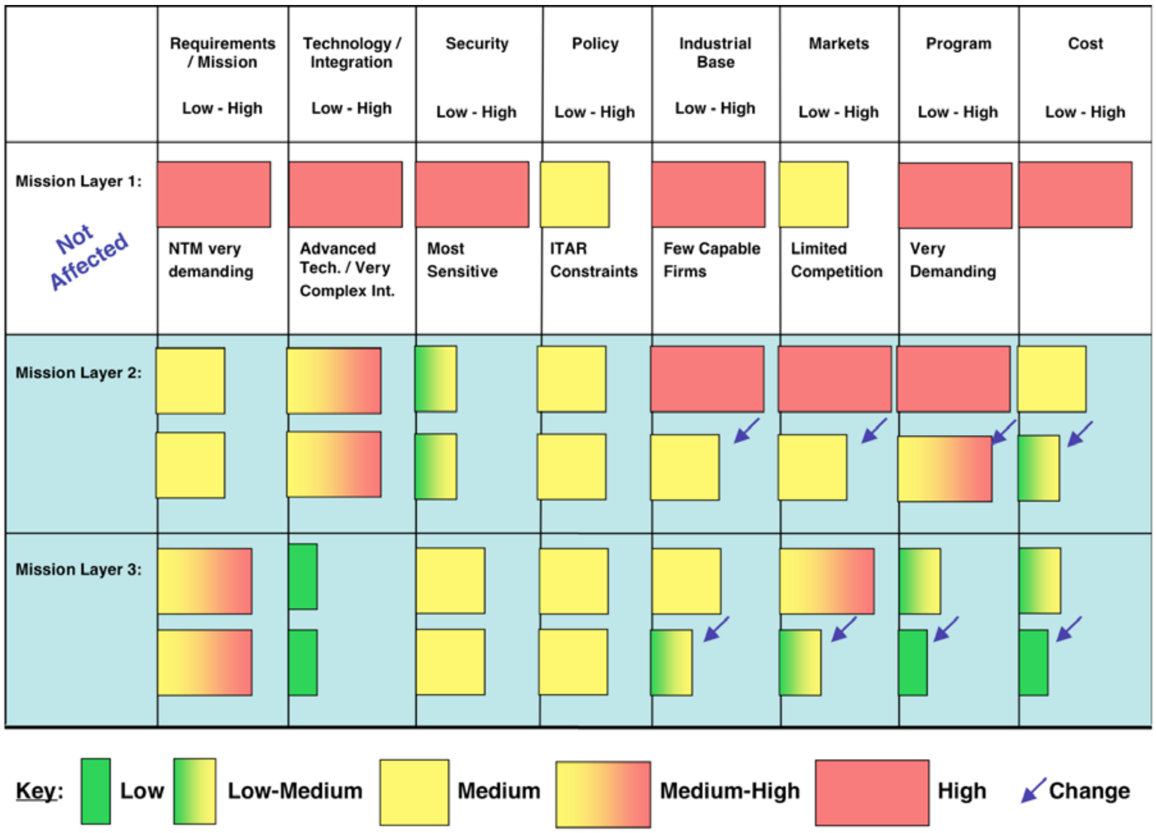

Figure ES-2: Summary of Business Case 4's Risk Mitigation

6. **<u>Commercially developed ground infrastructure can be managed to meet mission requirements</u>**.
   - **<u>Recommendation #1:</u>** Buy modular ground infrastructure consistent with "best commercial practices" and architectural philosophy.
   - **<u>Recommendation #2</u>:** Buy highly distributed ground infrastructure to ensure survivability.

7. **<u>Compete all contracts (as appropriate)</u>**.
   - **<u>Recommendation #1:</u>** Compete all contracts (as appropriate) when acquiring commercial remote sensing capabilities in order to ensure the competition of ideas and get the best value. The panel recognizes that there might be special "plugs" needed to meet mission requirements that do not lend themselves to competition or FFP contracts.

8. **<u>ITAR policies and regulations inhibit the global competitiveness of U.S. vendors.</u>**
   - **<u>Recommendation #1</u>**: Restructure ITAR policies and regulations to ensure that Mission Layer 2 vendors and suppliers have access to foreign markets so as they can remain a viable part of the U.S. industrial base.
   - **<u>Recommendation #2</u>**:Share the findings and recommendations of this panel with the ongoing reviews assessing current ITAR policies and regulations.

The panel determined that a significant amount of collection requirements (specifically in the broad area collection mission) could be satisfied by a constellation of multiple "commercial" Mission Layer 2 satellites. The recommended approach is consistent with the existing architecture. Use of a "block" approach supports the need for flexible and agile procurement strategies responsive to mission needs. The modular "plug and play" strategy facilitates the US government's ability to insert a wide array of new and proven components acquired separately.

1. INTRODUCTION

BACKGROUND

Significant debate is occurring within the U.S. government concerning how space-based commercial remote sensing capabilities might be better integrated into the National System for Geospatial Intelligence (NSG). The Office, Director of National Intelligence (ODNI) Phase 1 report on the Integrated Collection Architecture (ICA) addresses the future role of commercial vendors among a variety of issues. The ODNI strategic and architectural studies are continuing through 2007. The Congress directed that the National Geospatial Intelligence Agency (NGA) and the National Reconnaissance Office (NRO) increase their utilization of commercial remote sensing across the Intelligence Community (IC). In particular, Congress wanted commercial capabilities applied to the broad area collection mission and infrastructure improvements that improve integration of commercial data into the National Technical Means (NTM). Recently the Senate Select Committee on Intelligence (SSCI) argued that, given the increased technical sophistication of commercial capabilities, the U.S. government should incorporate more commercial capabilities into its Imagery Intelligence (IMINT) architecture.

In January 2007, the Directors of the National Geospatial-Intelligence Agency (D/NGA) (Vice Admiral Robert B. Murrett) and the National Reconnaissance Office (NRO) (Dr. Don Kerr) requested that Mr. Peter Marino (Chair, NGA Advisory Group (NAG)) constitute a small panel to address how the United States government might increase its use of commercial remote sensing capabilities in support of the NSG.[3] The panel was directed to:

1. Evaluate how vendors in the commercial remote sensing marketplace contribute to the National Technical Means (NTM) (e.g. national) and Department of Defense (DoD) missions (e.g., tactical), with particular emphasis on the broad area collection mission;
2. Assess the business viability of commercial satellite industrial base and imagery data providers in terms of their providing increased support to the national and tactical missions;
3. Define infrastructure improvements that can utilize commercial data as easily as NTM sources; and
4. Develop and evaluate viable business cases that the government might adopt that result in more efficient and effective use of commercial remote sensing capabilities.[4]

This study addresses how the U.S. government might mitigate its risks should it decide to increase its utilization of commercial remote sensing capabilities. Four business cases are defined and evaluated against government-industry identified risk categories.

ASSUMPTIONS

Six assumptions shaped the analysis:

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[3] The several government representatives participated in the panel: Mr. Jaan Loger, NGA; Mr. Frank Calvelli, NRO; Mr. David Svetz, ODNI.
[4] Appendix A contains the Terms of Reference.

1. NTM-obtained imagery and geospatial data is not a "free good" and more cost-effective means to obtain broad area search data are needed;
2. More imagery and geospatial products are needed to meet national and tactical mission demands;
3. Redundancy in the imagery architecture is highly desirable in order to mitigate potential mission gaps, provide a surge capability and ensure survivability;
4. The persistence mission must be provided for;
5. Agility and robustness of U.S. capabilities are key attributes of the architecture; and
6. The US government must have direct access to imagery data at all times.

KEY TERMS

Much of the terminology associated with commercial remote sensing is inconsistently used and/or not understood. For the purposes of this study the following terms were defined as follows:

Commercial Vendors and Suppliers, and Commercial Data Providers (CDPs): The U.S. government buys its spacecraft, all U.S. spacecraft developers and vendors are in the commercial marketplace. U.S. spacecraft developers provide spacecraft across the entire spectrum of mission capabilities – high-end technology, large spacecraft through the less sophisticated small satellites. Almost all spacecraft developers, regardless of size, acquire and sell systems, sub-systems, and components in the U.S. and in global commercial markets. In this study the term "vendor" means commercial satellite developer, while, the term "commercial data providers (CDP)" means the providers of imagery and geospatial products who sell their products to the U.S., foreign governments, and commercial companies such as Google and Microsoft (Appendix B contains a list of the U.S. vendors and CDPs). The suppliers to the vendors are the providers of components, sub-systems, and parts such as lens, buses, etc. In addition to U.S. vendors there are many foreign governments and foreign government subsidized companies who build satellites and sell them in the global marketplace. For suppliers also sell components and software on the global market and is often viewed by the US government as a security and availability issue.

Commercial Practices: This term is also often called "best commercial practices." It is predicated on the buyer – a company or the U.S. government – having a clear and precise understanding of the mission for the system and what system outcome is needed. A principal objective of applying "best commercial practices" is to manage requirements creep so that once core requirements are agreed to between the buyer and the developer, they cannot be changed; trade spaces usually involve ancillary requirements and these issues are defined early in the negotiations. In this model the buyer carefully prioritizes the mission performance needs and broad capability requirements that the system must possess to accomplish the mission. The definition of requirements, with well-specified outcomes, is essential to commercial practices so that trade-spaces are identified upfront and can be performed intelligently between cost and system performance. The satellite system must also fit within a predefined architecture. When "commercial practices" are used correctly the buyer does not dictate specific or detailed technical and design solutions to the contractor, but rather the buyer defines the general system and performance requirements necessary to accomplish the mission.

Foundational to the successful application of "commercial practices" is rigorous risk management; risk management includes technical, as well as, business risk. In satellite development, commercial practices also include the extensive use of standardized and modular design. The management of the technical and business risks require rigorous configuration control, at least one level below the overall system level. Most often the application of "best commercial practices" necessitates that the developer use heritage and well-proven technologies and designs. The approach necessitates managing risk as a trade variable. The design can utilize hardware and technology from previous missions/programs to the maximum extent possible, and minimize areas requiring new research and development (R&D) that drives up costs and significantly increases risk.[5] Strict use of only essential specifications facilitate the contractor's use of any technologies and components available in the global marketplace that will meet the mission requirements at the lowest possible cost. Spacecraft developers who use "Commercial Practices" also invest significant effort in systems engineering in order to ensure a full end-to-end solution; the end-to-end trade off analyses are worked in parallel with ongoing requirements assessments done within the clearly-defined mission costs and schedule.

Integral to the execution of commercial practices is the use of cost as an independent variable or CAIV. Cost is a priority that operates at a level at least equal to performance and schedule, and on occasion, is the key determinant. For this reason core system performance requirements must be defined up front because they are key cost determinants, particularly in "firm fixed priced" (FFP) contracts. Adoption of commercial practices can also specify how the buyer is involved in the acquisition once requirements and costs are determined; the contract vehicle specifically defines how the usual acquisition oversight mechanisms (cost, schedule, and performance) will be managed.[6] Often key to risk management is that the buyer is continuously involved in the decisions within the trade spaces defined during the requirements determination negotiations.

Lean Manufacturing: Lean manufacturing is a systematic process employed in recurring production. In our use, it means that a qualified vendor can develop and produce a standard design spacecraft (or vendors standardize buses and payloads) and ancillary support at a competitive price point due to repetitive procurement. Lean manufacturing can only be achieved through the efficiencies gained by engineering and producing the same items multiple times in the same manner (block acquisition) thereby resulting in significant cost savings due to the attainment of key efficiencies – non-recurring engineering, modern production equipment, and a stable proficient factory floor workforce. Successful lean manufacturing necessitates a sufficient number of same buses and payload systems in production to develop and sustain a "warm" production line, and

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[5] MDA Corporation, MDA Operational Smallsats, Process Description and Case Study (Briefing), Presentation to NGA Advisory Group, April 26, 2007.

[6] Mark Lorell, Michael Kennedy, Julia Lowell, High Levaux, *Cheaper, Faster, Better? Commercial Approaches to Weapon Acquisitions*, RAND Corporation, Santa Monica, 2000, pp. 20-27. MDA Corporation, MDA Operational Smallsats, Process Description and Case Study (Briefing), Presentation to NGA Advisory Group, April 26, 2007.

usually a state-of-the-art facility supported by a trained and knowledgeable workforce whose production proficiency is sustained by steady production lines. Examination of spacecraft productions suggests the number of spacecraft in a “block” to achieve lean manufacturing benefits is at least 2 or 3 and possibly as many as 6, depending on the complexities of the vehicle and support systems. The production of a minimum number of spacecraft before new technology upgrades are inserted into the subsequent “blocks” is a key attribute of lean manufacturing. Attainment of lean manufacturing also requires a modernized facility that supports the modular manufacturing and integration of multiple spacecraft, mission payload integration, system environmental testing in a clean room environment, etc. These state-of-the-art chambers and facilities enable low handling risk and saves time and cost. Redundancy in key capabilities – chamber redundancy, precision tools and handling cranes, etc. – facilitates streamlining the manufacturing process while rapidly assessing performance. Lean manufacturing utilizes earned value management (EVM) to inform managers on how the “production line” is operating and if the production is meeting well defined and understood production output and cost metrics that allow the constant push for efficiency.[7] EVM data also provides an archived knowledge of how much subsequent “blocks” will require in production schedule, costs, and risks. Evaluation of EVM data facilitates process improvements. The use of abbreviated documentation, particularly in the procurement request process contributes to driving down development costs and focusing on affordability.

Organizations who use lean manufacturing can also employ “best commercial practices,” but it is not required. The key to lean manufacturing in “block” spacecraft production is a flexible design that allows new technologies to easily be inserted in a manner that adheres to a rapid production schedule. Therefore, there are intrinsic benefits in leveraging on proven existing technologies with sufficient design flexibility that allow their adoption and integration into the production line. One lean manufacturer argues that after an initial development and launch schedule of approximately 36 months that subsequent spacecraft within a “block” could be produced on a compressed schedule of approximately 6 months.[8] Often spacecraft produced using lean manufacturing techniques are accomplished using a FFP contract.

Commodities. The term commodity in the context of this report means the widespread availability of an item (e.g., buses, sensors, components, sub-systems, software, etc.) produced by vendors, whether they be in the U.S. or overseas, resulting in the product being readily available so that it can be acquired at competitive prices in the needed quantities. The market dynamics to remain competitive fosters technological upgrades of the product while ensuring operational reliability and competitive costing.

[7] Massachusetts Institute of Technology, Lean Acquisition and Manufacturing Techniques, 2004; General Dynamics Advanced Information Systems, Integrated Space Systems (Unclassified Briefing), NRO-NGA Commercial Remote Sensing Panel, April 23, 2007

[8] General Dynamics Advanced Information Systems, Integrated Space Systems (Unclassified Briefing), NRO-NGA Commercial Remote Sensing Panel, April 23, 2007; Lean Aerospace Initiative, Transformation of Air Force Lean Acquisition, 28 January, 2004; Lean Aerospace Initiative, Lean Acquisition Initiatives Research Studies Applicable to Acquisition, November 2004.

ANALYTIC APPROACH AND METHODOLOGY

The panel evaluated data from the U.S. government – Congress, Office of the Director of National Intelligence (ODNI), DOD, NGA, and NRO– commercial spacecraft developers and imagery data providers, as well as, recognized experts in the field of broad area collection and the commercial remote sensing industry. Appendix C contains the list of individuals and organizational representatives interviewed. The panel reviewed policies, formal studies, as well as, contractor and government evaluations on commercial remote sensing capabilities in order to ascertain the technical and business viability of the commercial remote sensing industry and how vendors, suppliers, and CDPs operate in order to develop viable business cases.

The most difficult methodological problem the panel confronted was how to discuss and evaluate risks in such broad topics as requirements and mission. Therefore, at the beginning of the study, the panel asked government to provide an unclassified set of <u>minimally acceptable requirements</u> for remote sensing (See Appendix D) in order to focus the discussions on specific technical and mission needs. The panel requested that the various presenters discuss how they could meet or exceed the minimal acceptable requirements in their proposed business cases. The panel disaggregated the remote sensing mission into three mission layers based on the complexity of functions and technologies employed to meet mission demands to better understand the various business cases and their risks. Several different types of sensors are used in the various mission layers, depending on the mission requirements. The mission layers are defined as follows:

1. **<u>Mission Layer 1</u>** is composed of leading edge advanced technology that produces high-resolution remote sensing capabilities. The U.S. government is the principal owner and operator of U.S. remote sensing capabilities within this layer. These National Technical Means (NTM) capabilities are developed specifically to support national and military tactical mission needs. The systems are challenging to develop because the requirements demand high resolution, a lot of agility, accuracy, and almost real-time access. They collect broad area imagery in a single over flight and provide selected target area revisit capability because they are highly agile. Sophisticated, integrated ground stations support these systems. The NTM satellites weigh about 10,000 pounds or more to meet the high demands for resolution and a long lifespan of about 10 years depending on the orbit and use. Most of these systems are individually developed spacecraft meeting specific but highly demanding requirements given their incorporation of sophisticated technologies, needing complex integration and test. The majority of NTM satellites are unique and subsequent follow-on spacecraft using similar designs are developed to meet even more demanding requirements and use more advanced technology. Hence, the high costs and risks associated with advanced technology and complex integration of these spacecraft limit their development to only a very few highly skilled and experienced vendors working for the U.S. government. A satellite costs upwards of $1 billion, depending on its capabilities. To assure security and reduce risk, the spacecraft in this mission layer are launched only from U.S. government sites using proven launch vehicles developed specifically for the government.

2. **Mission Layer 2** is composed of proven and high technology with mid- to high-level resolution remote sensing capabilities. These systems by their very nature use proven technology components with some new developments focused on single functions to meet specific requirements. They include a mix of commercially-off-the-shelf (COTS) components and subsystems including hardware and software and with mostly well-proven technologies. Integration can be very demanding given the mix of high technology components and COTS, but the technologies are known and can be produced cost-effectively. This layer is comprised of medium satellites that weigh between 5000 and 9000 pounds. They cost, depending on their robustness, between $300 and less than $500 million. The spacecraft may be less agile than those found operating in Mission Layer 1. The lifespan, depending on the size, complexity, and orbit is between 3 to 7 years. Satellites or payloads produced to operate in Mission Layer 2 could be highly amenable to lean manufacturing practices if a "block" acquisition approach was adopted. They can also use "commercial practices" depending on the requirements; they can also often be acquired using FFP contracts. Spacecraft in this mission layer can be launched from both commercial and government sites using a variety of commercial launch vehicles.
3. **Mission Layer 3** uses only well known and proven technology in small satellites that yield low to mid-resolution, approaching that of medium spacecraft. They collect data in narrow swaths under limited conditions – limited cloud cover, accurate focus, etc. Many spacecraft are required to provide the coverage needed for foundational imagery data. They are built almost exclusively using COTS. Quality assurance of COTS parts is critical to the success of these systems. This mission layer is comprised primarily of small satellites whose imaging capabilities have a design life of approximately 3 to 7 years, depending on orbit. These satellites can be acquired for between $50 million and approximately $100 million or $250 million depending on their capacity and the numbers being produced. Most satellite developers in this mission layer utilize "best commercial practices" and lean manufacturing should the buyer want an ongoing production line. Most of these satellites are electro-optical.[9] Most small satellite developers rely exclusively on commercial launch capabilities and extensively buy commodity components on the global market. Integral to their "commercial practices" is extensive testing of any new parts in order to ensure success.

The panel identified several risk categories, many of which are those used by satellite developers and the U.S. government. The risk categories are:

- Requirements and mission
- Technology and integration
- Security

[9] Liam Sarsfield, The Application of Best Practices to Unmanned Spacecraft Development, Documented Briefing, DB-319-NRO, RAND Corporation, Santa Monica, California, 2000. MDA Corporation, MDA Operational Smallsats, Process Description and Case Study, Presentation to NGA Advisory Group, April 26, 2007.

- Policy, industrial base, and markets
- Program and costs

ORGANIZATION OF REPORT

The report contains 3 chapters and 6 appendices. Chapter 2 summarizes the baseline risk assessment and identifies and assesses four (4) viable business cases. Chapter 3 provides the findings and recommendations. The report contains six appendices: Appendix A contains the study Terms of Reference (TOR). Appendix B is a discussion of the commercial vendors and CDPs. Appendix C lists the organizations and individuals interviewed by the panel. Appendix D contains the unclassified minimal mission requirements provided by the U.S. government. Appendix E provides a historical overview of remote sensing and the risk assessment of the baseline capabilities. Finally, appendix F discusses the relevant U.S. legislation and policies on commercial remote sensing.

2. BUSINESS CASES

SUMMARY OF BASELINE RISK ASSESSMENT

Figure 1 summarizes the baseline assessment by risk category. The analysis of the baseline risk assessment provided the foundation for the definition of business cases. Appendix E contains the detailed risk assessment of the current baseline.

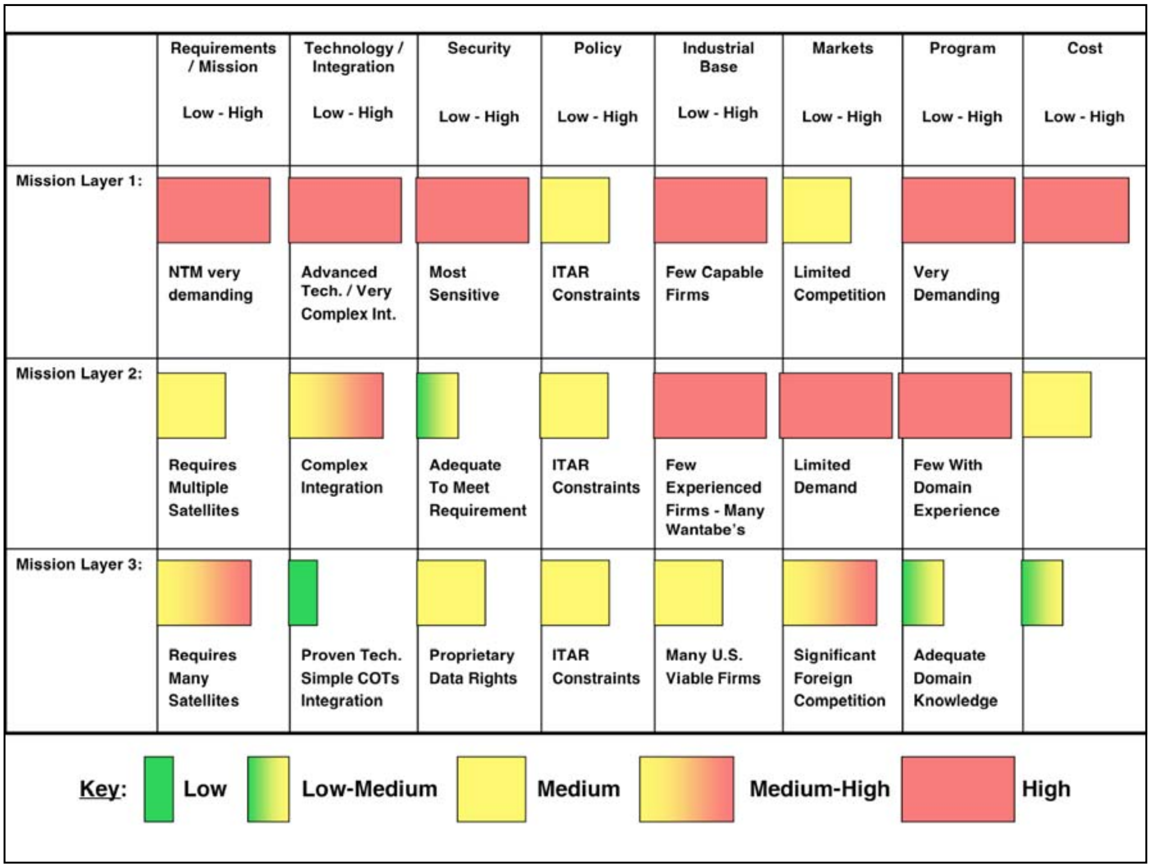

Figure 1: Summary of Baseline Risk Assessment

FINDINGS

The key study findings from the baseline assessment are:

- Legacy requirements continue to drive the characteristics of the U.S. remote sensing enterprise. However, the most demanding requirements – timeliness, image quality, and agility – are the key attributes of Mission Layer 1 and must be satisfied as long as there are national security requirements for high-resolution data.
- The uncertain mission environment necessitates that the US government must have direct access to imagery data at all times and the assurance that it has sufficient capacity to be responsive at all times.
- While much of the imagery data needed is and should be unclassified, the U.S. government must be assured that it obtains required data on demand when it is needed and that security issues can be managed.

- **"Commercial" encompasses more then just the CDPs**; vendors, suppliers, and CDPs that support all three mission layers are commercial companies that develop, buy, and sell remote sensing capabilities in the U.S. and foreign markets. U.S. policy must recognize and address the full spectrum of the commercial remote sensing enterprise.
- Satellite and ground station technologies that operate in Mission Layers 2 and 3 are sufficiently sophisticated to provide needed quality remote sensing capabilities and imagery products. They can be fully integrated into the IMINT architecture.
- The capabilities of U.S. and foreign commercial vendors and suppliers have improved since the mid-1990s. Foreign governments and foreign-government- subsidized commercial vendors and suppliers are increasing their global market share to the detriment of the U.S. remote sensing industrial base. The consolidation of the U.S industrial base and increased global demand has pushed some technology from Mission Layer 1 to Mission Layer 3 resulting in "commoditization." The Mission Layer 2 vendors and suppliers have been significantly impacted by these market-shrinking trends in this mission layer.
- ITAR restrictions and complexities are hindering the health of Mission Layer 2 remote sensing vendors and suppliers by limiting their ability to compete in the global market. Many foreign buyers are not satisfied with the "commodities" technologies from Mission Layer 3; they seek the more sophisticated, proven technologies developed for Mission Layer 2.
- The long-term survivability of the CDPs is in doubt due to the growth and maturing of foreign remote sensing capabilities and the likely saturation of imagery products in the global market beginning around 2010.

BUSINESS CASES

The detailed risk assessment (contained in Appendix E) drove out key attributes of successful commercial business cases. Although the commercial satellite industry and CDPs seek a business relationship with the U.S. government, most representatives argued that in order for a commercial industry-U.S. government partnership to succeed several attributes had to be present to manage their technical and business risks. Four key attributes were identified:

1. <u>Utilization of proven technologies</u>. The vendors, suppliers, and CDPs noted that they could meet almost all the minimal requirements provided by the government through the use of currently developed and proven electro-optical and radar technologies.
2. <u>Mission specialization is key to the success of buying commercial capabilities</u>. Unlike Mission Layer 1 in which multi-purpose sophisticated, advanced technology satellites are developed, commercial vendors prefer less complex single function satellites be developed in order to better manage their technical and business risks.
3. <u>A successful acquisition strategy must have well-defined cost, schedule and performance metrics that facilitates the use of FFP contracts.</u> These attributes, combined with 1 and 2 above, enable commercial developers to

manage technical and business risks. The adoption of an acquisition strategy with multi-year "block" buys, with a sufficient number of systems per block (2-6), will further drive down costs using "lean manufacturing techniques".

4. Government discipline and oversight in the acquisition of the programs is key to a successful commercial industry –U.S. government partnership. The government must adopt and execute consistent "best commercial practices" – definition of core requirements, agreement upfront on the trade spaces in cost, schedule, performance, and management of requirements creep to provide the needed discipline and oversight for successful partnerships.

FOUR BUSINESS CASES

Four viable business cases were developed and evaluated. The business cases concentrate on remote sensing capabilities for Mission Layers 2 and 3, given that these layers provide commercial imagery capabilities and products either through satellite vendors or by the CDPs. Each of the business cases is viable; each focuses on mitigation of the U.S. government's mission and financial risk, and each incorporates the attributes that industry describes as essential to a successful commercial industry-government partnership. The four business cases are:

1. Multi-Year Data Buys - CDPs
2. Satellite Production - Service Level Agreements (SLAs)
3. Multi-Year Satellite Buy – U.S. Government Manages
4. Hybrid of Business Cases 2 and 3

Business Case 1: Multi-Year Data Buys – CDPs (Most Risky)

Description

This is a known business case in that it emulates and continues the NGA NextView model. To mitigate the government's risk it contracts with two CDPs. The U.S. government commits to a predictable, multi-year data purchase of imagery and imagery products at a FFP. This model supports the CDPs and is consistent with a pure commercial model. It is managed the same way that commercial data sales occur. The government manages the data collected based on the contractual arrangement with the CDPs. Each CDP delivers the imagery to NGA at a given price per square kilometer, which varies regionally to account for commercial data regional capacities. The government obtains priority on satellites by paying a higher price for the desired imagery. The price is further adjusted to account for the size of the region being collected and also reflects the image's percent over cloud cover. The archiving pricing is different from the price of new, government-directed tasking.

The government has little or no say in the constellation design for it is up to the CDP to negotiate the most cost-effective and efficient means to obtain the data. The cost to the U.S. government is managed through volume pricing and the costs are spread across the entire customer base. Flexible licensing requirements can be negotiated into the contract up front. The government's agreement to purchase data facilitates the commercial data providers' ability to raise financial support from private financiers. The surge capabilities can be negotiated into the contract as can pre-emptive priority terms. The multi-year data buy approach could also facilitate the use of leading-edge foreign capabilities because the government is buying data over a specified period of time, but not specifying the type or source of satellites that can be used to meet its requirements.

Pros:

- The business case mitigates mission risk by providing some redundancy.
- The CDPs buy spacecraft that meet the specified imagery requirements and use well-proven technologies thereby minimizing technical and business risk to them and the U.S. government.
- Supports the industrial base for Mission Layers 2 and 3, depending on the specific imagery requirements.
- The approach can facilitate the use of leading-edge foreign capabilities unless "buy" American is specified in the contracts.
- CDPs get paid for delivered imagery.
- Large volumes of unclassified imagery can be collected.
- Surge capabilities can be negotiated into the contract as can pre-emptive priority terms.
- Meets the intent of NSPD 23 and PDD 27.
- Integration with NTM collection can be managed through ground stations.
- The U.S. government becoming the "anchor tenant" for the CDPs ensures their viability regardless of changes in the global market.

Cons:

- Does not mitigate any of the key risk drivers for the US government – direct access to data and sufficient architectural robustness and flexibility.
- The CDPs do not like this model because it does not enable them to move to value added products.
- The pricing mechanisms are very complex and hard to manage by both the U.S. government and CDPs since it is based on pixels rather than value added products.
- No mechanism is defined to implement globally efficient collection strategies such as common countdown, where multiple collectors are tasked to collect a given area and keep attempting until the aggregate of all imagery collected by the collectors covers the areas.
- The CDPs are paid for images that meet a given cloud cover specification in its entirety, leading to sub-optimal collection. A CDP may keep collecting imagery data for a given area multiple times, just to get cloud free portions of prior images (either from the same CDP or others) to achieve the requisite coverage.
- Utilization of commercial launch capabilities
- Risk of government deciding that it does not want to continue the partnership with CDPs.

Assessment

This business case is sub-optimum in mitigating the government's overall risk because the CDPs are paid based on the amount of cloud free imagery data they deliver, so each CDP is given incentives to maximize the volume of its collections regardless of whether they are the areas of most interest to the U.S. government. The tasking of each CDP is handled in "stovepipes" because in many instances the U.S. government's collection requirements (by area) are split up between the two CDPs. When a CDP receives an order it proceeds linearly to collect it regardless of whether there is a continuing need because there is no mechanism for feedback to the end user about the status of collection.

The government's objective to keep the CDPs' operations entirely unclassified (because they provide only augmentation to mission) causes further sub-optimization. The transfer of requirements of the national system to the CDPs is handled in a labor-intensive fashion by the U.S. government acting as a go between. Because each CDP only sees the targets it has been assigned there is no opportunity for "bonusing" because a CDP may already be collecting an area that is being tasked by another collector; however, this information is not shared, often resulting in wasted capacity. Because each CDP collects a given area in isolation, it takes longer then it would if multiple collectors could be brought to bear, and it also reduces the opportunities for synoptic coverage (i.e., all imagery is a given area collected within a narrow window).[10] If the government adopted this business case it would focus on "commodity buys" and would be limited to operation at the higher-end of Mission Layer 3.

Business Case 2: Satellite Production - Service Level Agreements (SLAs) (Very risky)

Description

Foundational to this business case are SLAs that define collection or product based services. This business case supports the collection, processing, and delivery of individual scenes. The CDPs support this business case because it ameliorates most of the problems identified in Business Case 1. The SLA specifies the allocated regions of the world to be collected and refreshed on a scheduled basis. It specifies mapping and imagery collection rather than the purchasing of just the pixels. The business transformation is that the SLA's precisely describe the service required, the availability and reliability of the service, and the rewards (or penalties) for meeting the specifications for a single price. Asset management and all of the operational controls move from the government and are placed with the CDPs; thereby redefining the business relationship between the U.S. government from one of pixels to total area collected and products. In this business case, the commercial systems are integrated into the overall IMINT architecture, and therefore, are no longer used as solely augmentation. Like the NTM systems the U.S. government does not worry about pricing, or fixed allocation of requirements to collectors, rather its focus is on maximizing requirements satisfaction across the constellation, given each collector's capacity. The U.S. government has preemptive priority on specific satellites (e.g., the NextView collectors), but usage is reimbursed by burning resource time (minutes) at a higher rate than normal. The data is collected and managed through a highly distributed set of ground stations, some of which can manage classified data. The increased integration between the CDPs and the NTM facilitates "bonusing," common countdown, greater synoptic coverage, and overall greater collection efficiency. The U.S. government adopts procedural protections to prevent needless use of preemption. The satellites are built based on the government's requirements. The U.S. government provides partial funding in exchange for accommodation of its requirements and priorities.

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[10] DigitalGlobe Memorandum, Simplifying the NGA-CDP Relationship, Moving to Service Level Agreements, 6 June 2007. NGA Interviews, 11 June 2007.

Pros

- The CDPs commit to the U.S. government certain tasking capacity from the satellite constellation, broken out by regions (to account for variations in capacity due to pre-existing agreements).
- It integrates the CDPs into the NTM architecture. The approach could also satisfy the war-fighting imagery requirements by providing direct downlinks to theaters.
- Capacity is measured by the satellite resource (time) used to satisfy the tasking. If exhausted in a given period (e.g., month or quarter), this capacity can be increased by mutual agreement between the commercial data provider and the U.S. government.
- Each CDP gives access to the U.S. government to all the data from its archive. The annual price paid by the U.S. government enables it to request, at no additional cost, imagery from a CDP archive.
- The government's satisfaction is ensured because each CDP is evaluated on its effectiveness in satisfying U.S. government requirements using similar scoring to NTM, factoring in requirements satisfaction, delivery times, system availability, etc.
- Meets the intent of NSDP 23 and PDD 27.
- The multi-year SLA contracts would provide stable funding for the CDPs to procure multiple satellites at affordable prices. The satellites would meet over 95 percent of the minimal requirements deck with the exception of those few targets with a NIIRS of 6.5 or greater requirement.
- Performance is tied to incentives for the CDPs.[11]
- The support of the CDPs provides a mechanism by which the U.S. government can ascertain insights into what foreign governments and foreign subsidized companies are doing in the commercial remote sensing arena.

Cons

- Costs and security associated with each CDP operating a SCI-level collection-planning cell with access to the U.S. government's requirements.
- The designation of the CDPs as the "middleman" between the government and acquisition of the satellites, and ultimately, the constellation's tasking and management.
- The viability of the CDPs after 2010 without additional U.S. government funding.
- Absolute assurances that the U.S. government can get data when it needs it, given the uncertainty of the CDP's continuing business viability.
- The flexibility and survivability of the constellation.

Assessment

The business case moves the CDPs from augmenting the NTM to full integration into the national imagery architecture. They provide "value added" that is based on clearly defined performance requirements and licensing agreements that include surge agreements. The CDPs collaborate with the U.S. government in the collection planning, and could, merge the U.S. government's collection requirements with its own to produce

[11] DigitalGlobe Memorandum, Simplifying The NGA-CDP Relationship, Moving To Service Level Agreements, June 6, 2007; GeoEye Memorandum, Service Level Agreements, Report to NGA-NRO Panel on Commercial Remote Sensing, March 15, 2007. General Dynamics, Advanced Information Systems, NRO-NGA Panel on Remote Sensing, GD-AIS Follow Up Discussions, May 24, 2007.

an unclassified collection plan. The CDPs could use this plan to task the constellation. Unclassified and classified data can be handled through a series of distributed ground stations some of which can input into the NTM systems. The distributed ground stations would ensure redundancy. This business case supports the sustainment of the data providers through the integration of the U.S. government's and CDPs' capabilities. The CDPs already use this business case with several non-U.S. government clients.

Business Case 2 is dependent on the government being an "anchor tenant" through the formation of a carefully structured government - CDP partnership. The government assists the CDPs in that it provides partial funding for acquisition of the spacecraft. The SLA defines all aspects of the business relationship including how the data providers will sell the excess data on the global market. The contractual arrangement between the government and commercial data providers is for the purchase of imagery and imagery products; therefore, the procurement would bypass DoD and IC system acquisition requirements. The satellites could be developed and on-orbit within 3 to 5 years from award of contract. Depending on one's perspective the major issue associated with this business case is that the CDPs own the satellite constellations and not the U.S. government. The inherent risk in this business case is whether the CDPs are viable in the mid-term (2012) without U.S. government support given projected global market changes.

Business Case 3: Multi-Satellite Buy – U.S. Government Manages (Minimum risk)

Description

The U.S. government partners with the commercial satellite industry to directly acquire assured imagery through the purchase of satellites. The business case optimizes operational assurance through the U.S. government buying blocks of medium satellites from commercial satellite vendors. In this model, the satellite developer is able to optimize production of a standard space vehicle and the needed support through the acquisition of a "block" of the same highly capable satellites. The business case focuses on using technologies from Mission Layers 2 and 3 – proven complex technologies from Mission Layer 2 and commodity components (where appropriate) from Mission Layer 3. The government contracts for the development of 2 to 4 medium sized on-orbit spacecraft. The satellites are EO (pan and MSI) and can provide centralized tasking, management and command and control, archival and dissemination of specified unclassified and classified data. The ground stations are distributed to handle high amounts of unclassified data; they are modular in design and fit within the existing architecture. The design accommodates the management of classified information when it is deemed necessary. The satellites and ancillary support are acquired on a FFP contract and can be fielded within 3 to 5 years.

Pros

- The government agrees to multi-year serial acquisitions of approximately 2 to 4 satellites per block prior to doing a block upgrade. The approach allows the spacecraft vendors to maintain a warm production base and proficient workforce (allowing use of lean manufacturing techniques) while assuring the government that subsequent blocks will have improved technological and COTS upgrades to sustain the U.S. commercial satellite industrial base particularly for the 2nd and 3rd tier component/sub-system developers and suppliers.

- Using appropriate technologies from Mission Layers 2 and 3 facilitates the adoption of "commercial practices" and could further contribute to lean manufacturing.
- Satellites can be bought in an architectural framework (lines of buses, lines of payloads) that support the "plug and play" construct.
- Critical to ensuring flexibility and survivability.
- The U.S. government has a number of satellites on orbit, some in reserve to hedge against failure, and some in serial production in order to manage mission risk and costs. Contractual agreements would specify termination issues if the government slows its procurement and/or decides to terminate a block.
- The government owns the design to allow options to compete future "blocks."
- With approved exemptions, the acquisition could be accomplished in approximately 3 to 5 years and use FFP contracts.
- The business case assures that the U.S. government will have access to data when it needs it and ensures a seamless insertion plan into the existing architecture.

Cons

- There are concerns about requirements creep and too much government oversight that would inhibit the ability to fully implement "commercial practices, while assuring that the contractor operates within a firm fixed price basis.
- The U.S. government may not be able to sustain a "block" acquisition approach over multiple years in order to achieve "lean manufacturing" cost benefits.
- Given that there are few qualified vendors who have produced medium satellites using FFP contracts, the U.S. government may not be able to assure competition in the contracts.
- This approach challenges the intent of NSPD 23 and PDD 27

Assessment

By drawing technologies from Mission Layers 2 and 3 to develop "blocks" of medium spacecraft that meet all of the minimal requirements, the business case enables the market for the Mission Layers 2 and 3 vendors and suppliers thereby strengthening the U.S. industrial base. If the acquisitions are competed it can facilitate increased competition between Mission Layer 1 and 2 vendors and redefine aspects of the current supply-chain. If acquired in "blocks" the cost per spacecraft drops significantly. Some projections are that costs would run between $1.4 billion and $2 billion depending on the size of the constellation (2-4 satellites), number of ground stations (dispersed modular ground stations are preferred), and the use of the EELV launch vehicles. Additionally, EELV costs will be driven down as more vehicles are launched based on existing United Launch Alliance contracts.

The business case requires that the U.S. government adopt "commercial practices" to achieve maximum cost savings. This includes acquiring the spacecraft and support capabilities on a firm fixed price basis. Success also necessitates that a "block" acquisition strategy be adopted that ultimately leads to lean manufacturing in order to gain further production and cost efficiencies. The key to creating a broader industrial base is to compete the contract; this necessitates drawing vendors and suppliers from Mission Layers 2 and 3. If the government decides that it wants to rely on its current set of contractors then it must ensure that it owns the technical data and drawings so that it might compete future "blocks" thereby ensuring access to the U.S. government markets by qualified Mission Layer 2 and 3 vendors and suppliers.

Business Case 4: Hybrid of Business Cases 2 and 3 (Minimum risk)

Description

The business case combines Business Case 3 and the best aspects of Business Case 2. In this model the U.S. government facilitates the CDPs acquiring two satellites in a "block" buy of four spacecraft, but at a lower product buy. The U.S. government provides up front funding non-recurring engineering costs (NRE) in order to assist CDP participation and to maximize cost benefits and attain lean manufacturing objectives. The SLA defines how the CDP's data will be managed, paid for, and sold on the global market. The hybrid case supports a seamless insertion plan and provides significant redundancy to the overall imagery architecture. Business Case 4 ensures that the U.S. government owns and manages its assets, but integral to the case is a mutually beneficial partnership with both commercial vendors and the CDPs. The approach supports development of competition and the potential entry of new vendors and suppliers into all the mission layers.

Pros

- All the pros of Business Case 2.
- All the pros of Business Case 3.
- Consistent with architectural philosophy.
- Ensures that the U.S. government manages its constellation, but includes access to the CDPs.
- Increases U.S. commercial remote sensing capabilities significantly.
- Spreads costs across the U.S. government and CDPs to foster the attainment of commercial practices and lean manufacturing.
- Increases the business viability of the CDPs in the post 2012 period.
- Meets the intent of NSPD 23 and PDD 27.

Cons

- Could create management issues between NGA and NRO concerning the acquisition of the spacecraft and the management of the CDPs
- Involves another party, the CDPs, in the acquisition process, but this risk is some what mitigated in that the government is responsible for the overall acquisition.
- Requires significant U.S. government discipline in both the acquisition of the spacecraft and the execution of the SLAs
- Requires selection of the CDPs to benefit from this relation with the government.

Assessment

The Hybrid Business Case mitigates significant risk in that it ensures that the U.S. government has access to imagery data when it needs it, but also builds in additional redundancy through incorporation of the CDPs. This business case mitigates the U.S. government's concerns about depending on the CDPs but also hedges risk in that it supports the CDPs long-term access to imagery data. The government purchase of the first couple of systems ensures that it can acquire the spacecraft using "best commercial practices" and possibly attain "lean manufacturing" because it will absorb the up front costs for the CDPs as well as for its own spacecraft. The business case drives down costs for the CDPs but also increases the efficiency of the "buys" in that the spacecraft are acquired in "blocks." The U.S. government acquires all the capabilities – satellites and data products – on a firm fixed price basis. A possible challenge to this model is the U.S. government management of an acquisition that might necessitate involving two government agencies in the acquisition and management of data.

SUMMARY

All the business cases define a way in which the U.S. government can "buy" its imagery capabilities, achieve needed redundancy, improve survivability, surge, and acquire sufficient quantities of unclassified imagery data; all cases are viable to meet the U.S. government's needs in the near- to mid-term. The four (4) proposed business cases include the attributes of successful commercial business cases; however, Business Cases 2 through 4 are more encompassing of the attributes than is Business Case 1. Although Business Case 1 is viable, the operational and costing complexities diminish its overall value as a "way ahead." It would be difficult to manage the actual data collection on using a FFP contract. The CDPs do not like the current model because it inhibits their ability to achieve their desired business goal of providing "value added" products and integration into the existing architecture. The CDPs have abandoned this business case with most of their other clients and moved to Business Case 2. Business Case 1 also does little to mitigate technology, industrial base, integration, and security risks.

Business Cases 2 through 4 include dispersed ground stations capable of handling all security levels. All the industry representatives and CDPs concurred that modularly designed and dispersed ground infrastructure mitigates significant mission risk through redundancy and distribution of data. The modular design enables the government to acquire the capabilities through "commercial practices", and if enough are acquired adoption of lean manufacturing. The distributed ground infrastructure also satisfies USSTRATCOM's issues of providing direct downlinks to the COCOMs to meet their mission needs.

Two issues hinder the adoption of Business Case 2: (1) The business viability of the CDPs beyond 2010, given economic projections that the global imagery market will reach saturation as more foreign-own capabilities come on line. The CDPs acknowledge these challenges and argue that their acquisition of airborne platforms expands their business viability. They also argue that moving into the imagery products market will, at a minimum, lead to retaining their current market size. Independent economic and business forecasts are less optimistic. They argue that further industry consolidation will occur as the market becomes more product saturated, noting that probably by 2010 probably only one CDP will be in business. (2) Regardless of these outcomes, the U.S. government must be assured of getting imagery data when it needs it. It is doubtful that if the U.S. government decides to integrate commercial imagery into its NTM architecture, that it will rely on the CDPs to provide this capability and operate as a middleman between the government data users and the satellite sources.

The business case analyses revealed that the U.S. government could satisfy most of its needs for commercial imagery through the acquisition of satellites developed using the technologies available in Mission Layers 2 and 3. This finding supports the government using "commercial practices" including FFP contracts to acquire the needed capabilities in a timely and cost effective manner. Business Case 3 analysis also revealed that significant pressures on Mission Layer 2's industrial base could be eased through buying sophisticated commercial satellites that incorporate proven complex technologies. However, ITAR regulations that limit technology transfers to foreign governments and companies inhibits Mission Layer 2's market expansion, global competitiveness, and ultimately, economic viability. Allowing vendors to incorporate selected commodities (e.g., components and software) from Mission Layer 3 can further reduce costs to the U.S. government. Business Case 4 – a hybrid of Business Cases 2 and 3-- mitigates the most risk for the U.S. government. It supports the U.S. government owning and managing from end-to-end the development and fielding of the satellites, while incorporating the CDPs' products and contacts with foreign countries. In Business Case 4 a lower product buy may be necessary to accommodate the added satellites.

Figure 2 below summarizes the potential for risk mitigation in each of the business cases.

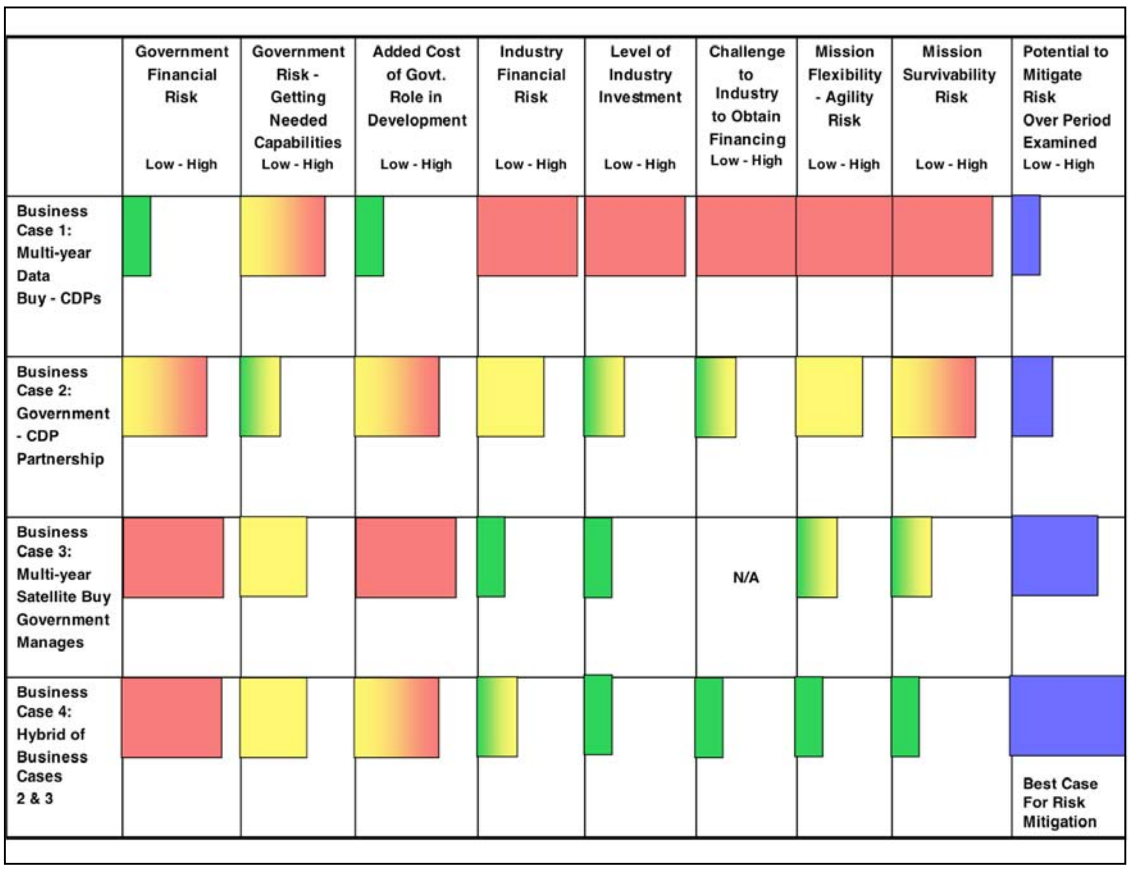

Figure 2: Business Case Assessment

The business case evaluation and assessment demonstrates that the government can competitively procure commercial satellites from vendors with Mission Layers 2 and 3 capabilities that meet the minimal requirements for large amounts of unclassified imagery data. The acquisition strategy should be competitive and designed to procure end-to-end systems including modular, distributed ground infrastructure in blocks to enable lean manufacturing and attain greater cost savings. The government must own the drawings in order to compete subsequent blocks to ensure competition in how best practices and costs.

The panel found that the most threatening challenge to the U.S. government's integration of commercial imagery into its defined architecture is its reluctance and lack of discipline in full adoption of "commercial practices" and following through with acquisition strategies that lead to "lean manufacturing". The key issue is clearly defining the core requirements, trade spaces, and oversight mechanisms up front and then adhering to those rules throughout the acquisition. The acquisition strategy needs to use FFP contracts to ensure that risks are shared and that vendors are held accountable to deliver a product within cost that meets the performance metrics.

3. FINDINGS AND RECOMMENDATIONS

The panel found that the U.S. government could acquire and integrate commercial imagery into the NTM architecture and fulfill most of its minimal mission requirements, mitigate significant mission risk, and attain the capabilities at a reasonable cost to support mission. The panel concurs that the U.S. government must be assured that it gets its data when it is needed; however, it concludes that many of the requirements can be met through the use and integration of commercial capabilities into the existing architecture. In order to ensure maximum mission flexibility and survivability the government needs to acquire multiple satellites from Mission Layers 2 and 3 that support a "plug and play" concept. Components – buses and payloads – can be acquired separately providing the ability to choose payloads "at the last minute". The panel concluded the U.S. government could have commercially acquired satellites and supporting ground infrastructure fielded within 3 to 5 years after contract award if it adopts many of the report's recommendations. The panel's recommended approach necessitates strong government discipline in the management of acquisitions that are based on "best commercial practices" and attainment of lean manufacturing. The recommended approach necessitates a pre-acquisition phase in which core requirements, performance metrics, trade spaces, cost and schedule, and government oversight mechanisms are defined, and then, adhered to throughout the acquisition. The panel acknowledges that there is little potential for developing commercial competition for capabilities in Mission Layer 1. Four (4) general findings emerged from this assessment:

1. The lack of common definitions across the DOD and IC hinders the ability of the government to discuss and decide at an enterprise level on how to proceed concerning the use of commercial imagery, its acquisition, and integration into the existing architecture. The lack of common and approved definitions for such terms as "commercial" imagery, "best commercial practices", "lean manufacturing", and even "requirements" confuse the debate and inhibit the ability of the government to decide on courses of action and their execution. The panel defined "commercial practices" and "lean manufacturing" in order to provide a common tableau for its discussions, findings and recommendations.
2. There is little potential for developing commercial competition for capabilities in Mission Layer 1.
3. In today's world "commercial remote sensing" is broader than the CDPs; all vendors, suppliers, and the CDPs are commercial providers.
4. The U.S. commercial remote sensing market is at risk without significant U.S. government investments in imagery products and satellite development for Mission Layers 2 and 3. The panel's recommendations specifically focus on improving the viability of Mission Layer 2 capabilities, the most seriously threatened, and to a lesser degree on Mission Layer 3.

The panel has eight (8) key specific findings, including identification of the business case that mitigates the most risk. Each finding is supported by a set of recommendations:

1. Define a minimal acceptable set of requirements;

2. Expand the concept of what constitutes “commercial” to reflect market realities;
3. Adopt “best commercial practices”, including FFP contracts;
4. Buy in “blocks” in order to apply “lean manufacturing” techniques as well as flexibility;
5. Business Case 4 provides the most flexibility, agility and survivability, and mitigates the most risk;
6. Ground infrastructure can be managed to meet mission needs,
7. Compete all contracts (as appropriate); and
8. ITAR policies and regulations inhibit the global competitiveness of U.S. vendors.

Finding 1: Define a minimal acceptable set of requirements

Legacy requirements continue to drive all remote sensing enterprise characteristics. The panel agrees that there is a need to satisfy the most demanding requirements – timeliness, image quality, agility, and the ability to share data - using Mission Layer 1 capabilities. There are, however, large numbers of requirements that can be satisfied using proven technologies, COTS, and commodity components from Mission Layers 2 and 3 capabilities. The legacy requirements construct continues to drive technology advancement that limits the trade space for the adoption of available technologies to fill some of the needs. The requirements deck operates as a decision-making paradigm that designates commercial imagery and imagery products as capable of providing only augmentation, for it defines mission needs primarily within the construct of technical improvements for NTM capabilities in Mission Layer 1.

The panel is aware that some Mission Layer 1 requirements have been somewhat disaggregated, but believes an additional assessment and clarification is needed to further delineate among what needs can be fulfilled using new, leading edge technologies (Mission Layer 1) as opposed to what can be acquired from commercial capabilities available in Mission Layers 2 and 3. The assessment should be driven by what constitutes “sufficiency” to fill a capability gap rather than always pushing the technological envelop.

***Recommendation #1**: Reassess the current requirements deck to delineate the requirements among the three mission layers based on the concept of sufficiency. The assessment needs to clarify definitions and institute common community-wide definitions to “get everyone on the same sheet of music.”*

***Recommendation #2**: Ensure that the requirements analysis defines outcomes rather than focus solely on technical improvements to NTM.*

***Recommendation #3**: Determine first if commercial capabilities fill mission gaps and the architectural approach. The approach could ensure that the most complex and demanding mission needs are met using “exquisite” technologies, while most others can be attained commercially.*

Finding 2: Expand the concept of what is “commercial” to reflect market realities

The concept of "commercial" has changed considerably since NSPD 23 and PDD 27 were written in the 1990s. "Commercial" remote sensing encompasses more then just the CDPs; vendors and suppliers in all mission layers are commercial companies that buy and sell in the U.S. and foreign markets. Satellite and ground station technologies have become commercially available on a global scale because the technologies can be produced at a relative low price point thereby facilitating their "commoditization." The U.S. and foreign commercial vendors and suppliers have improved their capabilities since the mid-1990s. The NRO and NGA by directive "buy" all of their capabilities.

***Recommendation #1*: Leverage on the commercially available technologies and the "commoditization" of many components available to support Mission Layers 2 and 3 to acquire needed capabilities.**

***Recommendation #2*: Update NSPD 23 and PDD 27 to reflect the changes in the commercial remote sensing industry. The D/NGA and D/NRO should urge the USD(I) and ODNI to undertake this activity to foster a community-wide dialogue on policy and better utilization of commercial remote sensing capabilities.**

Finding 3: Adopt "best commercial practices," including FFP contracts

The government needs to adopt "best commercial practices," including FFP contracts to the maximum extent possible when acquiring capabilities for Mission Layers 2 and 3. Key to this recommendation is the government incorporating proven and tested components and subsystems in order to attain cost savings. A successful partnership between the U.S. government and commercial industry most often uses "proven" technologies applied to specific mission requirements. Industries appetite for sharing cost and technical risk increases greatly when this attribute is present.

***Recommendation #1*: Develop commercial satellites that are single function in order to manage technical and business risks.**

***Recommendation #2*: Adopt an acquisition strategy using FFP contracts with well-defined requirements and cost, schedule, and performance metrics.**

***Recommendation #3*: Ensure that the government program manager is held accountable for executing the agreed to acquisition strategy through his performance appraisal.**

Finding 4: Buy in "blocks" in order to apply "lean manufacturing" techniques and for flexibility.

Lean manufacturing means that a qualified vendor can develop and procure a standard space vehicle and ancillary support at a competitive price point due to consolidated design and serial procurement. Lean manufacturing can only be achieved through the efficiencies gained by engineering and producing the same items in the same manner (block acquisition) thereby resulting in significant cost savings due to the attainment of key efficiencies – non-recurring engineering, modern production equipment, and a stable, proficient factory workforce and through the employment of a warm base production line. Sufficient numbers of commercial satellites and support systems are needed that the acquisition strategy can achieve the benefits of "lean manufacturing."

<u>Recommendation #1:</u> Ensure that the acquisition strategy for commercial satellite buys incorporates a "block" approach that drives to "lean manufacturing."

<u>Recommendation #2</u>: Develop multi-year procurement strategies and packages whose goal is the creation of a "warm base" production pipeline to develop and sustain a proficient workforce.

<u>Recommendation #3</u>: Ensure that the U.S. government owns the drawings and technical data to ensure that future "blocks" can be competed and that systems are acquired at a competitive FFP.

<u>Finding 5: Business Case 4 mitigates the most government risk and provides the most flexibility.</u>

Business Case 4 is a hybrid that combines Business Case 3 (Multi-Satellite Purchase – U.S. Government Manages) with the best attributes of Business Case 2 (Satellite Production – Service Level Agreement (SLA)). The business case optimizes operational assurance through the U.S. government buying "blocks" of highly capable medium satellites using technologies associated with capabilities in Mission Layers 2 and 3. The government contracts for the development of 2 to 4 medium sized on-orbit spacecraft that can provide centralized tasking, management, and command and control. Costs are spread through incorporation of the CDPs using SLAs as a way to define their roles. The government provides up front funding cover engineering costs that provide an attractive price to the CDPs to acquire satellites. A lower product buy can be defined in order to accommodate the additional imagery data and products provided by the CDPs. The SLA defines how the CDPs' data and products will be managed, paid for, and sold on the global market. Figure 3 summarizes how Business Case 4 mitigates risk.

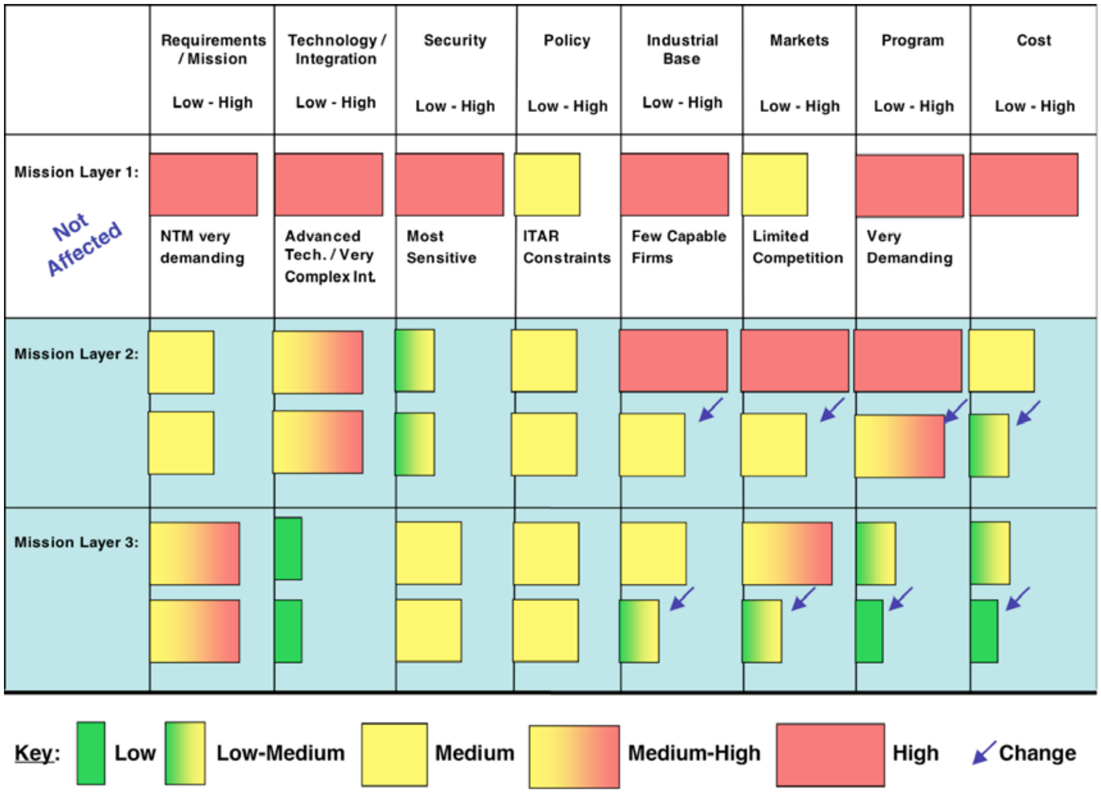

Figure 3: Business Case 4 – Risk Mitigation Summary

Business Case 4 contains all of the attributes ascribed by industry as essential to a successful commercial industry-U.S. government partnership – utilization of proven technologies, mission function specialization, core requirements, well-defined acquisition strategy using FFP contracts, and the government's role and responsibilities well-defined and understood as part of the acquisition strategy.

<u>Recommendation #1</u>: Adopt Business Case 4 because it mitigates the most risk for the U.S. government.

<u>Recommendation #2</u>: Use SLA's to define the CDPs roles and responsibilities. The incorporation of the CDPs allows the government to spread costs across the U.S. government and CDPs, while leverages on the CDPs contacts with foreign governments and foreign-subsidized industries.

<u>Recommendation #3</u>: Compete the contract and subsequent "blocks" in order to foster competition among vendors and suppliers and enhance the market.

<u>Finding 6: Ground infrastructure can be managed to meet mission requirements</u>

The panel found that commercially developed ground stations are capable of handling most of the minimal requirements. Since most of the data is unclassified, security issues are minimal and there are methods by which classified data can be handled. Commercial ground stations can handle direct downlinks to meet the COCOMs tactical mission demands for large volumes of unclassified data.

***Recommendation #1**: Buy modular ground infrastructure consistent with "best commercial practices"* **and architectural philosophy.**

***Recommendation #2:* Buy highly distributed ground infrastructure. Commercial designs can accommodate the GIG B, and have the ability to meet classified demands and surge. The designs can also handle COOP. The panel prefers a distributed ground infrastructure, because it ensures higher survivability. However, it is not necessary to meet mission.**

Finding 7: Compete all contracts (where appropriate)

Open competition will support the expansion of the industrial base and eventually contribute to greater competition across all the mission layers. In order for the government to ensure that it is getting the best value from industry in the acquisition of commercial capabilities it needs to compete all contracts. By focusing structuring the acquisitions as FFP contracts the government can manage significant risks. Some government representatives will argue that most Mission Layer 2 and 3 vendors and suppliers have little or no experience in the development of remote sensing satellites; however, the solicitations can be written in such a way to ascertain reasonable risk on the part of the government and foster partnerships among vendors and suppliers who have the requisite experience that the government needs.

***Recommendation #1:* Compete all contracts when acquiring commercial remote sensing capabilities in order ensure the competition of ideas and get the best value.**

Finding 8: ITAR policies and regulations inhibit the global competitiveness of U.S. vendors

The panel is concerned that ITAR policies and regulations hinder the ability of U.S. vendors and suppliers operating in Mission Layer 2 to compete in the global market. Even if the U.S. government decides to acquire commercial capabilities from Mission Layers 2 and 3, these buys will not make Mission Layer 2 vendors and suppliers economically healthy. Mission Layer 2 vendors and suppliers are the most affected by the ITAR prohibitions since most foreign countries and foreign companies want access to highly capable proven satellite technologies, rather than a lot of "commodity" capabilities available in Mission Layer 3. ITAR limited technology transfers from U.S. companies to foreign governments and companies inhibits Mission Layer 2's market expansion, global competitiveness, and ultimately, economic viability.

The panel is aware that there are two initiatives underway in the U.S. government that are reassessing ITAR policies and regulations. We strongly urge that the findings of this panel inform those activities.

***Recommendation #1**: Restructure ITAR policies and regulations to ensure that Mission Layer 2 vendors and suppliers have access to foreign markets so as they can remain a viable part of the U.S. industrial base.*

***Recommendation #2**: Share the findings and recommendations of this panel with the ongoing reviews assessing current ITAR policies and regulations.*

The panel finds that one of the most significant hurdles to the U.S. government's acquisition and integration of commercial imagery into its defined architecture is its reluctance and lack of discipline in adopting "commercial practices' and following through with acquisition strategies that lead to "lean manufacturing. The acquisition strategies for commercial remote sensing need to use FFP contracts to ensure that risks are shared and that vendors and suppliers are held accountable to deliver a product within costs, schedule and performance metrics. On the other hand, the government needs to adhere to core requirements, well-understood oversight, work with the vendors on resolving the issues defined as trade spaces during the pre-acquisition phase, and compete the programs.

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Appendix A: Terms of Reference

Background

The Intelligence Community (IC) is engaged in the development of the strategy and the definition of the Integrated Collection Architecture (ICA). An important aspect of the ICA is the future role of commercial vendors. In addition, the investments made in the U.S. commercial vendors by the IC, under the Next View Program, are planned to come to fruition in their second-generation collection systems in approximately 2007. These upcoming capabilities necessitate an assessment of their contribution and how they may evolve in the future.

Recently the Office of Director of National Intelligence (ODNI) directed NGA, with its mission partner, NRO, to develop business cases on how to improve IC utilization of commercial remote sensing. In particular, the guidance seeks to evaluate how additional capabilities might be obtained from commercial vendors – domestic and foreign – with particular emphasis given to broad area collection. This guidance also directed NGA and its mission partner to plan and develop infrastructure improvements that utilize commercial data as easily as NTM sources and that enhance the ability to get imagery products and information to users.

The ODNI plans an interim report to Congress by 15 March 2007. However, it has directed the strategic and architectural studies to continue throughout FY 2007.

The review will collect and evaluate relevant information from the government, contractors, interested elements of NGA and the mission partners, Congress, the Office of the Director of National Intelligence, and Department of Defense (DOD) staffs concerning the capabilities and application of commercial remote sensing and its ability to meet the technical and operational requirements of the near-, mid-, and long-term. The Review Team will share its insights and findings with the DD/NGA, D/NGA and mission partner as they emerge.

The Review Team

The Review Team consists of members from NGA's Advisory Group (NAG) and representatives from NGA and NRO:

- Peter Marino (Chairperson)
- Ed McMahon (NAG member)
- Evan Hineman (NAG member)
- Jaan Loger (NGA)
- Frank Calvelli (NRO)
- Leslie Lewis (Assistant to Chairperson)

Issues To Be Reviewed - TOR

The NAG with NGA and NRO advisors will address the following:

1. Review the IC-DOD requirements to ensure that they are clearly articulated and clearly define needed capabilities and their timelines.
2. Assess current approaches NGA and NRO are pursuing for satisfying requirements for near-term (2007-2009), mid-term (2010-2012), and long-term (beyond 2013).

3. Evaluate ground architecture capabilities and plans to improve integration with NTM TPED operations.
4. Identify and review policies and directives that relate to acquiring and using commercial imagery capabilities and products, both domestic and foreign.
5. Define a business case that satisfies NGA and NRO requirements.
6. Define and evaluate alternatives for how the business cases might be achieved. Ensure the alternatives include:
    a. Identify and assess U.S. and foreign developed commercial technologies and services that are currently available or will potentially be developed.
    b. Evaluate commercial industry's capacity to provide needed technologies, including timelines for availability of commercially developed capabilities; and financial viability of U.S. and foreign vendors.
    c. Address in the business case alternatives programmatic and operational attributes, and U.S. policies and directives that might encumber achieving the desired outcomes.
7. Make recommendations on the alternatives.

Review Outputs

1. Interim briefings to senior leadership at NGA and NRO.
2. Final report to senior leadership at NGA and NRO. A draft report will be developed for review and comment prior to the final publication.

Schedule

1. Initiate study in mid-January 2007
2. Complete study in six months, mid-July 2007

APPENDIX B: COMMERCIAL DATA PROVIDERS AND VENDORS

1. Digital Globe

Founded in 1992 as an Earth Imaging and Information Company by Geographic Information System (GIS) and Mapping users, this privately-held company has established itself as the world's most prominent supplier of the highest resolution commercial satellite imagery. Its competitive edge as the market leader comes from the technical superiority of its satellite imaging systems and its high standards of product quality. With its successful launches of its satellites like the QuickBird-2, and scheduled launches of its next-generation of imaging systems like WorldView-1 (mid-2007) and WorldView-2 (anticipated in 2008), explains why Digital Globe has become the current industry leader by delivering the best available commercial images and information.

According to Digital Globe's main website (www.digitalglobe.com), its QuickBird-2 satellite is the only commercial spacecraft able to offer "sub-meter resolution imagery, industry-leading geo-locational accuracy, large on-board data storage, and an imaging footprint 2 to 10 times larger than any other commercial high-resolution satellite." It also states that Digital Globe's soon-to-be launch satellite, WorldView-1, will be recognized as "the most agile satellite ever flown commercially and will have the capability of collecting up to 750,000 sq km per day of half-meter imagery" but, not after the launch of the company's WorldView-2 satellite. The WorldView-2 satellite will have the capability of "collecting up to 975,000 sq km per day of half-meter imagery" and have the ability to perform precise change detection and mapping with the addition of spectral diversity components.

2. GeoEye

As of January 2006, GeoEye is the largest commercial remote sensing company in the world. This newly combined company of ORBIMAGE and Space Imaging is headquartered in Dulles, Virginia with almost three-hundred employees. It currently owns and operates a constellation of three earth imaging satellites: OrbView-2, IKONOS and OrbView-3 and has GeoEye-1 (previously known as OrbView-5) currently under development.

In August 1997, OrbView-2 satellite was launched successfully into orbit and continues to operate and provide low-resolution images with spatial resolution which is ideal for broad area global coverage. Launched in September 1999, IKONOS satellite became the world's first high-resolution commercial remote sensing satellite with a ground resolution of .82 meters and continues to deliver imagery of any location on the Earth's surface. Four years later in June 2003, OrbView-3 satellite was successfully launched and has the capability of providing 1-meter resolution panchromatic and the 4-meter resolution multi-spectral imagery. According to its website (www.geoeye.com), the one-meter imagery "enables the viewing of houses, automobiles and aircrafts, and makes it possible to create highly precise digital maps and three-dimensional fly-through scenes." Also the four-meter imagery multi-spectral imagery "provides color and infrared information to further characterize cities, rural areas and undeveloped land from space." It covers the entire earth with revisits in less than three days.

Overall, these three earth imaging satellites benefit GeoEye's commercial and governmental organization customers around the world. For instance, GeoEye's single biggest customer, National Geospatial-Intelligence Agency (NGA), relies on GeoEye's high-resolution imagery to view, map, measure, monitor, and manage global activities. In other words, these types of satellites allow end users to visualize and understand critical events happening on earth, in the air, and in space.

3. Ball Aerospace & Technologies Corporation

Headquartered in Boulder, Colorado, Ball Aerospace and Technologies Corporation, a subsidiary of Ball Corporation, employs approximately 3,300 talented engineers, scientists, technicians and support staff worldwide. It maintains itself as an industry leader developing and providing advanced aerospace technology products and solutions for government and commercial customers.

Ball Aerospace continues to expand its knowledge and expertise in the fields of remote-sensing, astronomy, optics, laser communications, data exploitation and precision cameras. The combination of its past, present and future work labels this company as a competitive leader within the commercial remote-sensing arena. In 2001, Ball Aerospace was selected by AstroVision International to build its satellites and to integrate on-board instruments for the company's AVSTAR satellite system, which is to provide live, color coverage of the earth. Ball Aerospace's current programs like the QuickBird-2 satellite, became the highest resolution commercial satellite in operation when launched in 2001; and its newly assembled and soon-to-be launched WorldView-1, the next-generation commercial remote sensing satellite, will provide unprecedented high resolution imaging capability for Digital Globe's customers.

4. Space Systems/Loral (SS/L) – a subsidiary of Loral Space & Communications

Headquartered in Palo Alto, California, the company is one of the world's premier designers, manufacturers, and integrators of powerful geostationary satellites and satellite systems. It has manufactured more than 220 satellites, delivering in excess of 1200 years of on-orbit service, which was accomplished through the three-axis-stabilized 1300 series geostationary satellites. These satellites have the capability of delivering a wide range of services from broadcast video distribution to satellite mobile radio and data broadcast to defense communications to air traffic control. Among the list of satellites developed by SS/L is the Spainsat satellite, a government-communication satellite for Hisdesat, which provides dedicated communications for the Spanish Ministry of Defense; as well as the XTAR-EUR for XTAR, a Loral/Hisdesat joint venture for defense satellite communications. Space Systems/Loral was just awarded a contract to build a high-power satellite for SES NEW SKIES. This new satellite will be called NSS-12 and will provide critical communications services for many years for telecommunications providers, broadcasters, corporations, and governments around the world. These are just a few reasons of why SS/L is the world's leading provider of high-power commercial communications satellites.

5. ITT – International Telephone & Telegraph – Space Systems Division

Headquartered in Rochester, N.Y., ITT Corporation -- Space Systems Division (SSD) employs over 2,600 people worldwide with its core mission to provide the best value remote sensing products, services, and key applications to its government and commercial customers.

Among these innovative products and solutions is the creation of its digital camera system that was incorporated on to Space Imaging's (now GeoEye's) IKONOS commercial remote sensing satellite, which allowed the satellite camera to distinguish objects on the ground as small as one meter in size from 400 miles above the Earth. Not to mention, ITT-SSD was selected by General Dynamics C4 Systems (in support of GeoEye and its sponsor NGA) to build the *imaging systems* for both WorldView and GeoEye Satellites, which captures high-resolution images smaller than one-half meter. With these types of products, it allows end users to visualize and understand critical events happening on earth, in the air, and in space. It's essential to know what is going on in the world and the best way to safeguard the nation and its citizens.

6. AstroVision International

Headquartered in Bethesda, Maryland, AstroVision International, a privately-held commercial space company is developing the world's first satellite system which is set to deliver live, continuous, true color, high-definition images of the earth. The first satellite in this five geostationary satellite system (AVSTAR system) was launched in 2003, which provided coverage of the North America region and with subsequent satellite launches which started in mid-2006 will provide global coverage (North America and South America). This satellite constellation will deliver real-time weather and environmental information to its customers. It will capture and track catastrophic events *live* (hurricanes, volcanoes, forest fires, etc) and thus, help end-users be aware of events that are occurring around the world so that they can mitigate any potential risk and prevent any loss.

7. Lockheed Martin

Space Systems Company a division of Lockheed Martin, headquartered in Denver, Colorado, designed and developed the IKONOS satellite, the first commercial satellite with the capability of imaging objects smaller than one meter in diameter. The IKONOS satellite provides high-resolution black and white imagery, as well as multispectral digital pictures, to a multitude of customers. Images from the IKONOS and a variety of other commercial satellites are utilized in civil engineering and construction, land management, agriculture, mining, environmental monitoring, tax assessment, disaster relief, news gathering, infrastructure planning and management, as well as many other areas.

8. Boeing

The Space and Intelligence Systems (S&IS) division of Boeing Corporation in El Segundo, California serves as their headquarters for all intelligence and government/commercial space systems. The S&IS division provides "end-to-end intelligence services such as collection, communication, exploitation, and the creation of fused knowledge products and has competency in large-scale systems integration; Intelligence, Surveillance and Reconnaissance systems; communication systems; network systems; and protection and security systems" (www.boeing.com/defense-space/ic/sis/index.html). S&IS chief customers are the National Security Agency and the National Geospatial-Intelligence Agency.

9. Northrop Grumman

Headquartered in Redondo Beach, CA, Northrup Grumman Space Technology (NGST) specializes in developing end-to-end systems: systems engineering, spacecraft management, ground stations, and space instrument design. Northrup Grumman provides a variety of capabilities to their commercial and government customers. For example, the Geostationary Operational Environmental Satellite (GOES-R) provides imagery of the environment (weather) and allows end-users to monitor climate and warn citizens of any potential danger (i.e. Hurricane Katrina,etc). NGST is also developing the Milstar payloads, which are a series of advanced satellites linked to mobile ground terminals to provide assured command and control to U.S. forces worldwide.

10. Raytheon

Raytheon Intelligence and Information Systems, headquartered in Garland, Texas, has partnered with Ball Aerospace to produce the *Hudhud* satellite program, which offers high performance reconnaissance/surveillance capabilities, full integration with customer security operations, high reliability, maintainability and availability for its customers. The program offers two satellites the Hudhud-1 EO and the Hudhud-2 SAR. Raytheon offers a slightly different approach to commercial satellite procurement in that the customer owns the system once the satellite is delivered on-orbit; they have the ability to have full integration with classified systems and they offer commercial level documentation and customer reviews, as well as, commercial level satellite testing.

11. General Dynamics

Advanced Information Systems, a division of General Dynamics, headquartered in northern Virginia designs, develops, manufactures, and integrates information solutions within five key areas for the defense, intelligence, space and homeland security communities. AIS provides solutions for maritime combat systems, integrated space systems, actionable intelligence, surveillance and reconnaissance, information assurance and homeland security. A General Dynamics recently acquired, Spectrum Astro Space Systems, headquartered in Gilbert, Arizona, with the most advanced satellite manufacturing facility in the U.S. and offers engineering and management processes ranging from space electronics manufacturing to the design, manufacture, integration, test and on-orbit support of high performance space systems for both the commercial sector and the United States Government.

12. Oribtal Sciences Corporation

Founded in 1982 and headquartered in Dulles, Virginia, Orbital Sciences Corporation has since become the leading provider of small to medium class satellites. A little over one third of their revenue is generated from contracts with the Department of Defense and the Intelligence Community, 31% from commercial and international satellite operators, and the remainder is from contacts with NASA, other civilian agencies, and universities.

APPENDIX C: INTERVIEWS

EXTERNAL

Name	Date Interviewed	Organization / Office
Bastian, Joseph	9-Mar-07	Ball Aerospace
Berkowitz, Marc	9-Mar-07	Lockheed Martin
Behling, Tom	14-May-07	Department of Defense
Blersch, Don	12-Apr-07	ODNI
Brehany, Chris	12-Apr-07	ODNI/SAE
Cahill, Tim	9-Mar-07	Lockheed Martin
Cartwright, General James	17-May-07	STRATCOM
Cronin, Hilary	3-May-07	Open Source
Crumley, James	24-May-07	General Dynamics
Dodd, Joseph	9-Mar-07	Northrup Grumman
Doyle, Fred	9-Mar-07	Ball Aerospace
Driscoll, Gerry	24-May-07	ITT
Fitzgerald, Dennis	24-May-07	NRO
Gernhardt, Gary	24-Mar-07	ITT
Goddeke, Dale	8-Mar-07	Raytheon Corporation
Grant, Jeffrey	8-Mar-07	Northrup Grumman
Hall, Doug	15-Mar-07	MDA
Hanke, John	24-May-07	Google
Harris, Jeffrey	9-Mar-07	Lockheed Martin
Holz, Brian	9-Mar-07	Ball Aerospace
Houck, Jody	12-Apr-07	House Permanent Select Committee on Intelligence
Hsiung, Shang	23-Apr-07	Raytheon Corporation
Huybrechts, Steven		OSD/NII
Jacobvits, Aaron	12-Apr-07	Aerospace
Jilla, Cyrus	12-Apr-07	NRO/AS&T
Jones, Michael	24-May-07	Google
Keller,man, Anne	8-Mar-07	Raytheon Corporation
Klinger, Gil	23-Feb-07	ODNI
Knusten, Brian	8-Mar-07	Boeing
Larson, Wade	15-Mar-07	MDA
Lederman, David	24-May-07	Google
Lewis, Lindon	9-Mar-07	Ball Aerospace
Ludtke, Cary	9-Mar-07	Ball Aerospace
Marchetto, Carl	24-May-07	Orbital
McFarland, Scott	12-Apr-07	Boeing
McHane, Edward	23-Apr-07	Aerospace
Mitchell, Roger	15-Mar-07	MDA
Morrissey, Arthur	9-Mar-07	Ball Aerospace

Penn, Brian	12-Apr-07	Boeing
Pollard, Matt	12-Apr-07	Senate Select Committee on Intelligence
O'Connell, Matthew	15-Mar-07	GeoEye
Oldham, Stephen	15-Mar-07	MDA
Owen, Ray	4/23/2007 and 5/24/07	Spectrum Astro / General Dynamics
Rae, Doug	15-Mar-07	MDA
Scott, Walter	8-Mar-07	Digital Globe
Shingledecker, David	23-Apr-07	Spectrum Astro / General Dynamics
Sienicki, Dawn	8-Mar-07	Digital Globe
Smith, Jill	8-Mar-07	Digital Globe
Speckert, Glen	24-May-07	Google
Spruill, Yancey	8-Mar-07	Digital Globe
Stopher, John	24-May-07	Omega Inc./GD
Thomas, Darrell	24-May-07	General Dynamics
Von Thayer, Lewis	4/23/2007 and 5/24/07	Spectrum Astro / General Dynamics
Westbay, Joseph	24-May-07	ITT
Wills, Ann	12-Apr-07	ODNI/SAE
Wolf, Richard	24-May-07	Orbital
Yeakel, Glenn	4/23/2007 and 5/24/07	Spectrum Astro / General Dynamics

APPENDIX D: MINIMAL REQUIREMENTS

The ability of commercial imagery to support the National Geospatial Intelligence Agency's (NGA) diverse mission needs is being evaluated by the Commercial Remote Sensing Panel. The following is a broadly stated list of fundamental capability needs to a common reference point for contractor/vendor presentations to the panel on their technical capabilities.

The needs are divided into three parts: (1) Area Needs, (2) Point Needs, and (3) Additional Considerations. Again these broadly stated needs provide a framework for discussing your organization's technical capacity.

1. AREA

1. Foundation Data: Entire earth (~ 150M sq km) – refreshed every 2 years (Electro optical)
    - Low Resolution – 10 - 30 meter GSD Multi-spectral, monoscopic
    - Medium Resolution – 3 - 5 meter GSD, Multi-spectral monoscopic
    - High Resolution – 0.5 meter GSD, panchromatic, monoscopic " best" geopositioning accuracy
    - Bulk ordering and delivery

2. Elevation Data
    - 10m post-spacing world wide every 10 years
    - 3 - 5 meter post-spacing regionally (~ 250,000 sq km) within 120 days of request. Up to 10 regions/year.
    - 1 meter post-spacing focused areas (~2,500 sq km) within 120 days of request. Up to 25 areas/year
    - Bulk ordering and delivery

3. Feature Data Production Support
    - Stereo imagery, panchromic, .25 -.5 meter GSD, regionally (up to 250,000 sq km) within 120 days of request. Up to 25 regions/year.
    - Multispectral imagery, 3 - 5 meter, contemporaneous with panchromic stereo imagery
    - "Best" geopositioning accuracy
    - Bulk ordering and delivery

4. Synoptic/Contiguous Area Coverage
    - 10,000 - 70,000 sq km/day, .5-1m, panchromatic with contemporaneous 3 - 5 meter multispectral imagery, 5-30 day duration
    - As many as three simultaneous events, globally dispersed
    - Up to 25 events per year

2. POINT

1. Global Coverage

   - 500 - 2000 points/day, 5 km x 5 km, .25 - .5 meter GSD, panchromatic
   - Contemporaneous multi-spectral 3 - 5 meter beneficial
   - Distributed through the world
   - Sensitive bulk ordering and delivery

2. Focus Region Coverage

   - 25 - 100 points/day, 5 km x 5 km, .25 - .5 meter GSD, panchromatic, within a 25,000 sq km region
   - Contemporaneous multi-spectral 3 - 5 meter beneficial
   - 1 - 5 regions distributed throughout the world
   - 5 - 30 day duration of event coverage
   - Sensitive priority ordering and expedited delivery

3. Urgent Coverage

   - 10 - 25 point/day, 5 km x 5 km, .25 - .5 meter GSD, panchromatic, within a 25,000 sq km region
   - Contemporaneous multispectral 3 – 5 meter beneficial
   - 1 - 5 regions distributed throughout the world
   - 5 - 30 day duration of event coverage
   - Sensitive and priority ordering and expedited delivery

3. ADDITIONAL CONSIDERATIONS

1. Assurance of access
2. Assurance of longevity/continuity of sources
3. Proprietary needs
4. Data Licensing
5. Surge Capacity

Appendix E: Historical Overview and Baseline Assessment

Historical Overview

Space-based imagery has been available since the mid-1960s beginning with U.S.' need for photographic data that was not vulnerable to ground and airborne attacks and could operate relatively free of constraints. The mission focused on the photographing of static areas of interest. The U.S. was the leader in satellite development and use between the late 1960s and mid-1980s. U.S. government-industry partnerships developed satellite systems that pushed the technological envelop in imagery and launch capabilities; the technologies were government proprietary. Second and third tier providers manufactured the needed components – lens, buses, electronics, etc. – through contracts with the trusted development contractors or the government. The government-industry partnerships were structured to push the technological capabilities of the satellite systems because the requirements were defined to push technical performance on a satellite-by-satellite basis; therefore, no two payloads were the same. The payload/sensor technology drove all other aspects of the system – spacecraft, launch, and ground segments. Space-based remote sensing consists of four inter-related elements, all of which need to successfully operate in order to achieve mission success: (1) Payload/Sensors[12], (2) Spacecraft, (3) Launch, and (4) Ground Segments.

A paradigm shift occurred in the mid-1990s with the collapse of the Soviet Union. The mission moved from counting static things to one of persistence. Concurrently, satellite technologies became commercially available on a global scale because the technologies could be produced at a relative low price point thereby facilitating their "commoditization." Although the capabilities were relatively coarse when compared to those developed by and for the U.S. government, many U.S.- and foreign-owned commercial companies saw a huge market potential to provide unclassified imagery data to a global market. The U.S. industry also believed a large and viable commercial market would emerge. By the early 2000s the markets had not materialized, and the commercial vendors and imagery providers never attained the numbers of customers or revenue identified in the forecasts.[13] Nonetheless, several U.S. satellite companies did emerge

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[12] EO sensors provide black-and-white pictures and are the foundation of most commercial remote sensor companies. Current EO sensors can have a resolution of ½ meter GSD or coarser; the technologies are well understood and generally present a low technology risk. Optical systems can be divided into two broad resolution categories: Very high provides between .41 to 1m GSD resolution; high resolution is between 1.8 and 2.5m GSD. High-medium resolution is between 4 to 8m GSD with medium between 10 and 20 m GSD, and low-medium is between 30 to 56 m GSD. They all have differing coverage capabilities with very high resolution swaths covering between 8 to 28 kilometers, while nearly all medium swaths are between 60 and 180 km. SAR sensors utilize a mature technology that produces data with resolutions between approximately 5m and 30 m GSD or coarser. Hyper-spectral sensor technology is well known and derived from legacy ground and airborne hyper-spectral sensors. Multi-spectral sensors have also entered into the commercial marketplace. Recently, there has been an increased use of light detection and ranging sensors (LIDAR) in the commercial imagery market. W.E. Stoney, *ASPRS Guide to Land Imaging Satellites, Key Trends and Challenges in the Global Marketplace, 2006, p. 3.*

[13] The business cases developed for a viable commercial imagery and telecommunications market drove several key U.S. government decisions concerning launch capabilities. One critical area was U.S. launch; U.S. Air Force decided to consolidate and modernize U.S. government's launch capabilities through the commercial acquisition of the Evolved Extended Launch Vehicle (EELV). The EELV could be acquired at

during this period – DigitalGlobe, Space Imaging, and Orbital Imaging Group.[14] The entire commercial satellite-manufacturing sector in 2004 had revenues of approximately $10.2 billion; single satellite development costs including launch, currently range between $200 and $600 million depending on system complexity and the size of the payload.

By the early 2000s several foreign governments had initiated satellite and launch development as knowledge of technologies proliferated. Many of the nations now tie their national pride, geo-political security, and global stature to the development of space-based capabilities. Several of these nations also subsidize nationally owned companies to sell end-to-end space capabilities to other nations at a price point substantially below their development costs in order to be globally competitive. This is done to foster global recognition and to influence potential allies. Figures E-1 and E-2 show the current list of nations who have developed or are developing space-based imagery capabilities.

Country	Capability Source		Attributes
	Indigenous	Foreign Purchase	
Algeria	×	×	-Developing own capabilities -Government-industry development -Built and maintained by EADS
Brazil	×	×	- Developing capabilities with China
Canada	×		-Government-industry development -Rely on foreign capabilities
Chile		×	
China	× End-to-End Capability	×	-Developing own capabilities -Government-subsidized commercial sales to foreign nations -Utilize foreign-developed capabilities to augment
France	× End-to-End Capability	×	-Developing own capabilities -Government-subsidized global provider -Utilize foreign-developed capabilities to augment
Germany	×	×	-Government-subsidized global provider -Utilize foreign-developed capabilities -Partnerships with EU
India	× End-to-End Capability	×	-Developing own capabilities -Utilize foreign-developed capabilities

Figure E-1: Foreign Nations Involved In Satellite Development

a relatively low cost through a government-industry partnership in which to government would be an anchor tenant providing upfront funding along with Lockheed Martin Corporation and Boeing Corporation. The acquisition strategy was that most EELV costs would be reimbursed through the high commercial usage and the government would guarantee and pay for a percentage launch capability to support its national security needs. The concept failed when the commercial market failed to materialize. See: *National Security Space Launch Report, The Congressionally Mandated National Security Space Launch Requirements Panel*, RAND-MG-503-OSD, Santa Monica, CA, 2006.

The U.S. government has long debated utilization of commercially developed satellite capabilities, particularly in the area of imagery, in the performance of its National Technical Means (NTM) and DOD missions. The NTM mission has traditionally focused on gathering imagery on geo-political and strategic areas determined to be key to U.S. national security while the DOD mission has concentrated on more real time data gathering for the war-fighting mission. Since 2001, the differentiation between the NTM and DOD missions has narrowed. Now, key to both is the ability of the United States to systemically gather global geospatial and imagery data, combined with persistent surveillance over key high value targets and the ability to target and revisit critical areas of interest in almost real time. These high mission demands have increased requirements for geospatial and imagery data and suggest that both tailored and commercial assets need to be integrated in a manner that provides maximum coverage. The recent successful Chinese anti-satellite test in January 2007 further necessitates that the U.S. government manage mission risk by ensuring its ability to operate at will to collect needed imagery and geospatial information. One option is to increase the use of commercial satellites to ensure redundancy at a relatively low price point.

Country	Capability Source		Attributes
	Indigenous	Foreign Purchase	
Israel	✕ End-to-End Capability	✕	-Developing own capabilities -Government-subsidized global provider -Utilize foreign-developed capabilities to augment
Italy	✕	✕	-Developing capability with France -Government-subsidized commercial sales to foreign nations
Japan	✕	✕	-Developing own capabilities -Government-subsidized commercial sales to foreign nations -Utilize foreign-developed capabilities to augment
Korea	✕ End-to-End Capability	✕	-Developing own capabilities -Government-subsidized commercial sales to foreign nations -Utilize foreign-developed capabilities to augment
Singapore	✕		-Developing own capabilities -Utilize foreign-developed capabilities to augment
Spain		✕	-Built by SpaceSystems/Loral (SS/L) -Operated by Spain's HISDESAT for the Spanish Defense Ministry
Thailand	✕	✕	-Developing own capabilities with France (EADS Astrium)

Figure E-2: Foreign Nations Involved In Satellite Development

Since 1958, the U.S. government has passed legislation and enacted policies that define how space capabilities will be used and managed (See Appendix F), many of which have addressed commercial products. The 1988 Presidential Decision on National Space Policy (NSP) supported the utilization of commercially developed space products and services; it directed the government to "purchase commercially available space goods and services to the fullest extent feasible." Subsequent policies and acts underlined support for commercial entities providing products and value-added services in support of U.S. space capabilities. The Land Remote Sensing Policy Act of 1992 defined the legal boundaries for U.S. private firms wanting to own and operate remote sensing satellite systems. In January 1993 the Bush Administration issued the first license authorizing a U.S. commercial imaging satellite that could collect 3-meter resolution imagery. In 1994, the Clinton Administration wrote Presidental Decision Directive 23 (PDD-23) outlining the U.S. government's guidelines for granting operating licenses to American companies interested in commercial remote sensing satellites; the policy enabled U.S. firms to get permission for relatively high-resolution imaging satellites for both domestic and foreign sales. The National Oceanic and Atmospheric Administration (NOAA) was made responsible for the licensing of U.S. commercial remote sensing satellites for foreign sales.[15] However, none of the policies or directives specify desired outcomes (metrics) for utilization of commercial products, rather they concentrate on identifying conditions for granting operating licenses, legal obligations of commercial firms that receive government licenses, and the bureaucracy responsible for overseeing commercial imaging activities.[16]

Global competition, combined with the International Traffic in Arms Regulations (ITAR), has affected the U.S. commercial satellite-manufacturing sector as a whole. In 2004, the U.S. commercial satellite-manufacturing field had declined to about 50 percent of the market, down from 83 percent in 1999. The market decline is attributable to both the cumbersome U.S. export policies, ITAR, as well as the increase in foreign suppliers.

Several government-sponsored studies in the 1990s and early 2000s supported greater use of commercially developed satellites and imagery. The memorandum announcing the establishment of the National Imagery and Mapping Agency (NIMA) noted that one of its key thrusts is "to promote the use of commercial solutions."[17] A 1996 evaluation of the proposed National Imagery and Mapping Agency (NIMA) endorsed the greater use of imaging satellites and urged the U.S. government to foster U.S. companies being allowed to move to higher resolution as required by the competition and demanded by the marketplace.[18] The 2000 NIMA Commission Report endorsed this finding and went on to note that one of the key factors influencing the greater use of commercial imagery is that "NIMA has been a captive customer for satellite imagery provided by the National Reconnaissance Office (NRO)", whose primary function is to build and operate highly technical, tailored satellites.[19] In November 2002, the Vice Chairman of the Joint Chiefs of Staff issued a memorandum

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[15] Kevin O'Connell, John C. Baker, Beth E. Lachman, Steven Berner, David Frelinger, Kim Gavin, U.S. Commercial Remote Sensing Satellite Industry: An Analysis of Risk, RAND MR-1469-DOC, Santa Monica, Ca. 2001, p. 19.

[16] 10-Year Remote Sensing Industry Forecast, Phase IV-Study Documentation, The American Society of Photogrammetry and Remote Sensing, September 2006;

[17] U.S. Department of Defense, National Imagery and Mapping Agency Established, News Release No. 563-96, October 1, 1996

[18] The Information Edge, Imagery Intelligence and GeoSpatial Information in an Evolving National Security Environment, Report of the Independent Commission on the National Imagery and Mapping Agency (NIMA) (NIMA Commission), December 2000, Final Report, p. 15

[19] NIMA Commission, p.15.

stating that a balance "…should be maintained between satisfying the bulk of information needs that can be satisfied by spectral remote sensing and those high payoff information needs."[20]

Since 2002, NGA initiated the use of commercial imagery as an augmentation to national assets with the award of ClearView (2002), NextView (2003), and NextView2 (2004) contracts. Today commercial imagery purchases comprise only approximately 0.5 percent of NGA's overall budget. NGA investment dollars have been relatively constant across NGA's program with a minor decrease anticipated in the Future Year (FY) 2009–2013 program. NGA buys a spectrum of satellites with varying resolutions and capabilities. ClearView (initiated in 2002) provides the government imagery and imagery services from three domestic satellites at 1 meter ground sample distance (GSD) spatial resolution. NextView 1 and II are the follow-on contracts for imagery and imagery services from current and next generation domestic satellites; they provide up to .5 meter GSD resolution. The spectral response bands include both visible and near infrared light. The commercial satellite systems are designed to be operational in 2007 and are being built by DigitalGlobe and GeoEye through government assured funding.

The GeoEye 1 (NextView 1) sensor will collect imagery at a resolution of 0.41 meter GSD and multi-spectral imagery at 1.64 meter GSD at nadir. Worldview I (NextView II) will be launched in 2007/2008 and will acquire imagery and imagery-derived products at a lower price point through broad licensing agreements (one license for all official business) with faster delivery times and a nominal delivery of panchromatic imagery per year, per satellite. These capabilities allow increases in daily area collection of over 100,000 square km monoscopic and 40,000 square km stereoscopic imagery and 150 monoscopic/stereoscopic points.[21] The Worldview system includes shorter tasking timelines, more efficient imagery processing systems, and multi-satellite collection planning. It facilitates an expanded network of remote ground terminals and added spectral diversity to perform precision change detection and mapping.[22] This approach is considered a pure commercial buy for imagery and imagery products. These capabilities are currently costing the U.S. government approximately about $300 million per year with the government receiving capacity on the equivalent of one satellite plus one surge.

NGA also purchases imagery and imagery products from each of the following platforms: High resolution - GeoEye – IKONOS, GeoEye – Orbview 3, and DigitalGlobe – Quickbird. The medium resolution capabilities include: ERS –Spot 4 and 5, Indian Remote Sensing, Canadian Space Agency Radarsat, and NASA – Landsat 7 and Earth Observing.

The DOD continues to be frustrated by the inability to get direct theater down links (TDL) to the regional combatant commanders (COCOMs) who view current unclassified imagery information and products as critical to mission execution. The DOD's demand for persistent surveillance also continues to grow. U.S. Strategic

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[20] Memorandum for the Assistant Secretary of Defense For Command, Control, Communications and Intelligence, JROCM 190-02, 14 November 2002.

[21] Peter Paquette, National GeoSpatial-Intelligence Agency, Commercial Remote Sensing, NGA Briefing 07-154.

[22] Peter Paquette, National GeoSpatial-Intelligence Agency, Commercial Remote Sensing, NGA Briefing 07-154.

Command (USSTRATCOM) argues that utilization of tailored and commercial capabilities are essential to the DOD performing its global defense missions.[23] Many of these needs are for unclassified imagery data.

In January 2006, the Office of the Director of National Intelligence (ODNI) began the Integrated Collection Architecture (ICA) Study that was designed to assess future Intelligence Community (IC) collection needs, including the future role of commercial imagery vendors and data providers. The Phase 1 report was completed in early 2007 and gave only a slight nod to increased utilization of commercial remote sensing. In January 2007, Congress requested that the initial ICA Phase 2 work address how the Intelligence Community (IC) could increase its use of commercial remote sensing as part of a broader look at U.S. remote sensor capabilities. An interim report was to be completed by ODNI by March 2007 in order to influence the FY2008 budget and FY2009 program. The study's early findings (published in April 2007) determined that for the near- to mid-term, the U.S. government should continue its current course of relying primarily on NTM satellites while using commercial capabilities as augmentation. In the future, the government needs to assess how it can increase the integration of commercial imagery into the overall NTM architecture. The Congress was not satisfied with the study's recommendations, arguing that the ODNI assessment supported the current acquisition strategy for the near- to mid-term but lacked identification of alternatives for how the U.S. government might increase its utilization of commercial capabilities.

COMMERICAL VENDORS, SUPPLIERS, AND COMMERCIAL DATA PROVIDERS

The commercial remote sensing industry consists of: (1) vendors (satellite developers), (2) suppliers – lens, buses, software, components, etc., and (3) the commercial data providers (CDPs) or companies that sell imagery or imagery products. In the U.S., the commercial satellite vendors are comprised of approximately 6 to 8 large and medium size companies – Lockheed-Martin, Boeing, General Dynamics, Ball Aerospace, Raytheon Corporation, and Orbital Imaging – who are seeking to create financially viable businesses through the commercial development of small and medium satellites for the global market (See Appendix B). Several of the companies seek to develop and sell end-to-end systems, while others concentrate solely on the development of payloads and spacecraft. The key to the success of the commercial vendors is the development, successful launch, and initial operation of a reliable capability that meets a client's requirements at an acceptable price. Most satellite contracts are firm-fixed price with final payment due when the satellite is in orbit and operational for a specified initial period of time. Most developers insure the satellites against launch and on-orbit failure for a short period of time following launch. The vendors use both U.S. and foreign-owned companies to acquired needed parts, and commercial companies or foreign governments to launch their satellites at a competitive price.

There are two U.S. imagery data providers – DigitalGlobe and GeoEye – who compete in the global market to provide imagery data to governments for civil use and national security. They also are the key providers to private companies such as Google and Microsoft in support of their "paint the earth" imagery data needs. Sometimes the

[23] General James Cartwright (USMC), Commander , U.S. STRATEGIC COMMAND, May 17, 2007.

data provider owns a satellite(s) and negotiates rights to either lease part of the satellite to a customer or to provide specific imagery data at designated times to a customer. They often rely on Service Level Agreements (SLAs) that specify the amount and timeliness of the data to be provided and agreements on how and when the imagery data can be sold on the open market. Key to this business arrangement is the ability of the data provider to sell imagery data after a specified period of time on the second-hand-market. Google and Microsoft obtain most of their foundational data through purchasing imagery on the second-hand market from the data providers. In order for this business arrangement to succeed the data provider must have a sufficient number of satellites to meet customer needs and a large market in which to sell the imagery data. If the data provider needs to acquire a satellite in order to meet its customer's requirements, it almost always necessitates some upfront funding from the customer to initiate the building of the satellite(s) and/or guarantees of incremental funding as the satellite is being built. Once the satellite is on orbit, the data provider ensures that the imagery data or products are delivered to the customer according to the contractual agreements. The data providers are also acquiring aerial and airborne imagery capabilities to augment their satellites in order to provide a broader array of remote sensing products at the lowest price point. Another challenge for the data providers is the evolution of the market from imagery data to geospatial products.

The key challenge for the commercial remote sensing satellite vendors, suppliers, and CDPs is to devise viable business plans that are attractive to both the U.S. government and commercial imagery users whether in the U.S. or foreign owned. Second, the U.S. government must demonstrate a willingness to use commercial imagery in such volume that these businesses become an integral element of the U.S. national security. Currently, the U.S. government is the major source of funding for the data providers; it funds approximately 45 to 48 percent of their business through various business arrangements. Commercial vendors and internal financing make up the other 52 to 55 percent of their funding stream. There are significant ambiguities about the business viability of the commercial remote sensor developers and data providers over the mid- (2010-2012) and long-term (beyond 2013). Integral to this argument is who and what constitutes the U.S. commercial satellite industrial base. Uncertainty has increased in the U.S. commercial remote sensing satellite business because of the increase in foreign development and foreign-owned companies.[24]

The failure of the business forecasts of the 1990s to meet expectations combined with the potential for suppressed demand through foreign countries developing their own programs makes the future quite uncertain. Therefore, the financial markets are uncertain and skeptical to provide financing to many vendors and data providers. There is also significant uncertainty about the U.S. government and other customers wanting more imagery data and products. In addition, companies must factor in the cost of capital, insurance, and contract cancellation potential into program costs from the outset.[25]

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[24] O'Connell and al, *U.S. Commercial Remote Sensing*, p. 5.

[25] Steve Oldham, "New Approaches To Commercial Earth Observation, Presentation to NGA Advisory Group, MDA, Inc., March 15, 2007 (Unclassified)

BASELINE- RISK ASSESSMENT

A risk assessment was performed in order to ascertain baseline knowledge of mission gaps, what commercial capabilities were available to close them, and challenges that the business cases had to address. Figure E-3 is a notional depiction of the overlapping mission layers that were used in the assessment. The size of the mission layers (as depicted in the figure) shows the notional dimensions of where capabilities would be expected to operate and is not a depiction of the actual capabilities.

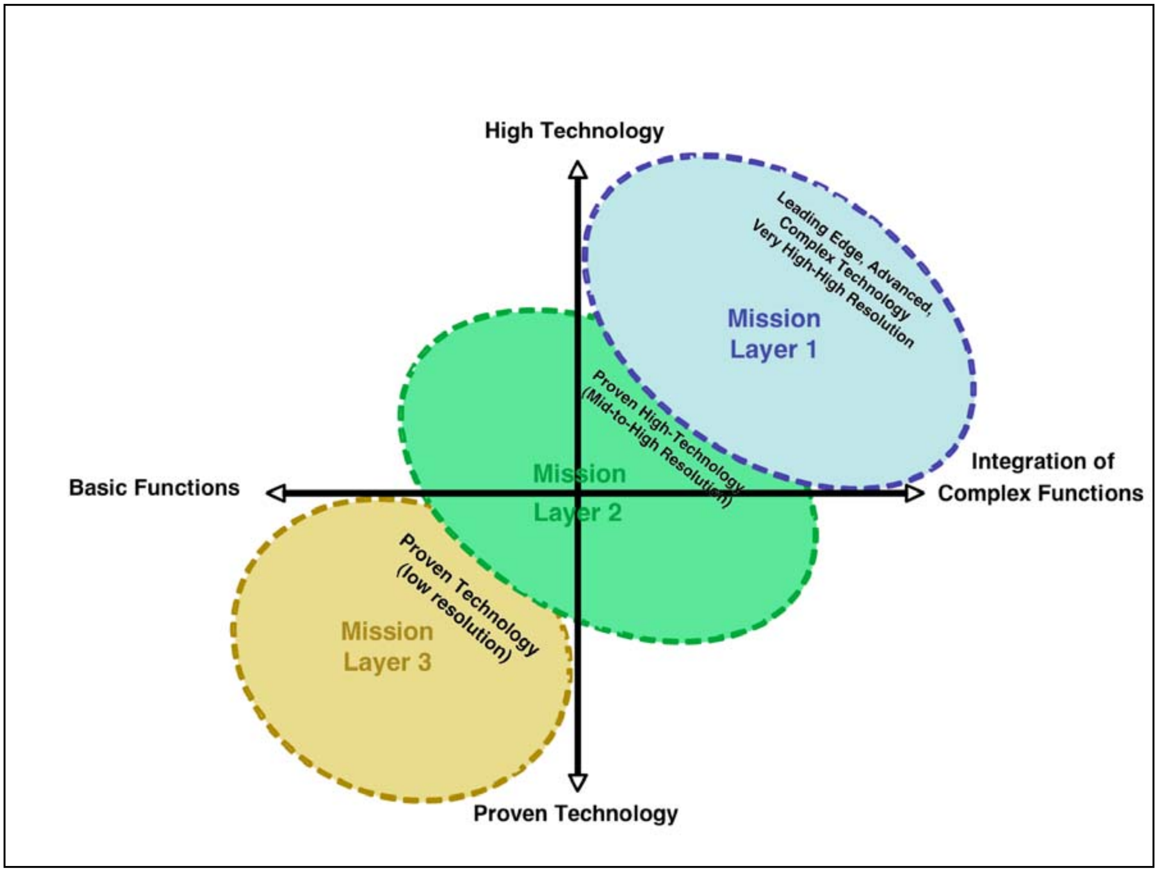

Figure E-3: Notional Depiction of Remote Sensing Layers

As noted earlier the risk categories are:

. Requirements and mission
. Technology and integration
. Security
. Policy, industrial base, and markets
. Programmatics and costs.

REQUIREMENTS AND MISSION

The government drives its needs for imagery from a requirements deck that has evolved over approximately 40 years. Its focus is on refining existent sophisticated technologies or developing new ones in order to achieve improved mission performance. In the initial years of satellite development this was the correct approach, for evolution in technological improvements was key to gaining and sustaining U.S. strategic advantage. Only the government and selected industry partners knew or understood the complex technologies involved and their integration; cost was not a major issue, for the technologies were new and risky, but mission needs were high. The legacy requirements construct continues to drive technology advancement that limits the trade space for adoption of available technologies to fill some of the needs. The requirements deck operates as a decision-making paradigm that designates commercial imagery and imagery products as capable of providing only augmentation, for it defines mission needs primarily within the construct of technical improvements for NTM.

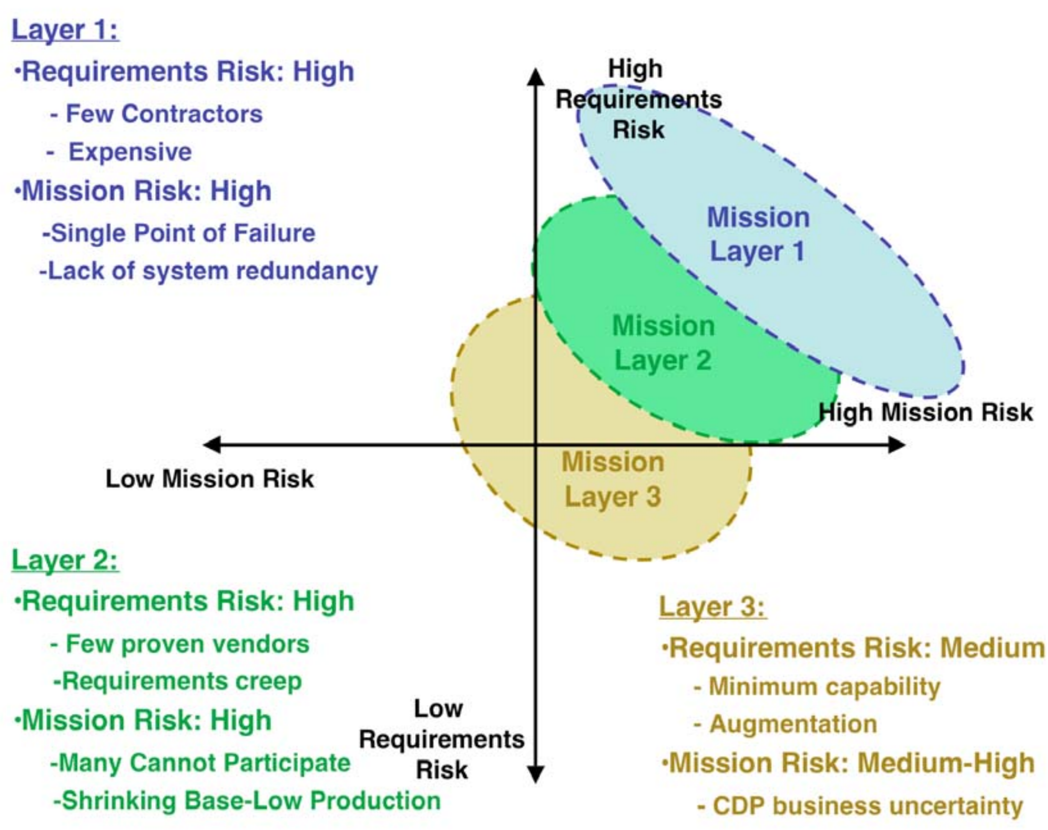

Figure E-4: Requirements and Mission Risk Assessment

The vertical axis of the figure shows level of requirements risk while the horizontal axis identifies level of mission risks from low to high respectively. Mission Layer 1 illustrates the area where satellite developers provide capabilities to primarily the high-end tailored programs in which most of the capabilities are developed exclusively for the U.S. government in the form of NTM. U.S. commercial vendors identified in the Mission Layer 2 are those companies who develop satellites for both the U.S. government and for the global commercial market. They utilize high-end proven technologies and COTS. Mission Layer 3 identifies the commercial vendors who utilize proven capabilities. The discussion points for each mission layer are color-coded. The complexity and predominance of the current requirements deck drives the U.S. government to try and satisfy most of its requirements with Mission Layer 1 programs. The Mission Layer 2 U.S. vendors are often precluded from competing in the high-end arena due to their perceived lack of experience in the related technologies. Mission Layer 2 and 3 vendors provide only augmentation for U.S. data needs. The CDPs capabilities operate in the high-end of Mission Layer 3 (e.g., NextView Program).

Another dimension to the requirements and mission risk assessment is that the uncertainties of the current operational environment necessitate that flexibility and agility not only reside in satellites operating in Mission Layer 1, but that the entire architecture ensure flexibility and agility in terms of its operational capacity. By this it means that redundancy and survivability are key elements that must be considered as part of the mission and requirements management.

TECHNOLOGY AND INTEGRATION

The technology and integration assessment includes payload/sensors, spacecraft, launch, and ground segments. The requirements review revealed that the pivotal issue is the complexity of the technologies needed to meet requirements in each of the three mission layers. Each mission layer has different technology complexity requirements. At the highest level, Level 1, the systems are significantly more complex in that they are developing and incorporating new and advanced technologies to meet unique operational requirements. The technologies can span the entire satellite system given that advanced technology development and incorporation can have a domino effect requiring changes to and/or a new spacecraft and ground stations and modifications to the launch system. These high-end systems can use some COTS components but for the most part are uniquely tailored systems designed to perform unique missions and multiple complex functions. Most of these systems are engineered from the sensor downward meaning that once the sensor/payload is designed the rest of the system follows including what launch vehicle will be used. The integration and test of new and complex technologies and incorporating them into an end-to-end operational system is a major challenge and usually very costly.[26] Launch risk is only medium given that they are launching most of these systems only on reliable government-owned Evolved Expendable Launch Vehicle (EELV) that, although a relatively new system, has a good track record for putting sophisticated systems successfully into orbit. The U.S. government builds only a few Mission Layer 1 systems.

Mission Layer 2 is comprised of complex but mostly proven technologies that have evolved from the Mission Layer 1 programs. They incorporate more COTS than the Mission Layer 1 programs, and because they are evolved from Mission Layer 1 programs, they usually require less engineering and integration on the sensor/payload,

[26] Liam Sarsfield, *The Application of Best Practices to Unmanned Spacecraft Development,* DB-319-NRO (Government Distribution), RAND Corporation, 2000, p. 57.

spacecraft, launch vehicle, and ground segments. Nonetheless, Mission Layer 2 programs present some technological risk because the baseline technologies are complex, and even though COTS is included, incorporation of upgraded parts, new software, buses, or interfaces to accommodate the COTS can impact every segment of the system. Often the risks to these programs are underestimated because risk assessment and cost estimations do not account for all the complexities involved in integrating COTS into existing systems and the domino effects of any changes on the entire system.[27] Today most satellite systems contain incremental technological improvements with each buy; therefore, lean manufacturing is rarely achieved because, like Mission Layer 1, systems, the majority of these satellites are few.[28] Some of these programs use NRO standards and are highly tailored to meet customer requirements. Mission Layer 2 comprises a small percentage of the government's remote sensing capabilities; many Mission Layer 2 vendors lack the experience to operate in the Mission Layer 1 and therefore focus their business in the Mission Layers 2 and 3.

The Mission Layer 3 programs utilize well-known well-proven and reliable technologies that can be easily acquired. These programs utilize mostly COTS products whose integration is relatively easy given that the functions are more basic and less technologically demanding. The software used in these systems is also well established and is used with little or no modification. In order to manage technological and integration risk, often these systems are designed from the bottom-up beginning with the selection of the launch vehicle and concluding with the payload/sensor, and extensively apply "best practices" in order to manage technical risks. Technological risk is managed through clearly specified mission and stable technical requirements, and the utilization of well understood, widely produced, and proven technologies. Design is driven to attain a capability at an affordable price. Technical and integration risk is further managed through extensive quality assurance procedures and parts testing (e.g., as part of commercial practices). Commercial vendors and CDPs fill Mission Layer 3. These capabilities provide augmentation to the Mission Layer 1 and 2 programs, and although Mission Layer 3 programs have increased based upon commercial demands for remote sensing data, they still provide only a small portion of imagery data to the U.S. government. The technological capabilities of Mission Layer 3 are improving given the increased "commoditization" of satellites and supporting capabilities. Figure E-5 depicts the technology and integration risks in each of the mission layers.

[27] Liam Sarsfield, *The Application of Best Practices to Unmanned Spacecraft Development*, DB-319-NRO (Government Distribution), RAND Corporation, 2000, p. 59-60.

[28] General Dynamics Corporation, Advanced Integration Systems, Briefing to the NRO-NGA Remote Sensing Panel, 23 April, 2007

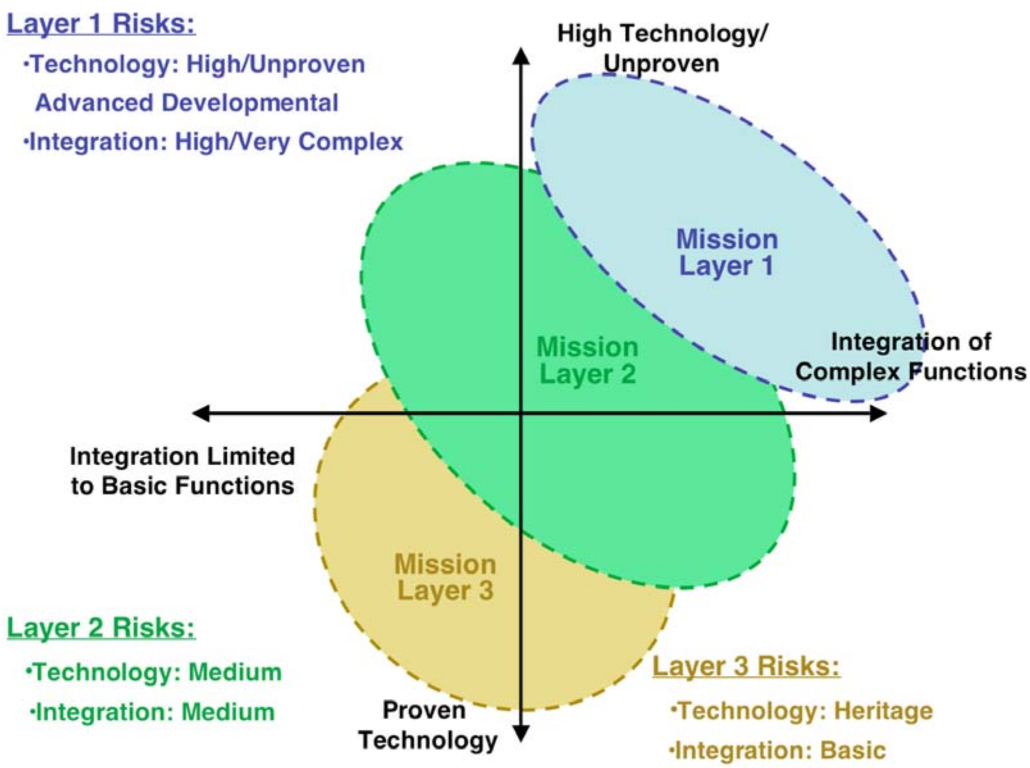

Figure E-5: Technology and Integration Risk Assessment

The vertical axis in Figure E-5 shows technology risks. The greater use of unproven and advanced technologies increase programmatic risks (discussed later in this chapter). The vertical axis (moving from the top to the bottom) shows that the more proven the technologies the less risk. The horizontal axis displays the risk associated with the complexity of integration from very complex to basic. The programs in Mission Layer 3 pose the least technological and integration risks while those in Mission Layer 2 are medium to high risk given that they use proven but complex technologies that are being integrated with COTS, and as expected, the Mission Layer 1 programs pose the most technological and integration risk.

SECURITY

Mission Layer 1 programs operate exclusively in a classified environment. Much of the information collected can be unclassified; however, specific data requests drive security classification and require sensitive handling. The Mission Layer 2 programs, depending on client and/or user, the technologies involved, and their Concept of Operations (CONOPS), can operate in both or either an unclassified or classified environment. The combination of national security clients and proprietary data rights cause this layer to be at medium to high risk. Most Mission Layer 3 programs provide large volumes of unclassified imagery data to a wide variety of clients, some government and many commercial users. The Mission Layer 3 programs operate outside of the NTM architecture as augmentation to the national and tactical missions; therefore, security is judged as a low risk. CDPs and vendors operating in this mission layer argue that they can readily handle all security requirements if embedded in the IMINT architecture.

INDUSTRIAL BASE, MARKETS, AND COMMERCIAL REMORE SENSING POLICIES

Key to the viability of 2nd and 3rd tier vendors and CDPs are the current-, mid-, and future demands for commercial remote sensing. On the other hand, for the U.S. government to increase it reliance on commercial developers and the CDPs it must be assured that they can provide the capabilities – data – when needed. There are inconsistent perspectives on this issue among the U.S. government, aerospace companies, commercial vendors, and the CDPs. Currently a few large contractors predominate in Mission Layer 1. The government argues that these select few contractors understand the complex technologies, maintain domain knowledge, and have had long-term collaborations with the government in developing successful NTM capabilities. Some decision-makers in the U.S. government argue that departures from these trusted government-industry collaborations to promote competition have most often resulted in significant program cost overruns, schedule delays, and some program failures. The Mission Layer 1 programs employ a small number of 2nd and 3rd tier contractors to provide unique or proven sub-systems – lens, control systems, electronics, software, etc. Fewer and fewer highly complex, multi-function satellites are being built given their complexity and high costs, and therefore, the 2nd and 3rd tier contractors, many of whom also supply the commercial vendors, are finding it increasingly more difficult to survive in a shrinking market. The survivability of many Mission Layer 2 vendors and suppliers is further challenged given that the Mission Layer 1 vendors have acquired their own suppliers thereby limiting access to the Mission Layer 1. The 2nd and 3rd tier vendors and suppliers often cannot attain production and cost efficiencies because an insufficient number of satellites are purchased in blocks to sustain a "warm production" base. The 2nd and 3rd vendors and suppliers access to markets is further hindered by ITAR regulations combined with the expansion of foreign capabilities at competitive price points. The cumbersome and complex U.S. bureaucracy discourages technology transfers to foreign countries, who most often want components from Mission Layer 2 vendors and suppliers and not the commodities from Mission Layer 3 that they view as lesser technology.

Vendors in Mission Layers 2 and 3 contend that unless there are substantial changes to the U.S. market driven largely by investment by the U.S. government and/or changes to U.S. commercial satellite policies that facilitate their ability to compete on the global market, their long-term survivable is questionable.[29] These policies are largely driven to protect the Mission Layer 1 national security programs while also supporting the regulatory development of U.S. commercial remote sensing industry but without providing the requisite guidance and resources to ensure their financial viability. Often these two goals are in conflict while the global capabilities of foreign competitors continue to expand. While Congress has encouraged the commercialization of remote sensing, it has also legislated restrictions on U.S. commercial remote sensing satellite

[29] Vendor interviews, March 8, 2007; May 24, 2007.

firms.[30] U.S. policies impact commercial remote sensing vendors and data providers in three ways:

- Performance restrictions that limit imaging capabilities allowed to be provided to foreign users
- Operational restrictions that constrain how U.S. commercial remote sensing firms can collect and/or disseminate imagery data to their customers
- Policymaking uncertainties in the length of time required to reach U.S. licensing and export decisions, as well as, how company proprietary data is handled.[31]

The U.S. industrial base and market survivability of the CDPs is uncertain at best. One cannot conclude that the increased demand for imagery and imagery products will lead to further expansion of the production of satellites and data providers. The global ability to produce more capable satellites at lower costs, combined with the increase in foreign providers has resulted in the increased availability of imagery data and imagery products. Market forecasts indicate that between 2006 and 2010 data providers will see a higher demand for their products based on the overall increase in the global demand for imagery. Many market forecasts indicate that the consolidation of the U.S. CDPs into two principal companies – DigitalGlobe and GeoEye – has narrowed the competition and stabilized the industrial base. There are differing views on how long this stability will last. It is projected that between 2006 and 2016, approximately $16.1 billion will be spent on imagery capabilities. It is estimated after 2012, the market will be relatively flat due to market saturation and more mature technologies. Therefore, few new players are seen as entering the remote sensing market either from the vendor or data provider industry. Some industry projections are that the CDPs will have significant business viability problems as the field becomes saturated and moves to sophisticated geospatial products.[32]

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[30] O'Connell and al, U.S. Commercial Remote Sensing, p. 71.
[31] O'Connell and al, U.S. Commercial Remote Sensing, p. 75.
[32] "*Commercial Remote Sensing Satellite Market Stabilizing*", EARSC, May 2007; Ryan Zelnio, "*The Effects of Export Control On the Space Industry*", Space Review, January 16, 2006; Charles Mondello, *"10-Year Remote Sensing Industry Forecast", Phase IV – Study Documentation",* The Photogrammetric Engineering and Remote Sensing Society, September 2006.

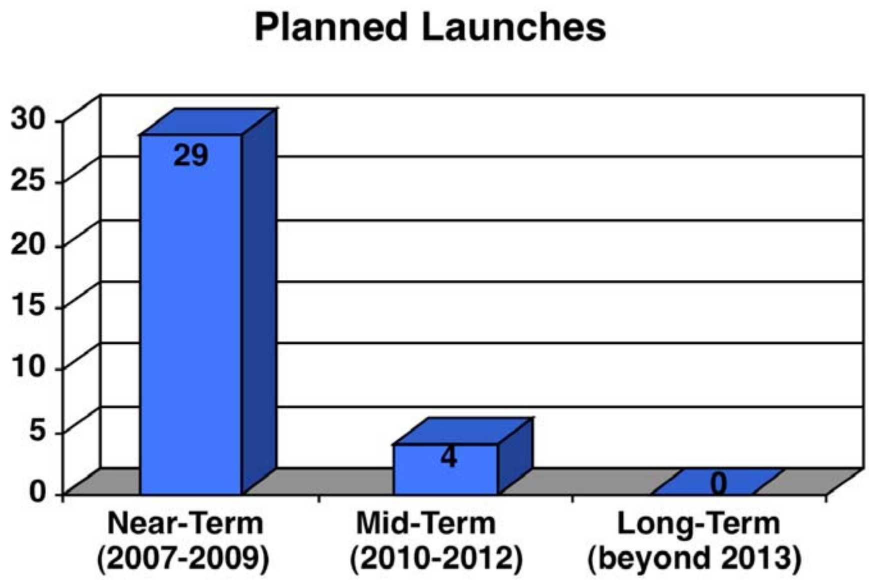

Figure E-6: Future Launch Projections of Commercial Remote Sensing Systems[33]

Figure E-6 is one depiction of the future demand for commercial remote sensing capabilities through an evaluation of proposed launches between 2007 and 2013. It is impossible to project launches beyond 2012 given that most future system requirements are defined within 2 to 3 years of launch dates. One can assume based on historical data that many scheduled launches in the near- and mid-term will be delayed to later years for a variety of reasons – funding, technical requirements changes, development problems, etc.; nonetheless, the proposed launch manifest for the mid- to long-term suggests that the business viability of the data providers and 2nd and 3rd tier U.S. commercial vendors is questionable.

The CDPs argue that the future market for imagery data is strong and will remain that way for the foreseeable future (at least the next decade). The data providers also argue that recent equity funding provides a financial basis to augment existing space-based capabilities – airborne and aerial – so as to expand their global competitiveness even if they do not get U.S. government business. They argue that the foreign markets and the large imagery data consumers such as Google will continue to demand global broad area coverage that in turn builds a compelling set of commercial capabilities that the U.S. government can use.[34] The data providers also argue that current programs – ClearView, NextView and WorldView – demonstrate that they can support U.S. government requirements. The future planned constellations provide more than sufficient capacity and assured access for the U.S. government.[35] Another issue for the CDPs is their ability to evolve their product lines as the demand for types of imagery products

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[33] Stoney, W. E., ASPRS Guide to Land Imaging Satellites, NOAA Commercial Remote Sensing Symposium: Key Trends and Challenges in the Global Marketplace, September 2006

[34] DigitalGlobe, Presentation to NGA Advisory Group, NGA and Mission Partners, March 8, 2007; GeoEye,

[35] DigitalGlobe, Presentation to NGA Advisory Group, NGA and Mission Partners, March 8, 2007; GeoEye,

changes from imagery data to refined imagery products. This said, in the early 2000s they have successfully moved from geospatial data providers to information services, so there is strong evidence that they will evolve their businesses in response to changing market demands. Figure E-7 summarizes the risk assessments for the industrial base, markets, and policies in each of the three notional remote sensing mission layers.

Mission Layer / Risk Area	Mission Layer 1	Mission Layer 2	Mission Layer 3
Industrial Base	High: -Base is shrinking -Little competition of ideas	High: -Consolidation due to narrowing market	High: - Global competition
Market	Medium: -Near monopoly -Few opportunities for new entries	High: -Limited to only a small segment -US Government must be principal buyer	Medium: -Strong global competition
Policy	Medium: -Continuing exclusive support for NTM	Medium: -Precludes offering sophisticated products to global market	Low: -Supports use of commercial but few resources provided

Figure E-7: Industrial Base, Market, and Policy Risks

PROGRAM AND COSTS

Program risk primarily addresses program management. Program management is included because of the need for highly experienced and competent program managers in both the government and industry to manage complex integration and technology programs. The ability to manage requirements and perform meaningful tradeoffs among cost, schedule and performance against true risk is imperative for both the government and industry. Other key factors in program risk assessment are understanding and managing requirements volatility and the use of commercial products to meet system requirements. Figure E-8 notionally depicts this risk assessment for each mission layer.

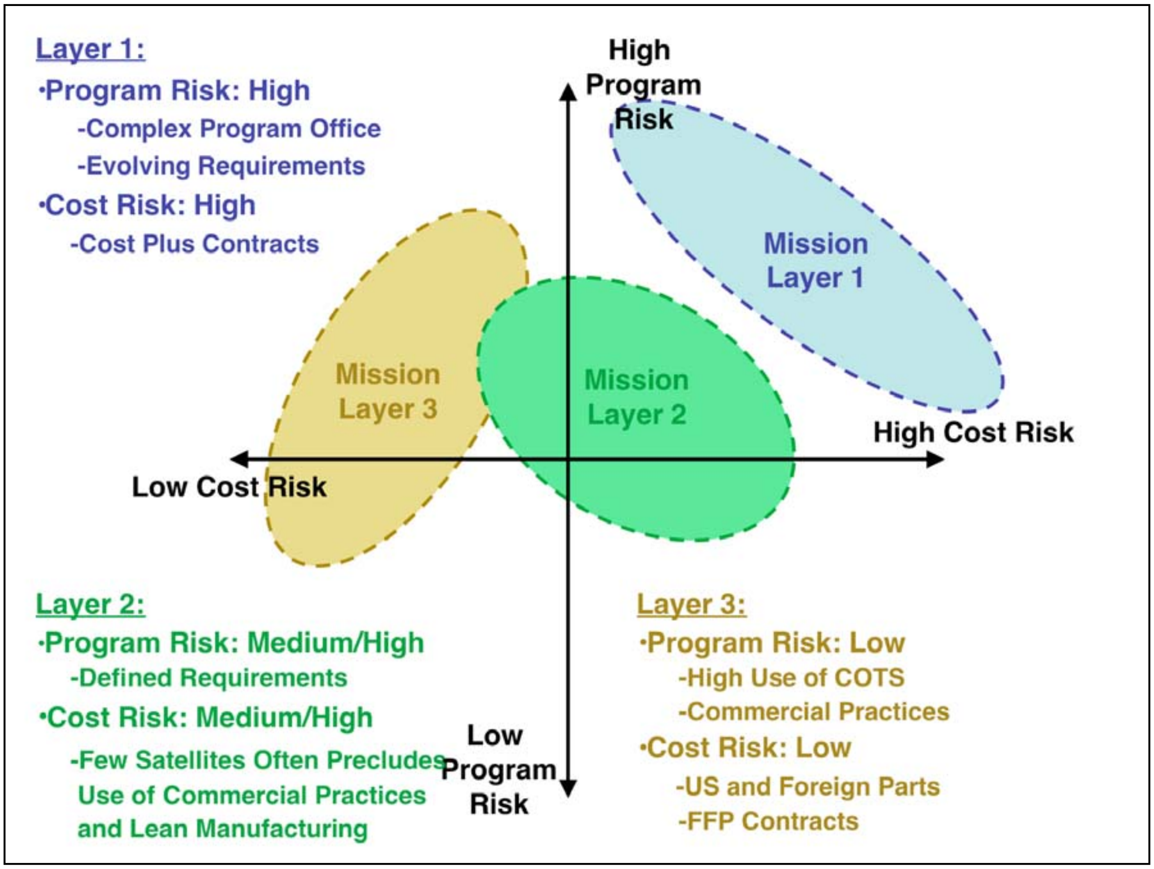

Figure E-8: Program and Cost Risks

Cost risk factors are largely driven by the level of technology and complexity of integration, for the more new, unproven, and complex technologies, the higher the costs. Other cost issues are related to the availability of resources, the established record of successful performance, and the uniqueness or serial production of the satellite. The production of a single unique satellite system generally costs more than a serial production of 2 to 3 per year; which is more cost efficient in terms of workforce proficiency and use of manufacturing facilities. Similarly, the complexity of integration also drives costs. The vendors and suppliers in Mission Layer 2 often are hindered in achieving lean manufacturing objectives because most government-commercial satellite systems in Mission Layer 2 are unique or "one-off" from the prior system even though their functionality may be the same or similar. The government-funded CDP programs have only marginally assisted the 2nd and 3rd Mission Layer vendors in keeping a warm satellite production base because the "buys" have been low in numbers and produced over several years. The availability of funding for new vendors without a history of success is scarce and very high risk to their sources of capital. Commercial vendors with diversified product lines and broad customer markets are able to cover risks of failure of their remote sensing satellites while the smaller firms with only remote sensing business must assure they preclude failure through the use of only proven technology and also guard against failure by having costly insurance. All these factors drive program and cost risks. Mission Layer 1 has the most risk in both program and cost largely due to complexity of new technology and changing requirements, and Mission Layer 3 is forced to operate in an area of reduced risk in both areas in order to remain viable.

RISK SUMMARY

The risk assessment is summarized in Figure E-9 below. The principal insight from this summary is that there remain in both Mission Layer 2 and 3, where commercial remote sensing is to be expected and fostered, several high risk areas that limit entry to those few U.S. companies that can meet these demanding challenges. Further, analysis of these risk areas strongly suggests that there is considerable latitude for the U.S. government to operate to reduce these risks and promote more commercialization without negatively impacting capabilities that support national security needs that by necessity operate in the higher risk domain of Mission Layer 1. Chapter 2 poses several business cases for how the U.S. government might attain greater use of commercial remote sensing capabilities while managing risk.

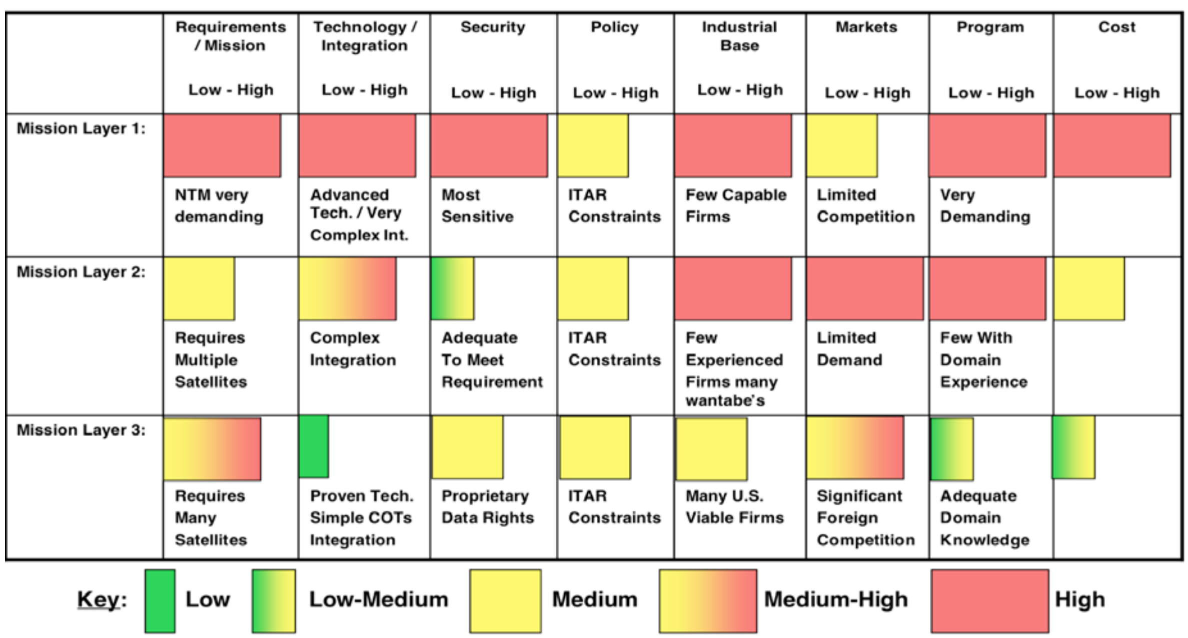

Figure E-9: Summary of Risk Assessment – All Categories

APPENDIX F: U.S. LEGISLATION AND POLICIES ON COMMERCIAL REMOTE SENSING

1958 – Nation Aeronautics and Space Act: Establishes the National Aeronautics and Space Administration.

1967 – Outer Space Treaty: Established to contribute to the broad international co-operation in the scientific as well as the legal aspects of the exploration and use of outer space for peaceful reasons.

1979 – Presidential Directive/NSC 54: Assigns NOAA management responsibility for civil operational land remote sensing and sets a goal for "…eventual operation by the private sector of our civil land remote sensing activities.

1982 – National Security Decision Directive (NSDD) 42, National Space Policy: United States cooperation in international civil activities will "Support the public, nondiscriminatory direct readout of data from Federal civil system to foreign ground stations and provision of data to foreign users under specified conditions."

1988 – Presidential Decision on National Space Policy: Directs governmental space sectors to purchase commercially available space goods and services to the fullest extent feasible and to avoid conducting activities with potential commercial applications that preclude or deter commercial sector space activities except for national security or public safety reasons.

1992 – Land Remote Sensing Policy Act (P.L. 102-555): Suspends Landsat commercialization strategy, assigns construction of Landsat 7 to DoD and NASA, and states a preference for a future private sector solution while mandating that value-added services and products be provided solely by commercial entities. Establishes DOI responsibility for a National Satellite Land Remote Sensing Data Archive.

1994 –Presidential Decision Directive/NSTC-3: A critical enabling document in that it specified the U.S. government's conditions for granting operating licenses to U.S. firms interested in commercial remote sensing satellites, including relatively high resolution imaging satellites. It also clarified roles and responsibilities among government organizations and sought to ensure continuity of Landsat-type and quality of data while reducing the risk of data gap arising from the 1993 launch failure of Landsat 6.[36]

1998 – Commercial Space Act: Directs NASA and other Federal agencies and scientific researchers to acquire, where cost-effective, space-based and airborne earth remote sensing data, services, distribution, and applications from a commercial provider.

2000 – Amendment to Presidential Decision Directive 23: Transfers Landsat Program Management responsibilities to NASA and DOI/USGS, with NASA developing and

[36] O'Connell and al., U.S. Commercial Sensing, p. 73.

launching Landsat 7 and Department of Interior (DOI)/USGS operating the satellite and ground system in addition to longstanding responsibility for data management.

<u>2003 – NSPD 27 -Commercial Remote Sensing Satellite Policy</u>: Declares that the U.S. government will rely to the maximum practical extent on U.S. commercial remote sensing space capabilities for filing imagery and geospatial needs for military, intelligence, foreign policy, homeland security, and civil users. The policy directive supports the creation of a robust U.S. commercial remote sensing industry that enhances the international competitiveness of industry, and discouraging the proliferation of foreign remote sensing space capabilities by fostering foreign reliance on U.S. remote sensing space capabilities

<u>2005 –Memorandum from Director, Office of Science and Technology Policy/EOP</u>: Directs NASA, DOI/USGS, and other agencies and EOP offices "…develop a long-term plan to achieve technical, financial, and managerial stability for operational land imaging in accord with the goals and objectives of the U.S. Integrated Earth Observation System."

<u>2006 – National Space Policy:</u> Outlines roles of U.S. civil space agencies and establishes land remote sensing leadership role for DOI.

<u>2006 – NSPD -29- Intelligence Community Focal Point For Implementing National Space Policy:</u> Directs the ODNI, jointly with the Secretary of Defense and in consultation, as appropriate, with the Secretary of State and other departments and agencies, to undertake broad activities to strengthen the nation's advantage in space. The DDNI/CO(R) is appointed the staff focal point to coordinate the endeavor.