Report to the Defense and Intelligence Committees of the Congress of the United States

on the

Status of the Space Based Infrared System Program

March 2005

Office of the Secretary of Defense
Washington D.C. 20301-1000

Executive Summary

The Space Based Infrared System (SBIRS) program is a transformational program created to consolidate operational military and technical intelligence Overhead Non-imaging Infrared (ONIR) requirements into a single space program. The SBIRS satellite constellation satisfies user requirements in four distinct mission areas: (1) Missile Warning (MW), (2) Missile Defense (MD), (3) Technical Intelligence (TI) and (4) Battle Space Characterization (BSC). The operational SBIRS system will be comprised of four Geosynchronous (GEO) satellites, two Highly Elliptical Orbit (HEO) payloads (P/L) riding on classified host satellites, one spare GEO satellite procured against launch or early on-orbit failure, and both fixed and mobile ground elements.

Although the SBIRS program completed the Nunn-McCurdy certification process in FY02, and was rebaselined, it has continued to experience developmental difficulties, leading to cost growth and schedule slips. As a result, in the FY05 Authorization Conference Report, the Secretary of Defense was directed to provide classified and unclassified reports to Congress by 1 Feb 05 (since extended to 15 Feb 05) "on the cause of the most recent SBIRS cost increases, schedule delays, and technical problems; the most recent Defense Support Program gap analysis and any effect that further delays will have on U.S. early warning, technical intelligence, and missile defense capabilities; steps taken to address the most recent SBIRS technical difficulties; any adjustments in management and contract arrangements with the contractor to reflect the most recent program challenges; remaining risk areas; and an assessment of the confidence level in the SBIRS schedule and cost estimates current as of October 1, 2004." Thus, DoD complied with the report language and addressed the issues as directed.

This report deals solely with the Engineering, Manufacturing, and Development (EMD) effort remaining on the SBIRS program (paragraph 1.3 provides content description). Currently, the timing and the acquisition strategy for the GEO 3-5 procurement (which would provide the remaining satellites to populate the constellation) are under review and, therefore, not discussed in the report. However, upon the final selection of the configuration for GEO satellites 3-5, the SBIRS program will revise the Acquisition Program Baseline. The final results of these changes will be presented to Congress in the appropriate Selected Acquisition Report (SAR), and can be provided in briefing format upon request. There are three primary reasons for the latest SBIRS program cost increases/schedule delays/technical problems: (1) latent defects, resulting from insufficient product assurance activity in earlier design and production activities; (2) insufficient schedule and budget to ensure robust GEO first article integration / test; and (3) process escapes due to human error / insufficient training / fragile processes. The steps taken to address the most recent technical problems involved: overcoming HEO P/L electromagnetic noise emissions; correcting halt conditions on HEO and GEO on-board computers; and developing a more robust GEO processing architecture, with well-designed software to enable efficient operations. Adjustments to the program management include: adopting an 'event-driven' approach, with both entrance and exit criteria for key events; adjusting the program business rhythm to enable more rapid information exchange to identify and address problems faster; increasing government participation in program test activities; and more rigorous and disciplined tracking of earned value progress. Development contract changes included: an 'over target baseline' adjustment

made to recognize the cost and schedule growth, with no addition of award fee; and restructuring of the remaining award fee. The remaining program risk was assessed and determined to be moderate, focused primarily in the areas of integration and test. The majority of technical risks existing at the program's beginning have been mitigated, or realized and largely overcome. Finally, based on the government's estimates for the remainder of the EMD program effort, the confidence in the program cost is medium-high and program schedule is medium. Given the uncertainties in the GEO 3-5 procurement, to include the most recent Nunn-McCurdy breach, the Air Force does not have the degree of confidence we want in the accuracy of the cost estimates and the associated technical baseline of this high priority space program. Accordingly, an Independent Program Assessment has been directed to review the technical and cost baselines of the program, to establish a clear and unambiguous program baseline and associated cost estimate.

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1.1 Background

The transformational Space Based Infrared System (SBIRS) program was created to consolidate operational military and technical intelligence Overhead Non-imaging Infrared (ONIR) requirements into a single program. Consequently, the SBIRS satellite constellation is charged to satisfy user requirements in four distinct mission areas: (1) Missile Warning (MW), (2) Missile Defense (MD), (3) Technical Intelligence (TI) and (4) Battle Space Characterization (BSC). In Fiscal Year (FY) 02, the Air Force (AF) completed the Nunn-McCurdy certification process, and established a revised cost and schedule baseline for the SBIRS program. The Department of Defense (DoD) directed the AF to fund the program at the revised budget requirements.

Co-incident with the submission of the FY05 President's Budget Request (PBR), the AF recognized that the requested SBIRS Research, Development, Test & Evaluation (RDT&E) budget for FY05 was insufficient to mitigate the impact of technical and programmatic issues that had been realized since the 2002 rebaseline. Without additional funding, the program would incur significant schedule delays. The AF requested, and Congress approved, an additional $91M for FY05, bringing the total RDT&E approved budget to $599M.

As a result of the cost growth, the conference report accompanying the FY05 Defense Authorization bill directed the Secretary of Defense (SecDef) to provide a report, in classified and unclassified forms, to the congressional defense committees no later than February 1, 2005 (later extended to 15 Feb 05) to identify:

- The cause of the most recent SBIRS cost increases, schedule delays and technical problems
- The most recent Defense Support Program (DSP) gap analysis and any effect that further delays will have on U.S. early warning, technical intelligence and missile defense capabilities
- Steps taken to address the most recent SBIRS technical difficulties
- Adjustments in management and contract arrangements with the contractor to reflect the most recent program challenges
- Remaining risk areas
- Assessment of the confidence level in the SBIRS schedule and cost estimates current as of October 1, 2004

Since 2002, the DoD has increased its oversight of the SBIRS program to assess its progress and its ability to achieve future milestones. The reviews included technical independent assessment, by the Director, Defense Research & Engineering (DDR&E), as well as programmatic reviews by the Defense Science Board and the Defense Acquisition Board, chaired by the Undersecretary of Defense Acquisition, Technology & Logistics (USD[AT&L]). The two-tiered SBIRS senior executive management oversight structure established in 2002 conducted additional program reviews. The Presidents' Meeting is held quarterly and is chaired by the Undersecretary of the Air Force (USecAF). The Executive Committee (ExCom) meets bi-monthly and is chaired by the AF Program Executive Officer for Space (AF PEO/SP). Both forums include senior executives from OSD, the AF, other SBIRS government stakeholders, and the SBIRS contractor team. These management oversight reviews focus senior executives' attention on program progress and on resolution of critical program issues. The reviews' objectives are to ensure management effectiveness; solid cost, schedule, and technical performance; and rapid program decision-making.

The past year included frank and in-depth dialog regarding the SBIRS activities, progress, issues and costs. Programmatic alternatives were examined in an attempt to find cheaper and quicker solutions to achieve the capability provided by the SBIRS program. At this point in time, no alternative to the SBIRS program has been identified that provides the same capability at an equivalent 'to go' cost, schedule and risk profile.

1.2 Report Overview

This document is unclassified and responds to the unclassified congressional concerns; the classified section of the report is provided under separate cover and it provides the most recent DSP gap analysis while addressing the impact of further delays on the early warning, technical intelligence, and missile defense capabilities. The unclassified report discusses the causal factors leading to the recent revisions to SBIRS program cost and schedule. It describes recent technical issues and solutions. It addresses the management initiatives implemented to address these factors, and an objective assessment of the program risks remaining. As requested by the conference report, the remaining risks are described separately from the assessment of cost and schedule confidence. For clarity, the schedule confidence and cost confidence are discussed in two separate sections. However, there is a strong interdependence among the three areas, and mitigating technical risks usually results in cost and schedule impacts.

On a positive note, the technical risk section highlights that the fundamental technology and design are well within the 'state of the practice', and that the known technical risks remaining are understood, characterized and manageable. The remaining program risks 'cluster' around key themes: first-time integration, mission assurance, product quality, and software execution and test. This is consistent with the latest assessment by the Director, Defense Research and Engineering (DDR&E) completed in 3rd Qtr FY02. During the 2004 replan activities, the System Program Office (SPO) identified additional schedule and budget to specifically mitigate the technical risks identified in Section 5 of this report to Congress.

SPO confidence assessments for the replanned schedule and cost are based upon the final, government-defined program plan, which was developed by a multi-step process. First, the contractor team provided an updated SBIRS schedule that adjusted future work based upon prudent content additions while assuming corrections to process problems experienced to date. This contractor schedule effectively delayed most major deliveries by about 12 months. The SPO assessed the contractor input, using both results from independent software modeling and insight into the historical experience of other DoD space program timelines. The SPO concluded the contractor's schedule was aggressive and not entirely consistent with the productivity achieved to date. The SPO also assumed that it would not be possible to eliminate all development process problems, even if they were identified and understood. Therefore, the SPO concluded that additional time, and funding, would likely be required for more robust testing, problem resolution / rework, software development, and related activities. All of these factors culminated in later delivery dates and higher cost projections than the contractor had estimated. So the SPO included the costs required to fund the probable schedule extensions in cases where the projected schedules for key product deliveries were later than the contractor's estimates. And the SPO replan costs include the funding required to achieve the more realistic program dates, and therefore provide the basis for confidence that the program can be executed within the revised cost and schedule baseline.

In 2nd Qtr FY05, the contractor will initiate their annual Comprehensive Estimate At Complete (CEAC) activity, which details the resources and schedule required to accomplish the remaining SBIRS RDT&E contract activities. The government will be a full participant in this CEAC activity, and the SPO anticipates that the CEAC results will substantiate the government's cost and schedule projections for the SBIRS work-to-go.

1.3 Other Considerations

This report focuses on the activities required to develop, test, launch and transition to operations the GEO 1-2 satellites and the associated ground system. The majority of the SBIRS HEO P/L program is complete, and this report addresses the HEO P/L activities only from an historical perspective. Delivery of the second HEO P/L is scheduled for 3rd Qtr FY05 and we will support integration activities with the host. Our remaining development efforts for the HEO segment of the program will be limited to the delivery of the final HEO ground software build along with the test and certification of the HEO Message Certification effectivity.

To satisfy all of the SBIRS requirements a constellation of four GEO satellites and 2 HEO P/Ls is required and this necessitates a future contracting action. Currently, the timing and the acquisition strategy for the GEO 3-5 procurement (which would provide the remaining satellites to populate the constellation) are under review. As directed by the last SBIRS Acquisition Decision Memorandum, the SPO will provide the results of a technology insertion analysis for the GEO 3-5 satellites. A decision will then be made by the DoD Executive Agent for Space, after consultation with the Defense Acquisition Executive, regarding the implementation of the recommendations for GEO 3-5 satellites. Subsequently, a new Acquisition Program Baseline will be established to reflect the modified SBIRS program.

2. SBIRS Mission Description

SBIRS is responsible for conducting four missions simultaneously, i.e., Missile Warning, Missile Defense, Technical Intelligence, and Battlespace Characterization, as illustrated in Figure 1. A more complete mission description is available in the classified annex.

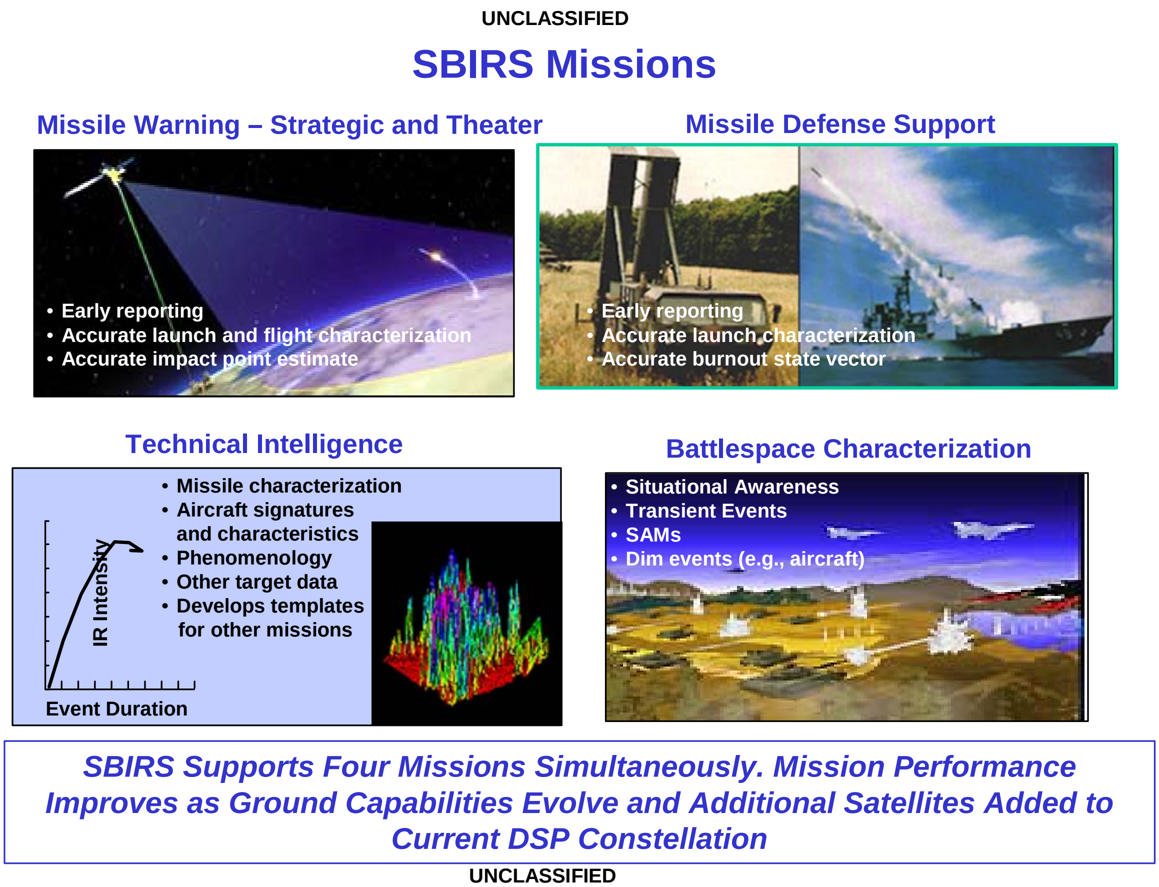


Figure 1. SBIRS Missions

- Missile Warning provides early warning of ballistic missile launches against the US, its allies, and other countries, through all phases of attacks.
- Missile Defense provides earliest possible warning of ballistic missile attacks and accurate state vector information to effectively cue other Ballistic Missile Defense System elements to support intercept and negation of the threat.
- Technical Intelligence provides infrared data on foreign weapon activity and testing in order to assess weapons deployment, tactics, and technical characteristics, and to conduct conflict monitoring and environmental monitoring. TI uses results of analysis to develop performance templates that are the basis for the other SBIRS mission areas.
- Battlespace Characterization provides data and reports to support battlefield situational awareness, to include battle damage assessment, suppression of enemy air defense, enemy aircraft surveillance, search and rescue, and location of enemy resources.

2.1 Mission Benefits

SBIRS will continue the assured missile warning performance that DSP has provided for over 30 years. The increased sensor sensitivity, improved revisit times, and tasking flexibility of SBIRS will allow detection of additional dim and short-burn events, and support the four SBIRS mission areas, as illustrated in Figure 2.

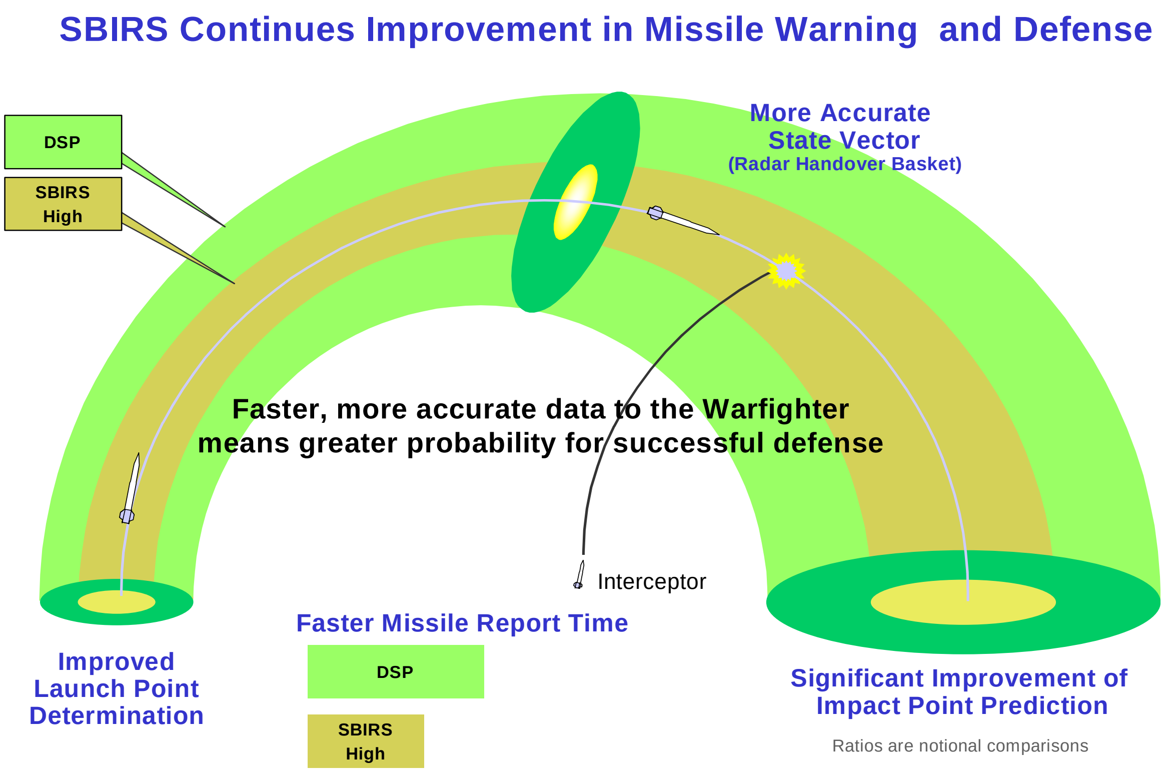


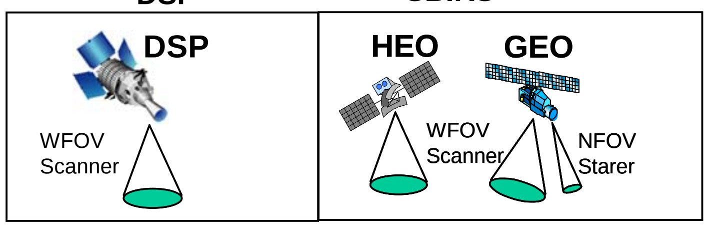
Figure 2. SBIRS Improved Capabilities

- SBIRS continues the Missile Warning mission and will provide earlier warning messages for worldwide strategic missile launches in support of Integrated Tactical Warning/Attack Assessment (ITW/AA), including launches from the polar region, as well as for shorter-range theater missiles. In addition, SBIRS will provide high-confidence detection of new and emerging short-burn theater missiles
- In support of Missile Defense, SBIRS provides earlier warning messages, more accurate launch point estimates to support Theater Attack Operations, smaller burnout state vector errors to allow radar cue for enhanced Active Defense for both Theater operations and GMD operations, and improved impact area predictions ensuring enhanced Passive Defense operations that will reduce force disruption
- SBIRS contributes to the Technical Intelligence mission by providing tracking of additional missiles to burnout, detection of short-burn events, detection of dimmer events, as well as transient events, to augment and improve threat assessments and intelligence preparation of the battlefield

- SBIRS has the capability to provide improved Battlespace Characterization by detecting these same Technical Intelligence events, and reporting these events in real time to improve situational awareness. Real-time ground processing for the Battlespace Characterization mission is a growth area for SBIRS, as exploitation of the full SBIRS capability represents a future area for capability improvement

2.2 Satellite/Sensor Descriptions

Characteristics of SBIRS and DSP are illustrated in Table 1.



	DSP	SBIRS	Benefit
Satellite	GEO-altitude spinning spacecraft	GEO: 3-axis stabilized HEO: Host	Polar coverage
Sensor	Spinning sensor	GEO sensors - Scanning, taskable - Staring, taskable HEO sensor - Scanning, taskable	Global coverage Focused coverage Polar & Focused coverage
Revisit Time	Fixed revisit time	Variable revisit times	Short duration events
Spectral bands	SWIR, 2nd Color	SWIR, MWIR See-to-Ground (STG)	Earlier missile detection Ground, low-alt events
Sensitivity	Nominal sensitivity	Improved sensitivity	Dimmer events
Satellite data transmission	Downlink of signal processed data	Downlink of signal processed and raw data	Data exploitation

Table 1. Satellite / Sensor Descriptions

- The DSP sensor is hosted on a spinning spacecraft and samples each point on the earth within its field of view with a fixed revisit time. Data are processed on-board the spacecraft to remove background and noise; exceedances are downlinked to the ground for mission processing.
- SBIRS GEO spacecraft will be a stabilized platform with a scanning sensor and a staring sensor. Sensor pointing will be accomplished with pointing mirrors in front of the telescopes.
  - The GEO scanning sensor will provide a shorter revisit time than that of DSP over its full field of view, while the staring sensor will be used for step-stare or dedicated stare operations over smaller areas.
  - The GEO staring sensor will have high agility to rapidly stare at one earth location and then step to other locations, with improved sensitivity compared to DSP. Several areas can be monitored by the staring sensor with revisit

times significantly smaller that that of DSP. A continuous staring mode will also provide an even smaller revisit time.

- SBIRS HEO sensor is a scanning sensor similar to the GEO scanner, with sensor pointing performed by slewing the full telescope on a gimbal.
- SBIRS GEO and HEO sensor raw unprocessed data will be downlinked to the ground so that the same radiometric scene observed in space will be available on the ground.

3. Causes of the Most Recent Cost Increases, Schedule Delays, and Technical Problems

The magnitude of the cost growth identified during FY04 was unexpected and disappointing, occurring only two years after the program restructure -- the contractor was unable to perform to their plan. Several factors contributed to the poor performance, which in turn increased program costs and schedule. However, the root cause of the majority of technical difficulties can be traced to one of the three factors described below:

- Latent Defects, Resulting From Insufficient Product Assurance Activity In Earlier Design And Production Activities
- Insufficient Schedule And Budget To Ensure Robust GEO First Article Integration / Test
- Process Escapes Due To Human Error / Insufficient Training / Fragile Processes

Another contributing factor was the staffing of the contractor team. The SPO noted on many occasions that the quality and sufficiency of personnel was inconsistent with the national priority of the SBIRS program. However, in the last year, key contractor personnel realignments have greatly improved the overall quality of the contractor staff. The current management staff is very experienced with strong technical backgrounds in critical disciplines. Corporate-wide resources are now being identified to assist in problem resolution as required. This is encouraging and the SPO anticipates this commitment continuing through program completion.

3.1 Latent Defects, Resulting From Insufficient Product Assurance Activity In Earlier Design And Production Activities

The Independent Review Team (IRT), formed in 1st Qtr FY02 to review the program and diagnose the root causes and contributing factors of the significant cost growth, identified that the program was too immature to enter the detailed System Design and Development phase. The 2002 plan acknowledged this immaturity but assumed that the design reviews, i.e., the Critical Design Review (CDR) in Oct 2001 and the Baseline Update in Nov 2002, retired this risk. HEO integration and test efforts proved that assumption invalid.

In FY03, the program experienced several setbacks in the HEO program, which began to affect other program elements. These technical issues, which included both design and workmanship quality, were not anticipated. For example, the development and implementation of the engineering design solutions to resolve the Electromagnetic Interference (EMI) exceedances required diversion of staff resources, originally planned for GEO P/L activities. HEO manufacturing, integration and test staffing levels were extended, which created severe pressure on the 2002 restructured program plan for both cost and schedule. The contractor continues to discover latent defects and manufacturing process escapes in the GEO hardware, and realistically the SPO expects these discoveries to continue throughout the ongoing GEO system integration and test sequence over the next three years.

These defects are the unanticipated result of the government's 'acquisition reform' policies of the 1990s, in which contractor commercial practices were substituted for government

Standards and Specifications on the SBIRS contract and government oversight was reduced. These government Standards and Specifications identified the key requirements to ensure industry followed sound system engineering processes and procedures. Unfortunately, when requested to follow commercial practices, due to cost pressure for higher efficiency, industry reduced the critical upfront system engineering design practices and follow-up quality assurance inspections. Also, during the SBIRS design phase, the SPO staff was reduced by about 25%. This diminished the effectiveness of the government oversight of the contractor processes. The SPO has since implemented activities to properly oversee and assess contractor performance, but still suffers from the fallout of the acquisition policies, which governed the basic system design and early fabrication period, i.e. 1996 to 2002. However, within the current baseline, the SPO implemented the appropriate design / production verification processes as well as cost and schedule adjustments to minimize the impact of previous design/fabrication shortfalls on the GEO satellite future delivery.

3.2 Insufficient Schedule And Budget To Ensure Robust GEO First Article Integration / Test

During the spring and summer of FY04, the contractor performed a detailed analysis of the methodology for future SBIRS testing. This was motivated in part by observations by the Defense Science Board Joint Task Force on Acquisition of National Security Space Programs, and similar expert groups, which indicated early, robust testing was the best approach to guarantee on-orbit success. This detailed look at future SBIRS testing led to the conclusion that more testing was needed in the 'to-go' SBIRS program. Then, because of the concern regarding latent defects, the contractor decided to inject additional testing and more perceptive testing earlier in the integration and test cycle for the remaining part of the SBIRS program. However, the resources needed to perform the more robust testing compounded the contractor's inability to achieve planned 'headcount' reductions due to the work backlog.

Accordingly, the SPO and contractor jointly conducted a systematic review of the work 'to go,' from the perspective of both the HEO and GEO experiences. The contractor acknowledged that due to earlier program design and workmanship flaws, there was insufficient time scheduled for GEO system integration and test, and added significant additional effort. In addition, the SPO concluded the ground software productivity levels were optimistic; the flight software architecture was not sufficiently defined to allow software coding; and inadequate on-orbit checkout time was planned. Finally, the resources and tools for simulations, analysis, and troubleshooting were inadequate and required more effort. Correcting these findings required more staff resources and increased time spans–all of which added cost.

3.3 Process Escapes Due To Human Error / Insufficient Training / Fragile Processes

Several recent program events required the contractor to rework various subsystem components. Root cause investigation of these anomalous events identified improper or inadequate processes, insufficient training, questionable inspection practices, and/or human error as causal factors. Recent events include excess debris or contamination in delivered hardware, improper use of soldering materials, improper installation of thermal blankets, and missing test procedure documentation. While many of the recently discovered escapes happened years ago (the latent defect problem described in section 3.1), there have been several since the 2002 restructure, including some in FY04. As a result of recent events, product assurance is a major focus item and has received corporate scrutiny and support. The contractor team has increased management involvement, instituted weekly reports, and conducted numerous process audits and improvement activities now under the oversight of corporate functional Vice Presidents. The SPO is starting to see some improvements in awareness and have documented instances where proactive inspections avoided potential problems. However, the discovery of historical process escapes will continue as the effects of the improved testing and surveillance are realized across the program. The cost and schedule impacts associated with required rework are the hardest future efforts to predict - they truly are the ‘unknown unknowns’ of development programs. The SPO plans to mitigate any potential cost associated with future process escapes through program reserves.

4. Recent Program Challenges

In 3rd Qtr FY04, the Air Force initiated a program replan to address the remaining 'to go' cost and schedule for SBIRS. Using the lessons learned from the Nunn-McCurdy restructure, the almost complete HEO effort, and the GEO work to date, the Air Force and the contractor identified and addressed several areas that were under-resourced on the 'to go' program. Recognizing the importance of maintaining a robust missile warning capability and providing increased war fighting capability to the theater commanders, DoD supported the revised cost requirements in the FY06 PBR. As discussed above, when the program was initiated in the mid 1990s, DoD adopted a risk tolerant, commercial-practice 'mission success' position on design and production. Since that time, national security space acquisition programs shifted to emphasizing 'mission assurance' as the paramount value in space program execution. This increased emphasis on rigorous and disciplined test methodology necessitates an increase in resources (funding, schedule).

4.1 Addressing Recent Technical Difficulties

The SBIRS team has addressed and resolved several technical issues over the last 18 months associated with the HEO P/Ls, GEO flight software and first time hardware integration activities. The HEO P/Ls perform better than specifications in many critical requirement areas and will add significantly to our war fighting capability. Nevertheless, the program has experienced several technical challenges, eroding both cost and schedule reserves. The major technical challenges included:

- A poor design and build implementation to comply with the EMI specifications of the HEO P/L
- Faulty hardware and software design of the HEO/GEO flight computers, i.e., the single board computer 'halt' anomalies
- An inadequate architecture design and a flawed flight software development plan for the GEO satellite's Signal Processing Assembly (SPA)

In addition to these design flaws, the SPO continues to discover latent defects and manufacturing process escapes in the system hardware that required significant unplanned resources. The following paragraphs discuss how recently resolved technical issues diverted resources planned for other program efforts.

4.1.1 Electromagnetic Interference (EMI)

EMI is the emanation of conducted or radiated electromagnetic energy that can result in electronic equipment malfunctioning. Due to the classified mission partner, it was critical that the HEO P/L design captured and prevented the escape of these radiated emissions. Unfortunately the design approach to contain these emanations was flawed, as was the implementation of EMI mitigations included in the baseline design. As a result, the HEO 1 EMI signature did not meet specifications. Due to potential schedule impacts to the Host, the option of a time-consuming redesign/rebuild of the HEO P/L was deemed impractical. Consequently, the contractor employed a series of cable and connector wraps, along with several grounding mechanisms, to the P/L to capture these radiated emissions. These techniques significantly reduced the noncompliance, and the classified mission partner has granted a waiver for the remaining specification deviations. In delivering the first HEO P/L, the contractor developed a better understanding of and capabilities for EMI design and test. Lessons learned from HEO 1 were applied to HEO 2 resulting in a significantly improved HEO 2 EMI signature. The HEO EMI issues are now believed to be successfully resolved, and do not impact host performance. The HEO 2 EMI run for record testing in 2nd Qtr FY05 will validate the performance assumptions. Since the GEO P/L flies on a SBIRS-only spacecraft the EMI requirements are much less restrictive. Consequently, the risk of a repeat EMI concern on the GEO satellite is very low, though the appropriate amount of attention is being paid to EMI to ensure it doesn't become a problem for the GEO satellite.

4.1.2 Single Board Computer (SBC) Halts

The HEO P/L receives and processes ground commands, reports on-board telemetry conditions, and formats mission data through the use of on-board processors called Single Board Computers (SBCs). During early HEO 1 Thermal-Vacuum (TVac) chamber testing in 3rd Qtr FY03, there were three occurrences of an unexplained P/L anomaly. The anomaly manifested itself in the actual halt of the SBCs, in which (a) all P/L telemetry data were lost and (b) the P/L would not respond to commands. The ability to troubleshoot this problem was limited by the loss of telemetry after the event, and no conclusions could be drawn from examination of the telemetry immediately before the event. The anomaly rarely occurred, and the next incidence of the problem did not happen until the second P/L thermal vacuum test, in 4th Qtr FY03. As with the previous anomaly, all telemetry was lost at the point of the halt.

Initial troubleshooting efforts isolated the problem to the SBCs, and it was noted that the halt was temperature dependent, occurring when the SBC temperature approached and exceeded 69°C. Troubleshooting isolated the halt to a hardware design problem with a control signal on an Application-Specific Integrated Circuit (ASIC). A software work-around was developed, implemented and successfully tested at the SBC and P/L levels.

Nearly all halts initially observed occurred while the P/L was at proto-qualification hot conditions, i.e., in excess of 69°C. There were, however, two P/L halts at cold or ambient conditions that could not be explained by the high temperature halt mechanism. Starting in late 1st Qtr FY03, there were additional P/L halts that occurred at ambient conditions. As with the high temperature halts, the investigation was hampered by the loss of telemetry resulting from the halt. In late 2nd Qtr FY04, a capability to monitor the SBC memory bus using a special piece of test equipment known as a logic analyzer was developed. An ambient SBC halt was then captured, and with the use of the logic analyzer data, root cause of the ambient halts was determined. This root cause was an intermittent error resulting from the software incorrectly configuring a portion of the SBC hardware. The software has been modified to correct this problem. The effectiveness of the software fix has been successfully demonstrated through test. Final corrections to the SBC software operating system have been incorporated into the flight code for both HEO and GEO. Both the high temperature and ambient halts are now closed issues.

4.1.3 Signal Processing Assembly (SPA) Software

The SPA is one of the GEO satellite's critical components. It provides the command and control interface from the spacecraft to the P/L, processes the radiometric mission data from the infrared sensors, and manages the mission data formatting and communication downlinks to the ground. In 2003, the SPO assessed SPA software development as high risk due to the state of the software architecture, a very aggressive contractor schedule, and inadequate planning. The SPO worked closely with the contractor to replan the SPA software development, resulting in a greatly improved, robust architecture. Successful preliminary and critical design reviews were conducted in the 3rd Qtr FY04 and 1st Qtr FY05 respectively. Consequently, the SPA software is now progressing into the coding phase and the risk assessment is lower. The remaining risk is in software integration and hardware/software integration and test to be completed in 4th Qtr FY06.

4.1.4 Pointing Mirror Assembly (PMA) Crosstalk Jitter

The GEO satellite both scans and stares at the Earth's surface using Pointing Mirror Assemblies (PMAs). These PMAs reflect the Earth's surface areas of interest into the satellite scanner and starer telescopes and are 'read' by the infrared sensors. Significant concern existed over the potential crosstalk jitter, i.e., motion of one mirror causing 'jitter' to the adjacent mirror. With the stringent requirements for line-of-sight accuracy and the critical importance of accurate pointing for the SBIRS Mission, this was a major issue. Design analysis indicated that the dual PMA would meet its allocated jitter requirements; however, to mitigate the risk, a crosstalk test was performed early in the program with engineering hardware. This test validated the ability to meet requirements. This test was repeated in 3rd Qtr FY04 with flight-like hardware and again demonstrated PMA crosstalk jitter to be within allocations to support meeting all system pointing requirements.

To further mitigate jitter concerns, a Space Vehicle (SV) jitter test is planned for 2005 utilizing the GEO 2 spacecraft structure, a P/L structural test article, and numerous mass simulators, sensors, and disturbance sources. This will provide additional characterization of disturbances due to spacecraft components such as reaction wheels, deployable light shade flap mechanism, solar arrays, and steerable antenna mechanisms and verification of PMA performance.

4.1.5 First Time Payload Integration

SBIRS GEO 1 will be a state of the art, first of its kind satellite. First time integration of any new complex space development has inherent risk. Integration encompasses the maturation of production processes and associated personnel as they assemble and operate the hardware and software for the first time. The ultimate result of the integration process is the validation of the system's design integrity. Because of the complexity of the SBIRS space system, prudent mitigation steps have been taken to reduce the possibility of significant schedule impacts.

For risk reduction on the GEO spacecraft, an Early Bus Test (EBT) was developed and is well underway. Testing has already proved successful in the identification and resolution of integration issues before they became critical schedule concerns. EBT is organized into 5 phases to ensure the GEO spacecraft achieves a complete checkout as early as possible. EBT phases 1, 2 and 3 include all spacecraft power-on safe-to-mate tests as well as initial flight software functionality checkout. Phases 4 and 5 add communication subsystem checkout as well as guidance, navigation and control, and the propulsion and thermal control subsystem initial testing.

Also, solid progress is being made on the GEO 1 payload flight article. The Infrared Sensor has been through performance testing and has been integrated onto the payload structure along with the Signal Processing Assembly (SPA) power supply and the Common Gyro Reference Assemblies (CGRAs). These are key steps on the way to allowing the GEO 1 payload to go into its first workmanship thermal-vacuum test. The test encompasses the initial checkout of integrated payload hardware and software in a space-like thermal and vacuum environment. The test will also include dry runs of the payload functional and performance-testing activities associated with formal acceptance of the payload. This event is a key risk reduction activity for the GEO program and is scheduled to complete in the 3rd Quarter of FY05.

The combined efforts of the spacecraft EBT and payload workmanship thermal vacuum test provide considerable risk reduction to mitigate first time integration concerns on GEO 1.

4.2 Adjustments to Management

The SPO/contractor management initiatives are designed to better focus resources on key program issues, and to provide increased visibility into progress on those issues. The goal is total mission assurance in the fielding of the satellites and implementation of the ground systems that control their operations and process/distribute their data.

4.2.1 Event-Driven Approach

At a strategic level, the SBIRS program has formally adopted an 'event-driven' approach, replacing the 'schedule-driven' mentality of the past. The event-driven approach requires definition of entrance and exit criteria for key events. If these criteria are not met, then the event will be postponed until program maturity is acceptable for entrance into the event. While this may add time to the schedule initially, it ensures the program no longer enters an activity unless the probability for success is high. This approach eliminates most, if not all, of the unscheduled activity generated from action items, which result from an unsuccessful event. Normally, this unscheduled activity, or work, was not captured in the previous earned value management process.

An example of the new 'event-driven' approach was the completion of the GEO Signal Processing Assembly software CDR. This activity was a high-level interest item because it defines the critical path for delivery of the GEO P/L. Working together, the contractor and SPO delayed the scheduled start of the review to allow additional time to mature CDR documentation and to resolve issues on throughput analysis. This decision was consistent with emphasizing mission success/assurance as the most important aspect of the work, while retaining appropriate focus on cost/schedule performance.

4.2.2 Revised Business Rhythm

The program's 'business rhythm' has been adjusted to increase the tempo of information exchange, which enables aggressive management response to emerging issues. A key element of the new rhythm is a series of weekly one-hour meetings on each key development effort/major area of interest. These meetings include telecon and collaborative computer connections, to enable participation by all interested parties, including government personnel. These weekly meetings complement and reinforce the monthly in-depth reviews conducted by the space, ground, and systems engineering segments of the program. In addition to these specific reviews, the system-level Program Management Review (PMR) has been revised in terms of discussion topics and participation. The PMR is a comprehensive, integrated program review of crosscutting issues and initiatives, held every six weeks. Interspersed between the PMR meetings are executive-level, business-focused discussions relating to cost performance, funding status, and detailed schedule metrics. Another aspect of the improved business rhythm is a weekly telecon between the System Program Director (SPD) and his contractor counterpart, supplemented by a small number of senior personnel as topics dictate, dedicated to addressing strategic program issues. Topics range from specific segment issues having crosscutting impact to industry-wide activities that offer potential program benefit. A final aspect of the revised business rhythm was implementation of more detailed and disciplined program baseline control. This increased level of oversight and review allows both SPO and contractor leadership to better manage personnel and resources to proactively bring in additional expertise to resolve issues.

In addition, the SPO has initiated a multi-pronged process designed to identify issues quickly, communicate specific concerns, collaborate to find effective agreed-to solutions, and ensure appropriate focus and senior level insight is maintained.

- Identify Issues – The revised business rhythm previously discussed has strengthened the identification process. The regularly scheduled, program segment specific, hour-long telecons highlight near-term critical path activities. The segment lead discusses performance metrics, detailed schedules, interdependencies, and risks. Briefing charts are posted on the program specific internal web site and are readily available. These weekly meetings provide almost near real-time identification of issues affecting the segment and potential impact on other areas.

- Communicate Specific Concerns / Collaborate on Solutions - The SPO provides a monthly feedback letter to the contractor. All issues are vetted between the SPO and contractor counterpart prior to inclusion in the letter. The letter identifies unresolved areas of concern that require program management attention. Normally, each item is discussed at the next program management review and a proposed approach for resolution is presented for concurrence and implementation. To reach early consensus on technical solutions, the contractor encourages candid assessments, open meetings, and a decisive appraisal of inter-segment dependencies to expedite issue resolution.

- Ensure Senior Level Insight / Focus – The SBIRS contractor provides the AF PEO/SP a monthly letter which highlights accomplishments, future risks and mitigating actions to minimize impacts. These letters originate at a senior contractor corporate level and drive an executive level, proactive-vice reactive-approach to detrimental programmatic events. These monthly letters are an additional means to ensure senior leadership is aware of emerging issues. For example, the focus on process escapes began as a monthly feedback item (Issues Identification) and quickly escalated as a special interest item discussed in the executive oversight meetings.

4.2.3 Collaborative Test Activities

The SPO staff has increased its participation in establishing test requirements, test plans, test procedures, test conduct, and data evaluation / reporting. SPO representatives gain further insight by participating in Test Readiness Review (TRR) and Test Exit Review (TER) activities for major subsystems, integration, qualification, acceptance, launch base processing, Initial Early Orbit Test (EOT) and Follow-on EOT and P/L Calibration activities. In addition, the SPO has TRR/TER approval authority for selected tests, such as space/ground interface tests and launch base confidence tests.

At the TRR, the SPO reviews test-specific documentation such as test requirements, plans, procedures, support equipment availability, etc. The SPO collects satellite and ground related test results and discrepancy information. This material is reviewed and the TER confirms that the test goals are met and there are no liens against proceeding to the next phase.

4.2.4 Performance Insight

Each month, the contractor’s Earned Value Management System (EVMS) information is reviewed and analyzed by the SPO’s cost analysis and technical staff. Results are briefed to the SPD and Program Managers and are also reported in the Monthly Acquisition Report to the AFPEO/SP.

Recently the contractor implemented a more disciplined system requiring business manager approval to implement baseline changes that affect any other element of the program. It also requires the working project managers to complete a quarterly review of their Estimate At Complete (EAC). The 2004 replan baseline was implemented in Real Time Project (RTP), a scheduling tool that identifies critical paths and links interdependencies across the program. This tool is very beneficial in conducting ‘what if’ analyses to understand effects of delayed milestones on future planned work. Early detection of potential program issues and future impacts provides the forward-looking insight required for successful program execution.

4.3 Adjustments to Contract Arrangements

The SBIRS Engineering Manufacturing and Development (EMD) contract is a Cost Plus Award Fee (CPAF) contract. While not changing the basic contract structure, three adjustments must be made to implement the 2004 program replan. The first adjustment is the contractor implementation of an Over-Target Baseline (OTB) to realign the program to the revised cost and schedule values. This OTB was developed with government insight and represents an aggressive, but executable, program plan. The risk profile for the contractor’s baseline is higher than the risk profile associated with the government’s cost and schedule projections. The OTB has been implemented in the contractor’s EVMS program and the contractor is reporting performance against the plan. The contractor and SPO team are also nearing completion through the configuration control process to update the Integrated Master Schedule / Integrated Master Plan (IMS/IMP) to reflect the new baseline.

The second adjustment was the revision of the incentive fee structure. The SPO modified the incentive program to ensure that the contractor was incentivized to perform on the ‘to go’ work. Key elements of the revision are: shortening the evaluation periods from 12 months to six months, focusing the evaluation criteria on specific areas and events, creating separate criteria to evaluate the sustainment activities, and realigning the available fee to the rescheduled program events. The revised incentive plan also deferred all FY05 RDT&E award fee to later award fee periods in order to reward actual delivery of capabilities. Finally, the cost plus incentive fee feature was removed from the contract, and all cost incentives are now contained in the award fee criteria.

The final adjustment is the inclusion of the program effort required to deliver the GEO-capable Multi-Mission Mobile Processors (GM3Ps). The SPO anticipates issuing a Request for Proposal (RFP) in 2nd Qtr FY05 and the shoulder-to-shoulder contracting effort will conclude in fall 2005.

5. Remaining Risk Areas

The SBIRS Program continues to face many risks due to its complexity, technical difficulties, and acquisition philosophy in place at program inception. The SPO has successfully identified and mitigated significant risks over the course of the development program. The contactor and the SPO jointly performed risk management from 1996 through 2002, since the contractor had Total System Performance Responsibility (TSPR). In 2002, the SPO reacquired TSPR. The current risk assessments shown herein represent the SPO's perspective, although most of the active risks are also recognized and managed by the contractor, either within their risk management system or as active issues**.** There are, however, some risks that accrue to the government, not the contractor, such as SPO staffing and access to operational assets for development testing. (See below, Section 5.3).

Section 5.1 presents the SPO risk management process, Section 5.2 reviews the current status of risks identified at previous points in the program, and Section 5.3 assesses current risks and discusses planned mitigation activities.

5.1 SBIRS Risk Management Process

The SBIRS SPO has implemented a structured process to identify risks, assess their impacts, and execute effective mitigation activities. The risks are handled at two levels: risks that impact the whole program or cut across more than one segment are managed at the system level by the System Risk Board (SRB), and those risks affecting only a single segment are managed by the segment risk process. The contractor team (including subcontractors) also has a structured risk management program following an approved process controlled by the prime contractor. Contractor and SPO risk management activities are coordinated (Figure 3) to avoid duplication, while ensuring that government and contractor-unique impacts are identified and managed by the appropriate process. Coordination occurs at multiple levels: between action officers, at the segment level, at the system level, and between program managers.

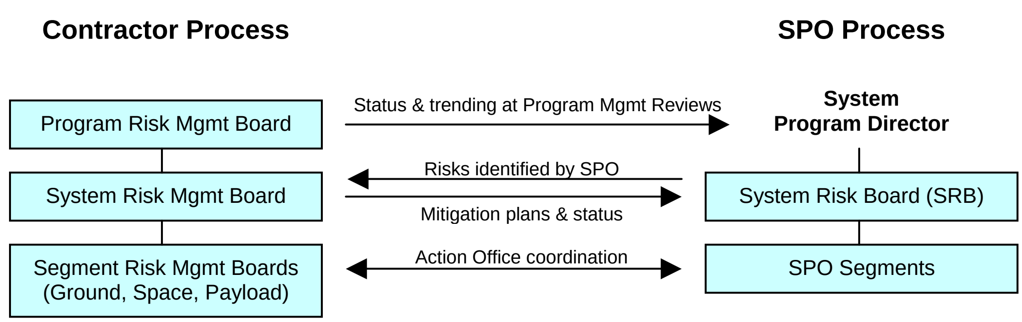
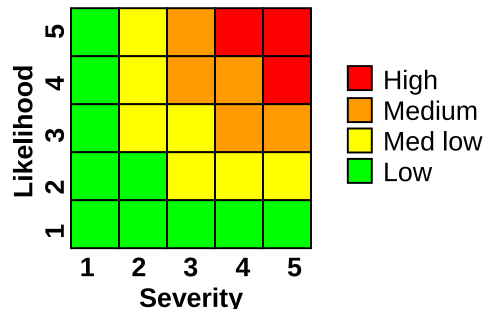


Figure 3. Coordination of SBIRS SPO and Contractor Risk Management Processes

The SPO-managed risks are categorized by both the potential severity of consequence as well as by the probability of occurrence; each category is graded as high, medium, medium/low, and low risk (Figure 4).

Likelihood	Rating	Technical Risks	For Cost / Schedule Risks
	1	< 0.5%	< 20%
	2	0.5% to 1%	21% to 40%
	3	1% to 5%	41% to 60%
	4	5% to 10%	61% to 80%
	5	>10%	> 80%



Severity						
Rating		1	2	3	4	5
Magnitude of Impact	Technical	Minor inconvenience; < 5% utility loss, e.g., infrequent safehold transition without damage	Significant impairment of margin or secondary missions; 6-15% utility loss, e.g. degradation in thermal control, ACS, or battery	Major impairment of margin, design life, or secondary missions; 16-45% utility loss, e.g. frequent safeholding or power shedding, high noise	Severe impact; 46-75% loss of utility, e.g. permanent loss of redundancy, failure to meet key mission objective, early mission termination	Catastrophic Beginning of Life (BOL) failure
	Schedule	Minimal or no impact	Erode segment schedule margin by > 5%	Erode system schedule margin by > 5% or segment margin by > 25%	Erode system schedule margin by > 25%	Delay key effectivity date or event, e.g. delay of launch, delivery of missile warning capability
	Cost	< $200K	$200K to $1M	$1M to $10M	$10M to $50M	> $50M

Figure 4. Severity and Likelihood Criteria for Program Risks

5.2 Historical Risks

The evolution and mitigation of SBIRS program risks is shown using the critical program risks identified in 1996, 1999 and 2002. At these junctures, rigorous and documented risk assessments were performed to support significant acquisition milestones/events.

5.2.1 Review of 1996 Risks

Table 2 illustrates the program risks as assessed in 1996, at the beginning of the EMD effort, along with the SPO's current assessment of those risks. Section 5.3 discusses the risks that are still active. The 1996 risks, originally scored in a wide range of values, have been recast as high (red), medium (orange), medium-low (yellow), and low (green).

The 1996 risk assessment anticipated numerous SBIRS-unique, technical challenges, such as the Focal Plane Assembly (FPA) and P/L thermal control. Some risks were mitigated, but others such as the CGRA were realized and led to technical difficulties. Over time the majority of these realized risks were resolved, except for software, which proved very troublesome during the HEO development activities and is assessed by the SPO as a continuing risk for GEO integration and test. (See 2004 risk list # 19, 22, 33 and 46 -- all address software risks). At this point in the program, the hurdles are not technical, but rather they are largely execution-related, with potential cost and schedule impacts.

Risk/ 1996 Assessment			2004 Assessment
System integration and test	H		Risk realized
Increment 1 and 2 ITW/AA certification	H		Risk realized for Increment 1
Ground Segment integration and test	H		Risk realized
Spacecraft software	H	M	Residual risk carried by S0019, S0022, S0025
Ground Segment network mgmt/control	H	ML	Residual risk carried by S0035
Payload signal processing	H	ML	Residual risk carried by S0022
External interfaces	H	L	Risk mitigated
Transition	H	L	Risk mitigated
Gimbal and pointing mechanisms	H	L	Risk mitigated
Focal plane assembly	H	L	Risk mitigated
Ground software cost and maintainability	M	ML	Risk realized, Residual risk carried by S0033
Mission Management software	M	M	Residual risk carried by S0035
Gyro Reference Assembly (CGRA)	ML		Risk realized
Integrated SV LOS	ML	ML	Residual risk carried by S0021
Communication architecture	ML	L	Risk mitigated
Survivability	ML	L	Risk mitigated
Replenishment (constellation concerns)	L		Not Applicable
HEO P/L integration and test	L		Risk realized
M3P cost containment	L		Risk realized
Launch vehicle selection	L	L	Risk mitigated
SV design integration	L	L	Risk mitigated
SV integration and test	L	M	Generally mitigated. Residual carried by S0025
S/C integration and test	L	M	Generally mitigated. Residual carried by S0025
Command and data handling	L	L	Risk mitigated
Communication link performance	L	L	Mostly mitigated. Residual carried by S0055
Solar scatter and corrector plate	L	L	Risk mitigated
P/L thermal control	L	L	Risk mitigated
GFE availability and dependability	L	L	Risk mitigated

Table 2. Risk Identified at 1996 EMD Start

All the other residual risks are more specific and should be more manageable. For example, communication link performance was treated as a one of the top 28 risks in 1996, albeit a low one, because future communication link performance was unknown and there was a question whether the links would close at all. Today, the risk is all but mitigated—confined to the confidence test of one link—and is managed with a well-defined mitigation plan. All other risks carried over from 1996 are likewise considerably less threatening.

5.2.2 Review of 1999 Risks

Table 3 shows the top ten SBIRS risks identified during the 1999 program restructure. Two risks were realized, four were completely or largely mitigated, two were partially mitigated. Again, flight software proved the exception—it did not receive much attention in 1999 but was found during HEO integration to be unexpectedly difficult.

Risk/1999 Assessment			2004 Assessment
HEO Payload Integration with Host	M		Realized due to EMI problems
HEO Payload development schedule	M		Partially realized (e.g., SBC halt)
GEO P/L integration, assembly, and checkout	M	M	Risk carried by Risk S0025
Integrated Line-of-sight performance	M	ML	Risk carried by Risk S0021
Focal Plane performance, yield, schedule	M	L	Successfully mitigated
Pointing Control Assembly: Performance	M	L	Successfully mitigated
Payload Signal Processing Hardware and algorithms	M	L	Residual risk carried by several lower impact risks in specific areas
Flight software development and integration	ML	M	Risk carried in part by Risk S0025
Ground software development and integration	ML	ML	Risk carried by Risk S0033
Space to ground integration/interface	ML	L	Successfully mitigated

Table 3. Status of Risks Identified by the 1999 Joint Evaluation Team

5.2.3 Review of 2002 Risks

The status of risks highlighted in 2002 as a part of the Nunn-McCurdy certification are shown in Table 4 (the 2002 assessment used 3-levels and some of its ratings have been adjusted to the 4-levels currently adopted by the SPO).

Again, most of the 2002 risks were either completely or partially mitigated. For example, as discussed earlier, the wide-ranging concern with GEO downlink closure was reduced to a low-level risk regarding a specific space-to-ground link, with an approved mitigation plan.

The risk rating on two items has increased over time. First, the contractor had an Anomaly Detection and Resolution (ADR) plan and therefore rated the risk ‘low,’ but as the contractor implemented the plan in 2003, they realized that the plan was under-scoped, making it necessary to reclassify the risk of meeting derived ADR requirements as ‘medium.’ Second, based on the HEO development experience, the SPO reclassified the risk for developing GEO databases to ‘medium’ even though much progress was made in this area over the past five years.

Three risks remained at the same nominal level in 2004 as in 2002, but mitigation paths have been approved in each case. In 2002, a concern with anomaly management process resulted in Risk SY-29. Today, the concern is focused specifically on the process by which Failure Review Board (FRB) actions are captured by the anomaly management documentation. Although this particular 2004 risk has sufficient severity and likelihood to keep it ‘medium,’ in fact considerable progress has been made.

Risk/2002 Assessment			2004 Assessment
SY-2 SPOTS availability	M		Successfully mitigated
SY-3B GS HEOT Schedule	M		HEOT Delivered
SY-43 HEO FSW Schedule	M		HEO FSW Delivered
SY-13 Space-to-Ground interfaces	M	L	Successfully mitigated
SY-9 M3P Milstar Certification	M	L	Successfully mitigated
SY-45 Increment 2 Flight S/W schedules	M		Risk realized
SY-11 HEO Payload database	M	M	Improved, database risk carried by Risk S0046
SY-16 End-to-End verification	M	M	Risk carried by Risk S0051
SY-39 Integrated GEO LOS	M	ML	Risk carried by Risk S0021
SY-14 SBIRS Information System	M	L	Successfully mitigated
SY-5 System Transition Plan	M	L	Successfully mitigated
SY-8 Assured access to space	M	L	Weight issues were successfully mitigated
SY-10 Increment 2 Interdependencies	M	L	Risk mitigated
SY-12 Theater impact point prediction	M	L	Risk mitigated
SY-25 HEO interdependencies	ML		HEO 1 Delivered
SY-1 HEO P/L schedule	ML		Risk realized
SY-41 Proto-qual failures	ML		Risk realized
SY-42 GEO databases	ML	M	Carried by Risk S0046
SY-29 Anomaly management	ML	ML	Risk carried by S0058
SY-4 KGV-30	ML	L	Risk mitigated
SY-15 Increment 2 SASC availability	ML	L	Risk mitigated
SY-40 SORD funding	ML	L	Risk mitigated
SY-7 GEO downlink closure	ML	L	Mostly mitigated – tracking risk S0055 is 'low'
SY-32 No exploitable holes definition	ML	L	Risk mitigated
SY-30 Ground ADR	L	M	Carried by Risk S0045

Table 4. Risks Identified During the 2002 Nunn-McCurdy Certification

5.3 Current Risks

The SBIRS SPO actively tracks 21 risks, none of which are rated high, but eleven are rated medium risk. These risks are discussed below in Section 5.3.1. Section 5.3.2 summarizes items that have been of interest in the past, but are currently considered to be low risk by the SPO.

5.3.1 Top Program Risks (SPO Risk Board Assessment)

Few of the remaining risk items that the SPO is tracking represent technical challenges in the sense that the science or hardware is in question. Early program concerns about the performance or producibility of the sensors have been mitigated. Items remaining are predominantly integration, process, and execution challenges while technical risks are mostly associated with flight and ground software and with first-time integration efforts.

5.3.1.1 Quality and Mission Assurance Risks

As shown in Table 5, a number of the risks cluster around issues of quality and mission assurance. These new risks result from program experience and reflect the concerns recognized in the Report of the Defense Science Board/Air Force Science Advisory Board

Joint Task Force on Acquisition of National Security Space Programs. This task force pointed out that SBIRS was "implemented during an era of questionable practices" and predicted the necessity for "additional testing to mitigate omissions and embedded problems." These program risks provide a discipline for tracking the program's efforts to drive out any remaining latent problems and to implement 'best practices' in mission assurance. Section 4 of this report provides additional discussion of these corrective actions.

Risk #	Risk Description	Rating
S0020	Payload Reference Bench Contamination	ML
S0026	Limited Payload Testing at SV Level	ML
S0029	Hardware Quality & Process Escapes	M
S0051	Test Like you Fly adherence	M
S0052	Mission Assurance	M

Table 5. SPO Risks Associated with Quality and Mission Assurance

5.3.1.2 First Time Risks

Another group of risks shown in Table 6 address the fielding of the first elements in a new system. The integration of new system elements (spacecraft bus, satellite, launch vehicle, ground systems) is inherently risky because this is the first time that the interfaces for these flight articles are exercised. The use of a proto-qualification approach rather than building a qualification unit for the GEO space vehicle requires Integration & Test (I&T) risk reduction via simulators or testing on flight hardware. Deployment of the first assets and the transition of facilities to operational use will add complexity to the integration and test of the second wave of vehicles, e.g. GEO 2, because of the requirement to use operational assets in developmental testing. The maturity of operational tools, including mission processing algorithms, flight operations products, and user interfaces (human factors) for three new sensors will continue to be a focus item.

Risk #	Risk Description	Rating
S0013	Complexity in first launch vehicle integration may impact schedule	ML
S0025	G1 SV 1st Article H/W & S/W Integration & Test	M
S0028	Limited GEO Test bed Capability	ML
S0030	Test Resource Availability	M
S0034	Human Factors Engineering (HFE) Maturity	M
S0035	Mission Processing Maturity Plan Inadequately Defined	M
S0058	Flight Operations Products Immature	ML

Table 6. SPO Risks Associated with First Time Events

5.3.1.3 Software Related Risks

Program risks remain in the execution of the software development and test efforts (Table 7). The SPA software CDR has provided increased confidence in the way forward for the software development program, but the program continues to carry risks associated with the integration and total performance of the combined SPA and Pointing and Control Assembly (PCA) hardware and software elements. The ground software development is progressing steadily, but the SPO is maintaining continued vigilance on the total size of the software Equivalent Lines of Code (ELOC) and on contractor coding efficiency, either of which could impact schedules. Problems with database development have impacted the ground software development efforts and have delayed system test events. While a number of steps are being implemented to improve the database tools, processes, and staffing, the SPO carries database quality as a risk until the benefits of these improvements are realized.

Risk #	Risk Description	Rating
S0019	SPA & PCA S/W Integration Risk	M
S0021	GEO Line of Sight (LOS) Performance	ML
S0022	GEO SPA H/W & S/W Performance	ML
S0033	Growth in Contractor Ground Software ELOC	ML
S0046	SBIRS Database Quality	ML

Table 7. SPO Risks Associated with Software and Data

5.3.1.4 Additional High Priority Risks

Table 8 shows three other risks that the SPO currently rates as medium. Two are technical and one is a management/resource issue.

Risk #	Risk Description	Rating
S0031	SPO Staffing / Skill Mix vs. Need	M
S0045	Ground ADR Implementation	M
S0057	Theater Probability of Warning and TI Focused Area Probability of Collection	M

Table 8. Other Medium-Rated SPO Risks

S0057 is a risk to some theater performance requirements for specific targets under certain conditions. Identified resolutions are under review by both the space and ground segments and their recommendations will be brought to the program's System Engineering Review Board (SERB) early in Calendar Year (CY) 2005.

S0045, the ground ADR implementation risk was discussed above, in Section 5.2.3.

Risk S0031, SPO Staffing, is an issue that affects all Air Force space system acquisition programs. The SPO is mitigating this concern by adopting a robust training program for junior staff, stabilizing levels of Federally Funded Research and Development Center (FFRDC) support and increasing civil service and System Engineering / Technical Assistance (SETA) personnel.

5.3.2 Other Risk Items of Interest

Table 9 presents a list of risks that have been of interest to the program and to various other stakeholders, that the SPO presently rates as low. (See also Section 4.1.)

Risk #	Risk Description	Rating
S0015	SPA Software development and Test	L
S0042	Solar Flyer Risk	L
N/A	Mirror Jitter Coupling	L
N/A	GEO Electromagnetic Interference	L
S0043	Starer Sensor	L
S0055	Link Closure	L

Table 9. Summary of Other Risks of Interest

Perhaps the most visible of the risks in Table 9 is SPA software development. SPA software development was, until recently, considered to be at much higher risk. However, with the successful completion of the SPA software critical design review (to the satisfaction of the prime contractor, the SPO, and DDR&E) the risk forward for SPA software development has been reduced substantially. The SPO Risk Board is still carrying risks associated with SPA and PCA hardware and software integration and performance.

The solar flyer concept is the subject of continued performance analysis with final demonstration during EOT. However, the concept has been demonstrated on other operational programs, and the risk to go is rated as very low.

There has been concern that it will not be possible to eliminate mirror jitter and/or cross-talk for the GEO P/L. The SPO now considers this risk to be low. Substantial mitigation was achieved in a mirror cross-talk test completed in 3rd Qtr FY04 using flight hardware. A complete space vehicle jitter test, planned for 4^{th} Qtr FY05 is expected to retire this specific risk item, and residual risk will be carried in an overall GEO Line of Sight (LOS) pointing/control confidence risk.

Given the difficulties experienced with HEO sensor EMI, interest in EMI for the GEO space vehicle is natural. The SPO considers this to be a low risk item because requirements for GEO are significantly less stressing than for HEO and therefore more easily achievable. Early P/L unique tests are planned to verify performance is adequate.

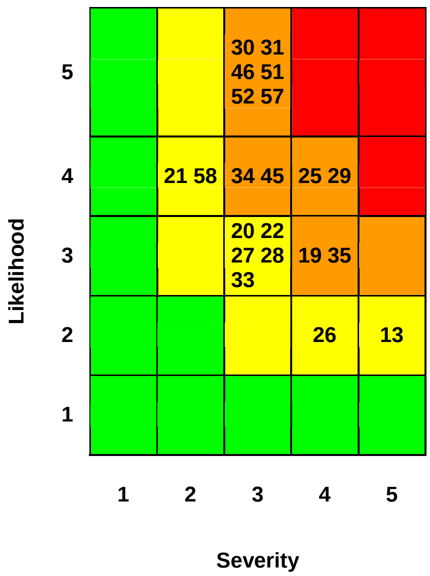
Early in the program there was concern that the starer design and requirements were not achievable. This risk is largely mitigated by the facts that: the HEO focal plane, which has a high degree of commonality with the GEO focal planes, has been delivered and performed better than specifications required in ground testing; and the GEO 1 starer sensor flight hardware has been built, tested and is currently being integrated into the P/L. Residual risk is carried under algorithm and other signal processing risks discussed in Section 5.2.2.

The Link Closure risk is discussed above, in Section 5.2.1

5.4 Summary Program Risk Assessment

Figure 5 summarizes the 21 top risks identified by the SPO's Risk Board. The board assessed ten of these risks as being medium and eleven as being medium-low.

All of these risks have mitigation plans. If all the planned mitigation steps for these top risks were successful, then nineteen of the risks would burn-down to a low risk assessment. Two of the risks, S0051 (Test like you fly) and S0052 (Mission assurance) would burn-down from medium to medium-low. Of course, some mitigation steps may encounter difficulties and also new risks will be identified as the program continues. However, the risk management process anticipates both contingencies.



Risk #	Risk Description	
S0013	Complexity in first launch vehicle integration may impact schedule	ML
S0019	SPA & PCA S/W Integration Risk	M
S0020	Payload Reference Bench Contamination	ML
S0021	GEO Line of Sight (LOS) Performance	ML
S0022	GEO SPA H/W & S/W Performance	ML
S0025	G1 SV 1st Article H/W & S/W Integration & Test	M
S0026	Limited Payload Testing at SV Level	ML
S0027	Limited Spares for GEO 2 Production & Test	ML
S0028	Limited GEO Testbed Capability	ML
S0029	Hardware Quality & Process Escapes	M
S0030	Test Resource Availability	M
S0031	SPO Staffing / Skill Mix vs. Need	M
S0033	Growth in Contractor Ground Software ELOC	ML
S0034	Human Factors Engineering (HFE) Maturity	M
S0035	Mission Processing Maturity Plan Inadequately Defined	M
S0045	Ground ADR Implementation	M
S0046	SBIRS Database Quality	ML
S0051	Test Like you Fly adherence	M
S0052	Mission Assurance	M
S0057	Theater Probability of Warning and TI Focused Area Probability of Collection	M
S0058	Flight Operations Products Immature	ML

Figure 5. Summary SPO Risk Board Top Risk Items

The charter of the SPO's Risk Board requires that the board members remain actively engaged in monitoring risk burn-down efforts. In addition, the SPO's risk management process calls for risk identification to be an ongoing process. In short, the SPO has a process to ensure that existing risks are successfully mitigated, to systematically identify any new risks that develop, and to successfully mitigate these new risks.

SBIRS remains a challenging program, with noticeable risks to mitigate. However, the development program has progressed to the point that known risks are largely execution risks, not technology maturity risks.

6. Schedule Confidence Assessment

6.1 Schedule Analysis Process

The SPO used a qualitative approach to assess the schedule. SBIRS Space, Ground, and Systems Engineering, Integration, and Test (SEIT) segments provided subjective assessments of the schedule based upon selected evaluation criteria. The segment leads' assessments were based upon program management reviews with the contractor, software modeling, and historical experience from other space programs. The basis for the assessment was the government schedule, vice contractor schedule, as of 1st Qtr FY05. The assessment derives from the methodology used to develop the 2004 replan schedule. The contractor team provided a replan schedule that the SPO assessed as too optimistic. As a result, the SPO allocated additional time and money to ensure a higher confidence schedule. The SPO identified longer time spans to complete probable rework resulting from first time integration and test issues, and more robust testing, software development, integration, qualification test and system tuning.

6.2 SBIRS Schedule

The current SBIRS government schedule is displayed below in Figure 6. These dates represent the SPO's current estimates and were used to develop both schedule and confidence assessments.

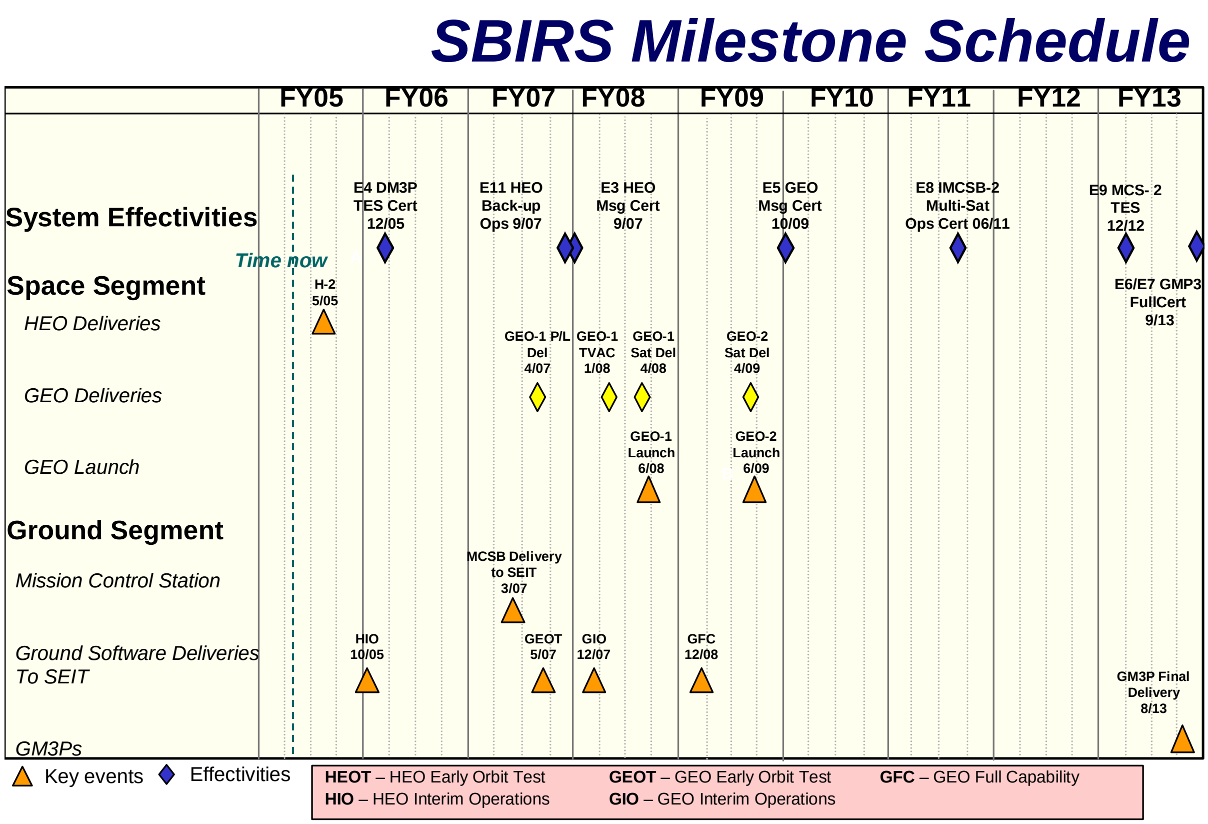


Figure 6. SBIRS Program Schedule

6.3 Technical/Schedule Risk Analysis Methodology

The SPO used the following criteria, in conjunction with management judgment, for evaluating the schedule.

High Confidence Level

- Schedule has significant slack time (greater than 20%)
- Analogies (recent and for SBIRS) exist for these type of activities
- Event-driven schedule

Medium Confidence Level

- Schedule is adequate
- Analogies exist for these type of activities
- Mostly an event-driven schedule

Low Confidence Level

- Schedule is too short (e.g., negative slack time)
- Management-directed schedule and not an event-driven schedule

The items identified for evaluation included the SBIRS System Effectivities, milestones contained in the Selected Acquisition Report (SAR) and selected significant activities.

6.4 Schedule Risk Analysis Results

The resulting schedule assessments are displayed below in Table 10. The Effectivities and Space events have a confidence level of Medium. The Ground Segment events have a confidence level ranging from Medium to High. The overall schedule confidence level is Medium. These confidence levels are based upon the current SPO schedule with the milestone dates specified below.

High Confidence   Medium Confidence   Low Confidence

EVENT	DATE	CONFIDENCE LEVEL
SYSTEM EFFECTIVITIES		
DM3P TES Certification (E4)	Dec-05	Medium
HEO Back-up Ops (E11) (MCSB-H)	Sep-07	Medium
HEO Message Certification (E3)	Sep-07	Medium
GEO Message Certification (E5)	Oct-09	Medium
IMCSB-2 Multi-Satellite Certification (E8)	Jun-11	Medium
MCS Inc 2 TES Certification (E9)	Dec-12	Medium
GEO M3P Full Certification (E6/E7)	Sep-13	Medium
Increment 2 Complete (E10)	TBD	TBD
SPACE SEGMENT		
HEO Sensor 2 Delivery	May-05	Medium
GEO 1 Payload Delivery	Apr-07	Medium

EVENT	DATE	CONFIDENCE LEVEL
GEO Satellite 1 TVAC	Jan-08	Medium
GEO Satellite 1 FIST	Apr-08	Medium
GEO 1 Satellite Delivery	Apr-08	Medium
GEO 2 Satellite Delivery	Apr-09	Medium
GEO 1 Launch	Jun-08	Medium
GEO 2 Launch	Jun-09	Medium
GROUND SEGMENT		
MCSB-H Delivery to SEIT	Mar-07	High
HIO	Oct-05	Medium
GEOT	May-07	Medium
GIO	Dec-07	Medium
GFC	Dec-08	Medium
GM3Ps Final Delivery	Aug-13	Medium

Table 10. Schedule Confidence Summary

6.5 System Effectivities

A system effectivity date is the point at which a major system capability becomes available to the user. Effectivities are not tied to accomplishment of specific Operational Requirement Document (ORD) requirements (many of which are specified at a constellation level, and therefore will not be achieved until four GEO satellites and two HEO P/Ls are in orbit in the next decade). Effectivities are defined by joint agreement between the SPO, user community, and contractor, and are tested appropriately to confirm the agreed-to level of capability is achieved. To date, two effectivities have been delivered to the user, i.e., the Interim MCSB and the Integrated Training Suite (ITS). In addition the Increment 1 MCS was also delivered to the user prior to the establishment of effectivities. There are nine remaining effectivities described below. A confidence assessment, for meeting the effectivity date, is provided for each effectivity.

- The Defense Support Program (DSP)-capable Multi-Mission Mobile Processor (DM3P) Theater Event System (TES) Certification (Effectivity 4) provides initial TES certification for two DM3P Theater units. Significant work has been accomplished on this effort but there is little schedule margin remaining should a significant latent defect be discovered during final testing. Schedule confidence for meeting this capability is Medium.

- The HEO Mission Control Station-Backup (MCSB-H) effectivity (Effectivity 11) provides the ability to process and disseminate HEO sensor data to the military and intelligence community users from a fully certified, ORD-compliant operational facility. This effectivity closely follows Effectivity 3 (discussed below) and will carry the same confidence rating as that effectivity due to the close coupling of activities. Schedule confidence for meeting this capability is Medium.

- The HEO Message Certification (Effectivity 3) provides HEO 1 P/L and associated ground hardware and software functionality to generate HEO mono track data for processing in the IMCSB-1 and MCS-1, in addition to providing HEO data to the

Intelligence Community. While the HEO 1 sensor has already been manufactured, tested, and delivered and the IMCSB-1 and MCS-1 are operational, there are still challenges associated with tuning of a new sensor and demonstrating that its data can be fused successfully with the operational SBIRS system without performance degradation. Schedule confidence for meeting this capability is Medium.

- The GEO Message Certification (Effectivity 5) provides GEO 1 satellite/P/L and associated ground hardware and software functionality to generate GEO monotrack data (from the scanning sensor) for processing in the MCS-1 and the IMCSB-1. Currently the GEO space hardware unit / box-level integration, test, and checkout is underway. The ground segment hardware and software configuration items are being designed or procured. While significant risk for the GEO 1 space vehicle has been retired (most of the GEO 1 hardware has been procured and built-up and the software development is back on-track), risk remains in the integration, test, and checkout of the space vehicle and its primary sub-systems. For the most part, the ground segment has finalized their design efforts and is beginning coding and unit-level integration and test. Thus, confidence in the space and ground segment deliveries leading up to E5 is rated at medium. In addition, there are still challenges associated with tuning of a new P/L and demonstrating that its data can be fused successfully with the operational SBIRS system, without performance degradation. Schedule confidence for meeting this capability is Medium.

- The IMCSB-2 DSP/HEO/GEO Multi-Satellite System Certification (Effectivity 8) provides integrated DSP, HEO, and GEO mission capability in the IMCSB-2. This effectivity is the first time where integrated DSP, HEO, and GEO operations (Tracking, Telemetry, and Control (TT&C), mission processing, and ground system control) will be integrated into one facility. This Effectivity also includes the activities necessary to deliver both HEO 2 P/L and GEO 2 satellite capabilities to orbit and the Government Extended DT&E/operations approval of these capabilities, as well as those associated with the HEO 1 P/L and GEO 1 satellite. The confidence in delivery of the HEO 2 sensor is rated at medium and the confidence in GEO 2 delivery / launch and GFC delivery is medium. This effectivity requires substantial external agency coordination including the AFOTEC and AFSPC test and certification events. Schedule confidence for meeting this capability is Medium.

- The MCS-2 ITW/AA System, TES, and NMD System Certifications (Effectivity 9) are the conclusion of major program activities that certify the MCS-2 capable to perform Increment 2 missions and declare that the MCS-2 is a valid source of Increment 2 mission messages. This effort is replicating the Effectivity 8 capability into the MCS, an ORD-compliant operational facility. Substantial government margin has been added to reduce the risk of meeting this effectivity. Schedule confidence for meeting this capability is Medium.

- The GEO Air Force M3P Survivable/Endurable ITW/AA System Certification (Effectivity 6) provides four Air Force M3Ps with GEO capability, GEO M3P (GM3P) software, and ancillary DSP S-Band Kits. The Army GM3P Survivable/Endurable ITW/AA System and Theater Event System (TES) Certification (Effectivity 7) provides five Army Theater M3Ps with GEO capability and GM3P software (upgrades the five DM3P units provided for E-4). The associated System DT&E / Multi-service OT&E program will also demonstrate that the Army Theater GM3Ps can provide the survivable/endurable relay capability required to support survivable/endurable ITW/AA System operations. As discussed previously this effort requires a final contract modification to complete the 2004 replan. The schedule for this remaining effort has already been developed based upon events leading to Effectivity 4. Schedule confidence for meeting this capability is Medium.

- The Increment 2 Complete (Effectivity 10) concludes the Increment 2 development and deployment of the SBIRS full constellation. Confidence in the E10 schedule is impacted by the accumulation of medium confidences for earlier effectivities. In addition, E10 requires the full SBIRS constellation on orbit (4 GEOs and 2 HEOs) and there remains some uncertainty regarding the procurement schedule for GEO 3-5, due to the ongoing review of the technology insertion / block upgrade options. Until a decision is made on the block upgrade schedule, confidence on this final increment cannot be reliably assessed.

6.6 Space Segment

The SBIRS constellation consists of four GEO satellites (the fifth satellite is planned as a replacement spare) and two infrared (IR) HEO sensors hosted on classified satellites. The GEO spacecraft bus is based on cost-effective use of existing commercial production line facilities and practices. The IR sensors for GEO and HEO are based on a cost-effective design with a high degree of parts commonality. The HEO spacecraft bus is provided by another organization and will provide a platform for the SBIRS HEO IR sensor. The GEO satellite weight and volume will be consistent with both the Medium Atlas and the Intermediate Delta Evolved Expendable Launch Vehicle (EELV). Launch of the first GEO satellite is projected to be in 3rd Qtr FY08. HEO 2 P/L will be delivered to the host for integration in 2nd Qtr FY05. The first HEO P/L was delivered in 4th Qtr FY04.

6.6.1 GEO Payload Integration

The GEO P/L is a first-of-its-kind system. Due to early program decisions, there is only a modest P/L integration test bed capability for development/integration path finding. While the SPO is taking full advantage of the knowledge transfer from the HEO P/L integration experience, the HEO and GEO P/L configurations are different, with GEO being more complex. This puts increased schedule risk on the first GEO P/L, which is the critical path to delivering the satellite. Second, as with HEO, the SPO is discovering latent defects and manufacturing process escapes in the GEO hardware. The SPO expects these discoveries to continue throughout the ongoing system integration and test sequence - a major focus of the remaining test program is to find these defects as early as possible in the assembly/integration/test process, to allow rework time without impacting the launch schedule.

6.6.2 Latent Defects

Since 2002, the SPO has taken measures to regain the ability to properly oversee and assess contractor performance. However, the program is realizing the fallout from the acquisition policies governing the basic system design when the contract was awarded in 1996. As previously discussed, latent defect and process escapes are being identified during the AI&T activities. These have cost and schedule impacts for rework efforts as the GEO program progresses.

6.6.3 Space Segment Schedule Confidence

The SPO Space Segment confidence in the government schedule estimate is medium. The contractor has 176 days of margin along the critical path for P/L and space vehicle integration and test. However, there is no margin dedicated to the P/L signal processing software development schedule, which is a key schedule driver on the critical path. To mitigate this, the SPO performed software cost modeling and determined there was a potential for a nine-month schedule extension. This potential nine-month requirement is included in the SPO’s cost and schedule estimates. These nine months, combined with the contractor’s schedule margin for integration and test, provide a total of 35% funded schedule margin. While this should equate to a high schedule confidence, due to the inherent risk of first article integration, the overall confidence assessment is medium.

6.7 Ground Segment

The SBIRS Ground Segment will be developed and fielded in blocks of capabilities, and consists of three major components: two fixed operational sites, relay ground stations that send data back to the fixed sites, and nine mobile ground elements. The term Increment 2 refers to the ground system upgrades at both fixed and mobile facilities required for operational certification of the full SBIRS system, i.e., HEO, GEO and residual DSP assets. The SBIRS ground segment will provide capabilities to support transition, launch, and mission operations for both the GEO satellites and HEO sensors, as well as supporting on-orbit operations for the residual DSP satellites. The baseline plan recognizes that a backup MCS (MCSB) is required. A HEO-capable MCSB (MCSB-H) has been added to the program baseline as an intermediate step in creating a robust MCSB capable of operations for HEO, GEO and residual DSP legacy assets.

6.7.1 Facility Upgrades

Increment 2 facility availability dates were estimated based on actuals from the IMCSB and later facility modifications. This same contractor team has performed similar facility updates and has exhibited excellent schedule management. They are accordingly judged as High confidence.

6.7.2 Ground Software

The contractor has implemented improved practices and demonstrated greater maturity in all aspects of ground software development. The software required for HEO Early On-orbit Testing (HEOT) has been delivered and both HEO Initial Operations (HIO) software and DSP-capable M3Ps (DM3Ps) unit deliveries are planned in detail though CY05. Each of these deliveries has sufficient technical maturity that it is reasonable to expect that they will close on schedule with only 0-2 months of schedule risk.

The GEO Early On-Orbit Test (GEOT) software was planned in detail through FY05 and the schedule incorporates lessons learned from previous software deliveries. Later schedule events were estimated using the SEER/SEM software tool. The contractor estimates contain margin on each of the block deliveries and are close to the independent government estimate. The contractor's estimate is highly dependent on linkages from other program segments, e.g. delivery of database elements from Space and SEIT segments. The government estimate includes more time for the later software blocks, i.e., GEO Initial Operations (GIO) and GEO Full Capability (GFC) in recognition of their relative size and complexity and this increased schedule margin is funded and is embedded in the later SPO estimates for effectivity deliveries.

The overall confidence improves as the software maturity improves within the development cycle. The relative maturity is reflected in the confidence ratings in the table for each of the remaining software blocks.

6.7.3 GEO Capable M3P Closure

Replan of the GM3P activity has not yet been fully implemented in the SBIRS contract. The SPO and contractor have developed a detailed schedule that will be added to the contract in FY05. This provides delivery of first GM3P units early in FY12, with final units fielded in FY13. This schedule estimate was based on actuals from the DM3P integration. Based upon experience with the DM3P program, this activity has Medium confidence.

7. Cost Confidence Assessment

A cost confidence assessment measures the degree of certainty that a program's baseline (and respective budget) is adequately funded to ensure successful program execution. This assessment is due to the uncertainty surrounding a given program baseline due to cost estimating concerns, inadequate schedules and/or technological difficulties. This cost confidence assessment focuses on the activities required to develop, test, launch and transition to operations the GEO 1-2 satellites and the associated ground system.

7.1 Risk Analysis Process

An assessment of the confidence level of a program's baseline requires that a cost risk analysis be performed to capture the technical / schedule risks and estimating uncertainty as it applies to cost. The approach used herein has been historically applied on the SBIRS program and uses a quantitative statistical analysis process. This SBIRS cost confidence assessment is based on executing the program of record with the identified budget. The basis for the cost risk baseline (1,957 TY$M) was the RDT&E EMD contract using the September 2004 Cost Performance Report (CPR), covering the period FY05-11, excluding contractor management reserve and fee. It also includes additional government-identified funding for the SPA schedule slip and SEIT impacts. This baseline (and therefore this risk analysis) does not include GEO-Capable Multi-Mission Mobile Processor (GM3P) costs, Other Government Costs (OGC), SPO management reserve, items not on contract, and other appropriations.

7.2 Technical / Schedule Risk Analysis Methodology

SPO personnel were briefed on the ground rules and assumptions, cost baseline content, and the risk survey forms used to capture technical/schedule risk assessments. SPO personnel completed risk surveys through the level-four work breakdown structure (WBS). The risk surveys addressed the following risk categories

- Required technical advance (considers whether or not the science is understood)
- Technology status (pertains to the ability to apply the science through engineering development of hardware or software)
- Complexity (integration, production steps, degree of testing, and quality control required)
- Personnel/equipment capability
- Schedule quality

For each WBS element surveyed, ratings and rationale were provided for each risk category. Survey ratings were compiled, resulting with a single risk assignment for each lower level WBS element. This overall assessment of the technical/schedule risk for each WBS element was translated into one of the following triangular distributions shown in Figure 7.

		Triangular Bounds		
Risk Level	Risk Rating	Low	Mode	High
Low (Insignificant)	1.1	0.9	1.0	1.1
Medium (Moderate)	1.4	0.9	1.0	1.4
High (Substantial)	2.0	0.9	1.0	2.0
Very High (Very Substantial)	3.0	0.9	1.0	3.0

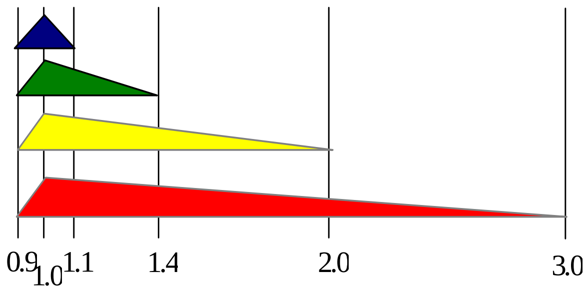


Figure 7. Risk and Triangular Distributions

Tecolote Research Inc derived the risk levels and triangular distributions based on original research conducted by TASC (The Analytical Sciences Corporation). The TASC report used the Selected Acquisition Report (SAR) data and derived a curve fit for cost growth versus technical difficulty. From this, Tecolote developed end points (low, high) for triangular distributions for different levels of risk. Tecolote developed three specific triangular distributions from these and added a very high risk triangular distribution to account for extreme risk and cost growth. For example, for a medium risk triangular distribution, the costs can range from .9 times the original estimate on the low end to upwards of 1.4 times the estimate on the high end.

7.3 Technical/Schedule Risk Rating Results

The resulting technical/schedule risk assignments are displayed below in Table 11. The values listed are for the high end of the technical risk triangle e.g. 1.4 is the medium risk triangle.

Low Risk =1.1 | Medium Risk = 1.4 | High Risk 2.0 | Very High 3.0

WBS	Name	2004	WBS	Name	2004
4200	Program Management	1.4	1210	GEO IAT&C - Payload	2.0
6200	Eng, Mgmt & Supt	1.1	1220	GEO Optic Telescope	1.4
3A00	Infrastructure	1.1	1230-H/W	GEO PCA H/W	2.0
3B00	Increment 1 Algorithm Optimization	1.4	1230-S/W	GEO PCA S/W	1.4
3CA0	Inc 2 S/W - S/W PM & Supt	1.1	1240	GEO FPA	1.4
3CB0	Inc 2 S/W - S/W Engineering	1.1	1250	GEO Thermal CS	1.4
3CC0	Inc 2 S/W - S/W SEI&V	1.1	1260-H/W	GEO Signal Proc H/W	1.4
3D00	IHEO Software	1.1	1260-S/W	GEO Signal Proc S/W	2.0
3E00	Mission Control Station (MCS) - Inc 2	1.1	1270	GEO PSDS	1.4
3F00	Interim MCS Backup (IMCSB) Inc 2	1.1	1410	HEO IAT&C - Payload	1.1
3G00	Interim Test Center	1.1	1420	HEO Optic Telescope	1.1
3H00	Relay Ground Station (RGS)	1.1	1430	HEO PCS	1.1
3J00	Multi-Mission Mobile Processor (M3P)	1.1	1440	HEO FPA	1.1
3M00	Combined Task Force (CTF) CLIN 51/52	1.1	1450	HEO Thermal CS	1.1
3R00	MDA Integrated State Vector	1.4	1460	HEO Signal Proc	1.1
UB	Undistributed Budget	1.1	1470	HEO PSDS	1.1
1110	HOSV Mgmt & Bus Ops	1.1	4110	Mgmt & Bus Ops	1.1

WBS	Name	2004
1120	Specialty Engineering	1.1
1130	Design Engineering	1.1
1140	Assembly and Test	1.4
1150	P/L Design Integration & Support	1.1
1160	Launch System Integration	1.1
1170	Common Database	1.1
1180	Launch Operations	1.4
E300	Trans & Storage	1.1
1310	S/C Mgmt & Bus Ops	1.1
1320	Structure & Mechanics	1.4
1330	Thermal (TCS)	1.4
1340	Electrical (EPS)	2.0
1350	Guidance (GNCS)	1.4
1360	Flight Software	1.4
1370	Command & Data Handling	1.4
1380	Communications	1.4
1390	Propulsion	1.4

WBS	Name	2004
4120	S/W Proc Mgmt	1.1
4130_C-A-04	Configuration Management	1.1
4130_C-A-05	Req. Analysis & Verif.	1.4
4130_C-A-06	SASC/SPOTS Reqs & Verif	1.4
4140	Analysis	1.4
4150_C-A-03	SIS/DB Dev	2.0
4150_C-A-11	HSIM / GSIM	2.0
4150_C-A-12	Colorado Ops/Sus Int/Comm Arch	1.4
4150_C-A-13	Product Integration	1.4
4160	Specialty Engineering	2.0
4170	Integrated Log Support (ILS)	1.1
5100	System DT&E	1.4
5300	Model and Sim V V & A	1.4
C200	Flight Operations Support	1.4
C300	CTF [CLINs 51 & 52]	1.4

Table 11. Technical/Schedule Risk Assignments

7.4 Cost Estimating Risk Analysis Methodology

In addition to addressing technical/schedule risk (which does impact program cost), this risk analysis also addresses the uncertainty of the cost estimating methods used in developing the program estimate to complete. The factors influencing the accuracy of the cost estimate are statistically independent of the program's technical/schedule risk, both of which can affect a program's cost. In addressing cost estimating uncertainty, this analysis assumed a +/- 20% normal distribution that is supported by data from the SAR database and the Unmanned Space Vehicle Cost Model (USCM) database.

7.5 Risk Analysis Implementation

This risk analysis also addressed the interdependencies (correlation) between WBS elements. For example, a schedule slip in the SPA software delivery may impact the development of SPA hardware. Tecolote applied correlation to each WBS element based on historical data, estimator judgment, and discussions with technically cognizant individuals.

Tecolote used the RI$K software program, which uses a Monte Carlo technique, to combine all the individual WBS element distributions, taking into account the technical/schedule risks, cost estimating uncertainties, and WBS element interdependencies. The process produces statistical information, which allows us to generate a curve that shows the probability versus total program cost. By combining probability information, a confidence curve, known as an S-curve, can be calculated. On the S-curve, the Y-axis is confidence (probability) and the X-axis is total cost. A given point on the S-curve tells us the probability (% confidence) that the program will come in at that budgeted cost or less. To evaluate the quality of the S-curve, one must examine the cost variation of going from 0-100%. A 'steep' S-curve (Figure 8a) is characteristic of a lower risk program. Theoretically, if one assesses a low risk program properly, one would see a steeper S-curve. For a little money, you can buy more confidence. Alternatively, a properly assessed higher risk program will generate a ‘flatter’ S-curve (Figure 8b). For a lot of money, you can buy more confidence.

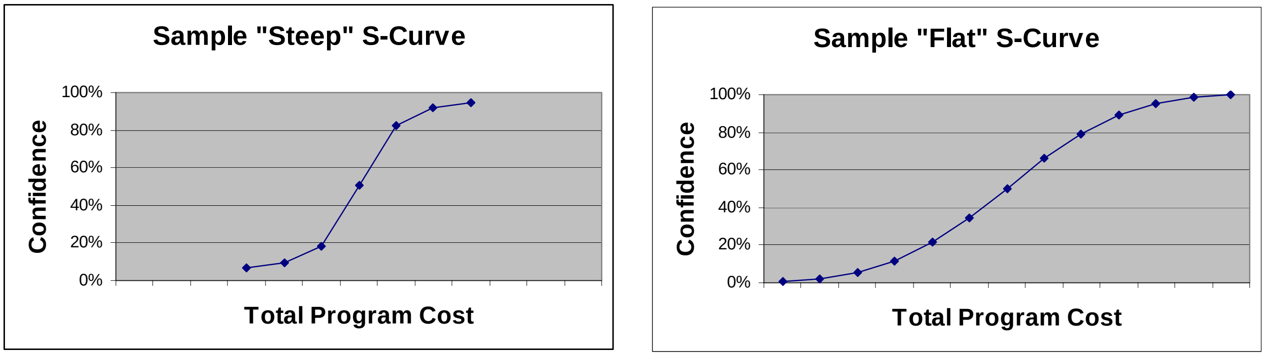
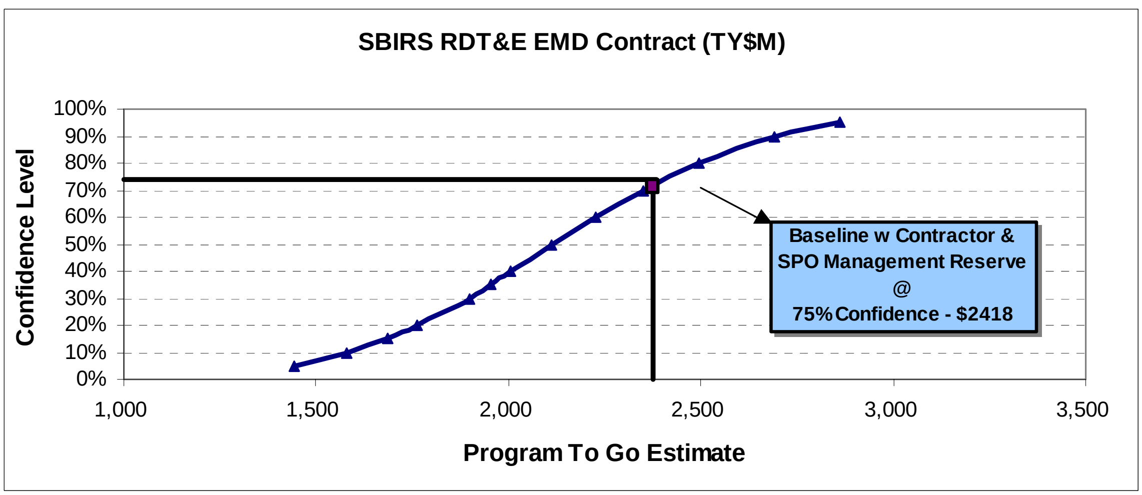


Figure 8a, 8b. Sample S-Curves

7.6 Risk Analysis Results Interpretation

The results for this analysis produced the S-curve shown in Figure 9.



TY$M											
Percentile	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%
ETC with Risk	1,442	1,578	1,763	1,900	2,005	2,112	2,225	2,351	2,493	2,692	2,860
Risk only	-	-	-	-	49	156	269	395	537	736	904

Figure 9. SBIRS Confidence Curve

The ‘to go’ budgeted SBIRS program is $2,418 (TY$M) (RDT&E EMD contract and SPO/contractor management reserve). Based on the S-curve shown in Figure 9, the current program is at the 75% confidence level. The budgeted SBIRS program includes contractor management reserve and SPO management reserve, which amounts to $462 (TY$M).

Using an approximation algorithm, the $462M was allocated to lower level WBS elements. This algorithm considers both the baseline estimate (Estimate to Complete) and the risk rating for each WBS element. Results indicated the following four WBS elements as high-risk areas on the SBIRS program. This was based upon their assigned high (2.0) schedule/technical risk rating, as well as, the amount of risk dollars required by each element to reach the 75% confidence level. Below is a list of these high-risk areas, rationale for their ratings and the percentage of the risk dollars allocated to each element. For example, the GEO P/L IAT&C element requires ~ $94M, which represents 20% of the overall risk dollars required for the program, to reach the 75% confidence level.

- GEO P/L Integration, Assembly, Test and Checkout (IAT&C) ($94M, 20.3%)
    - Integration of complex IR system
    - Testing to a tough set of requirements
    - Insufficient slack in schedule for rework / test anomaly investigations

- GEO PCA H/W ($21M, 4.5%)
    - Very complex subsystem, e.g. pointing mirror and LOS computer
    - Schedule does not have slack time for problem resolution

- GEO SPA Software ($12M, 2.6%)
    - Personnel experience and schedule uncertainty

- S/C Electrical Power Subsystem (EPS) ($10M, 2.3%)
    - Communication between the spacecraft EPS team and system engineering is inadequate
    - The Power Switching Distribution Unit (PSDU) failed TVac testing; no root cause has been identified yet

In addition to the high-risk areas above, the following WBS elements accounted for a significant portion of the overall risk dollars. The reason for their impact on risk dollars is mostly due to the large amount of effort to go and associated costs in these areas.

- Program Management ($51M, 11.1%)
- Flight Operations Support ($39M, 8.5%)
- High Orbit Space Vehicle (HOSV) Assembly and Test ($26M, 5.7%)
- Ground Infrastructure ($21M, 4.6%)
- System Analysis ($20M, 4.2%)
- System Development, Test, and Evaluation (DT&E) ($15M, 3.2%)

The above areas combined represent 67% of the total management reserve, i.e. $462M. Again, the risk dollars required is for the overall SBIRS program. Allocation of these dollars shown above is for planning purposes only.

The SBIRS cost confidence assessment indicates that the program of record provides 75% confidence of program execution. The shape of the SBIRS S-curve is consistent with a technically challenging RDT&E development program. It indicates a realistic estimate of the cost to buy additional confidence.

8. Closing Thoughts

The SBIRS program execution difficulties have quite naturally raised concerns, such as those that motivated the Defense Authorization Conferees to call for this report. However, these cost and schedule difficulties should not overshadow the real accomplishments and progress achieved. The first HEO P/L was delivered in 4th Qtr FY04, and the second HEO P/L is on track to meet a 2nd Qtr FY05 delivery, well before the need date in 3rd Qtr FY05. Both sensors perform better than their specifications require, and both will provide significantly enhanced capabilities to the war fighter. Solid progress has been made on the GEO satellite development as well. The SPA power supply and the Common Gyro Reference Assembly (CGRA) are integrated onto the P/L structure. These were key events leading to the GEO 1 P/L's initial space-like environment thermal-vacuum chamber performance test scheduled to complete in 4th Qtr FY05. For early risk reduction on the GEO spacecraft, the EBT at Sunnyvale has entered the third phase, integrating flight hardware onto the surrogate bus structure. This testing has been extremely successful in the early identification and mitigation of hardware/software integration issues before they become schedule critical path concerns. The DM3Ps are in test and on track for operational certification by 1st Qtr FY06. Finally, the initial SBIRS support to the Missile Defense Agency mission is in place and met the President's mandated schedule objectives.

The DoD and USAF appreciate Congress's strong support for the development of the next generation early warning system. The information provided in this report should provide confidence that the program will deliver these capabilities within the baselined cost and schedule.

Attachment 1 - Congressional Language

The text below is extracted from the records of the 108th Congress

Space-based infrared system[1]

The budget request included $508.4 million in PE 64441F for development of the space-based infrared system (SBIRS). When deployed, SBIRS will provide improved early-warning, missile defense, and technical intelligence capabilities. The committee notes that the SBIRS program has had persistent cost, schedule, and technical problems over the last several years of its development. Unexpected technical difficulties on the first SBIRS P/L resulted in cost overruns and schedule delays. These problems and further technical difficulties have, in turn, resulted in a delay of at least a year in the first launch of a SBIRS satellite in geostationary orbit. The committee notes that the Commander, U.S. Strategic Command, in testimony to the Strategic Forces Subcommittee, Committee on Armed Services of the Senate, indicated that continued progress in the SBIRS program ‘‘is absolutely essential’’ to his command, and the Under Secretary of the Air Force testified before the same subcommittee that technical challenges and schedule delays have resulted in a budget shortfall in the SBIRS program. The committee remains supportive of the SBIRS program because of the critical nature of its mission. The committee recommends an increase of $35.0 million in PE 64441F to help address the SBIRS budget shortfall, overcome development difficulties, and minimize the schedule delay. The committee directs that none of this recommended increase may be obligated or expended until the Secretary of Defense provides to the congressional defense committees a new analysis of alternatives for the early warning mission.
http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=108_cong_reports&docid=f:sr260.108.pdf

Space based infrared system[2]

The budget request included $508.4 million in PE 64441F for the space based infrared system (SBIRS). The House bill would authorize the budget request. The Senate amendment would authorize the budget request. The conferees agree to authorize an increase of $35.0 million in PEG 4441F. The conferees remain concerned with continued SBIRS cost increases, schedule delays, and technical problems. The conferees note that the initial 1996 cost estimate for SBIRS was $3.6 billion; that estimate has increased by nearly $4 billion in the last three years and is now $10.0 billion. While strongly supportive of the development of next generation early warning capabilities, the conferees do not believe that continuation of

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[1] SENATE, 108TH CONGRESS 2d Session REPORT 108–260 Calendar No. 503, NATIONAL DEFENSE AUTHORIZATION ACT FOR FISCAL YEAR 2005 REPORT [TO ACCOMPANY S. 2400] ON AUTHORIZING APPROPRIATIONS FOR FISCAL YEAR 2005 FOR MILITARY ACTIVITIES OF THE DEPARTMENT OF DEFENSE, FOR MILITARY CONSTRUCTION, AND FOR DEFENSE ACTIVITIES OF THE DEPARTMENT OF ENERGY, TO PRESCRIBE PERSONNEL STRENGTHS FOR SUCH FISCAL YEAR FOR THE ARMED FORCES, AND FOR OTHER PURPOSES TOGETHER WITH ADDITIONAL VIEWS COMMITTEE ON ARMED SERVICES UNITED STATES SENATE,
MAY 11, 2004—Ordered to be printed

[2] HOUSE OF REPRESENTATIVES 108TH CONGRESS 2nd Session REPORT 108–767 RONALD W. REAGAN NATIONAL DEFENSE AUTHORIZATION ACT FOR FISCAL YEAR 2005, CONFERENCE REPORT TO ACCOMPANY H.R. 4200 OCTOBER 8, 2004.—Ordered to be printed

this program can be justified if such increases continue in the future. The conferees direct the Secretary of Defense to provide a report in classified and unclassified form to the congressional defense committees no later than 2nd Qtr 1, 2005 on the cause of the most recent SBIRS cost increases, schedule delays, and technical problems; the most recent Defense Support Program gap analysis and any effect that further delays will have on U.S. early warning, technical intelligence, and missile defense capabilities; steps taken to address the most recent SBIRS technical difficulties; any adjustments in management and contract arrangements with the contractor to reflect the most recent program challenges; remaining risk areas; and an assessment of the confidence level in the SBIRS schedule and cost estimates current as of October 1, 2004.
http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=108_cong_reports&docid=f:hr767.108.pdf

Attachment 2 - Acronym List

ACEIT	Automated Cost Estimating Integrated Tool
ACS	Attitude Control System
ADR	Anomaly Detection and Resolution
AF	Air Force
AF PEO/SP	Air Force Program Executive Officer / Space
AI&T	Assembly, Integration and Test
ALERT	Attack and Launch Early Reporting to Theater
ASIC	Application-Specific Integrated Circuit
CDR	Critical Design Review
CEAC	Comprehensive Estimate At Complete
CGRA	Common Gyro Reference Assembly
CONUS	Continental United States
CPAF	Cost Plus Award Fee
CPR	Cost Performance Report
CTF	Combined Task Force
CTSR	Consent To Ship Review
CY	Calendar Year
DAC	Defense Authorizations Conference
DDR&E	Director, Defense Research and Engineering
DM3P	DSP Capable Multi-Mission Mobile Processor
DoD	Department of Defense
DSB	Defense Science Board
DSP	Defense Support Program
EAC	Estimate At Complete
EBT	Early Bus Test
EELV	Evolved Expendable Launch Vehicle
ELOC	Equivalent Lines of Code
EMD	Engineering, Manufacturing & Development
EMI	Electromagnetic Interference
EOT	Early On-orbit Testing
EPS	Electrical Power Subsystem
ERS	European Relay Station
ETC	Estimate To Complete
EVMS	Earned Value Management System
ExCom	Executive Committee
FFRDC	Federally Funded Research and Development Center
FIST	Final Integrated System Test
FPA	Focal Plane Assembly
FRB	Failure Review Board
FY	Fiscal Year
GEO	Geosynchronous Earth Orbit
GEOT	GEO Early On-orbit Test
GFE	Government Furnished Equipment

GFC	GEO Full Capability
GIO	GEO Initial Operations
GM3P	GEO Capable Multi-Mission Mobile Processor
GMD	Ground Midcourse Defense
GS	Ground Segment
HEO	Highly Elliptical Orbit
HEOT	HEO Early On-orbit Testing
HFE	Human Factors Engineering
HIO	HEO Initial Operations
HOSV	High Orbit Space Vehicle
IHEO	Interim HEO
HQ	Headquarters
H/W	Hardware
IBR	Integrated Baseline Review
IMCSB	Interim MCS Backup
IMCSB 1	Interim MCS Backup, Increment 1
IMCSB 2	Interim MCS Backup, Increment 2
IMS/IMP	Integrated Master Schedule / Integrated Master Plan
IOC	Initial Operational Capability
IPT	Integrated Product Team
IR	Infrared
IRT	Independent Review Team
ITC	Interim Test Center
ITW/AA	Integrated Tactical Warning / Attack Assessment
I&T	Integration & Test
JTAGS	Joint Tactical Ground Station
KTR	Contractor
LOS	Line of Sight
M3P	Multi-Mission Mobile Processor
MCS	Mission Control Station
MCSB	Mission Control Station Backup
MCSB-H	Mission Control Station Backup-HEO Capable
MR	Management Reserve
NMD	National Missile Defense
OGC	Other Government Costs
ONIR	Overhead Non-imaging Infrared
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
OTB	Over-Target Baseline
PBR	President’s Budget Request
PCA	Pointing and Control Assembly
PE	Program Element
PM	Program Manager
PMA	Pointing Mirror Assembly
PMR	Program Management Review
P/L	Payload

PSDU	Power Switching Distribution Unit
RDT&E	Research, Development, Test & Evaluation
RFP	Request For Proposal
RGS-E	Relay Ground Station-Europe
RGS-P	Relay Ground Station-Pacific
RGS-M	Relay Ground Station -Mobile
RTP	Real Time Project
SAR	Selected Acquisition Reports
SBC	Single Board Computer
SBIRS	Space Based Infrared System
S/C	Spacecraft
SCFT	Spacecraft Functional Test
SECDEF	Secretary of Defense
SEER/SIM	System Evaluation & Estimation of Resources/Software Estimation Model
SEIT	System Engineering / Integration & Test
SERB	System Engineering Review Board
SETA	Systems Engineering / Technical Assistance
SDI	Strategic Defense Initiative
SMC/IS	Space and Missile Center / Infrared Systems
SMCS	Survivable MCS
SORD	Simulations Over Recorded Data
SPA	Signal Processing Assembly
SPD	System Program Director
SPO	Systems Program Office
SRB	System Risk Board
SRGS	Survivable Relay Ground Station
SPOTS	SBIRS Payload Orbital Test Station
SV	Space Vehicle
S/W	Software
TASC	The Analytical Sciences Corporation
TCS	Thermal Control System
TER	Test Exit Review
TES	Theater Event System
TI	Technical Intelligence
TRR	Test Readiness Review
TSPR	Total Systems Performance Responsibility
TVac	Thermal Vacuum
TY	Then Year
TY$M	Then Year $ Million
USAF	United States Air Force
USCM	Unmanned Space Vehicle Cost Model
USD (AT&L)	Undersecretary of Defense, Acquisition, Technology & Logistics
USecAF	Undersecretary of the Air Force
WBS	Work Breakdown Structure

Annex A

Classified Annex to the Report to the Defense Committees of the Congress of the United States on the Status of the Space Based Infrared System Program

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