NPOESS

Political from Day One

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ISE 550 Final Paper
Dec. 13th, 2000
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Introduction

The GOES satellites producing the nightly news weather pictures are not America's only weather satellites. The Air Force and NOAA each operate a pair of low-flying sun-synchronous weather satellites that provide high-resolution imagery of the whole globe. While operated in similar fashion, the DMSP (military) and POES (civil) systems are in different orbit planes, carry different sensor suites, and focus on different user communities. A series of review panels had considered merging the systems but the first eight agreed that they should remain separate.

In 1993 Vice President Al Gore led the Re-Inventing Government Task Force in examining all areas of Federal Government activity. The primary focus of this effort was finding cost savings through improving the efficiency of necessary activities. The weather satellite systems were one area that the task force chose to re-invent.

On May 5, 1994 Presidential Decision Directive NSTC-2 was issued ordering the two sun-synchronous weather satellite systems to be merged into a single program managed by both DoD and the Dept. of Commerce (NOAA's owing department). An Integrated Program Office (IPO) was formed and both agencies agreed to provide 50% of the funding for the project. NASA was also part of the IPO, not bringing any direct NPOESS funding but sponsoring technology insertion and a prototype satellite mission.

The urgency of the development effort was limited by the existence of a number of completed and under construction satellites for the heritage programs, enough to keep them operating until between 2005 and 2010. Nevertheless, a competition was initiated to select an NPOESS prime contractor. This effort lasted until 1996, when a new IPO director looked at the schedule, rescinded the RFP that was about to be issued, and scaled down the efforts of the competing contractors from 100-strong proposal teams to study contract offices of a dozen or less.

Currently the competitors—now only Lockheed-Martin and TRW—are preparing for a proposal for the full NPOESS contract next year. The system requirements still show complexities resulting from the "shotgun wedding" of the sponsoring agencies, and integrating the preparation for a full system development with support to NASA's prototype mission (NPP) is proving troublesome. However, the program has received sufficient Congressional support to accelerate the planned award of the EMD contract, and it seems secure for now.

Heritage Systems—POES and DMSP

The first American weather satellite was TIROS (Television Infra-Red Observation Satellite), launched in 1960. This evolved into the Polar-orbiting Operational

Environmental Satellites (POES) system operated by the National Oceanographic and Atmospheric Administration (NOAA), which is responsible for civil weather research. POES consisted of two sun-synchronous satellites at 1330 and 0730 local times of ascending nodes (LTANs)[1]. The orbit planes were chosen to support daily weather forecasting needs. NOAA provides funding and operates the satellites while NASA handles design and procurement. NOAA has its own satellite operations center (SOC) located at Suitland, MD, and stations for satellite commanding and data acquisition (CDAs) at Fairbanks, Alaska and Wallops, VA.

The POES user community ranges from real-time aviation weather monitors to climatologists tracking long-range changes in the Earth's temperature and other characteristics. Most users prefer completeness of the data set to speed of delivery. Weather data is also broadcast in the clear from the satellites so that any interested user can receive data in real time.

The military analogue to POES was the Defense Meteorological Satellite Program (DMSP) which began in 1963 as a black (classified) program. The existence of DMSP was declassified in 1973. DMSP also provided weather data support to military units worldwide through forecasting at Air Force and Navy facilities as well as encrypted real time broadcasts for units in the field. The system was controlled by a SOC at Offutt Air Force Base (AFB), Omaha, Nebraska, through remote tracking stations (RTSs) at Fairchild AFB, Spokane, Washington, and Loring AFB, Maine. The Loring station was decommissioned in the late 1980s in favor of access to the Air Force Satellite Control Network's worldwide array of RTSs. DMSP had originally been assigned to the Strategic Air Command but was transferred to Air Force Space Command when that was formed in May 1983[2]. Like POES, DMSP has two sun-synchronous satellites, but the orbit planes are typically at 0530 and 0930 LTANs, providing better coverage of the early-morning sun angles of interest in military operations. The LTANs will vary from launch to launch to reflect current needs.

The primary mission of DMSP is "to support highly classified programs with presidential interest that are assigned the highest US Air Force precedence."[3] Other users are interested in data such as cloud imagery (deciding if laser guided munitions are usable on a target) and soil moisture (is the ground firm enough for tanks to cross?). A major emphasis was placed on rapid delivery of data in DMSP operations—combat units need to know what the weather is in real time and bombers have been diverted to different targets in mid-flight on receipt of DMSP data about target conditions. DMSP sensors

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[1] A "sun-synchronous" orbit drifts at a rate that matches the sun, so all observations are made with sunlight at the same angle. An orbit is described by the local time that the satellite takes images at the equator.
[2] McConnell, Don and Ted Zambos, "History of 4000th Satellite Operations Group", http://www.zianet.com/jpage/airforce/history/wings/4000th.html
[3] US Dept. of Commerce, NOAA, NESDIS, "ENVIROSAT-200 Report: Comparison of the Defense Meteorological Satellite Program (DMSP) and the NOAA Polar-orbiting Operational Environmental Satellite (POES) Program", October 1985, AD-A165 118.

were geared to support military requirements by providing constant spatial resolution across the sensor swath and night time imagery. The penalty for this was providing fewer spectral channels (2 vs. 5) and having four times the weight and six times the cost of the equivalent POES sensor.

Eight studies had been done on the potential for cost savings through combining the two systems up to 1990.[4] National policy was explicit that military and civil space programs were to be kept separate.[5] Cost savings were found by using common components for the systems—both used a single satellite bus manufactured by RCA AstroSpace, East Windsor, NJ, with the payloads supplied by separate contractors and customized for the different missions. The data processing centers for each system exchanged data to provide support for additional analysis. In 1992 both systems were planning for block changes—DMSP had let a study contract for the Block 6 upgrade, and POES had contracted for the last satellites of the current block and had begun studies on the OPQ upgrade.[6]

National Performance Review—1993

In 1993 the new Clinton Administration initiated the National Performance Review (NPR) under the leadership of Vice President Al Gore. This was a "cost rules" effort to reduce the cost of the Federal government without reducing any of the services to the taxpayers. One of the targets of the NPR was to eliminate duplication of effort between government agencies and the DMSP and POES constellations were selected for review.

This was a classic example of "Perception is often more important than the truth." The systems had different sensors, minimally overlapping user communities, and by operating at different sun angles weren't even accessing the same data. But at the overview level these distinctions were hard to explain and were therefore ignored.

A third system was added to the mix in an attempt to gain greater savings. NASA's Earth Observation System (EOS) planned to launch a satellite every five years to support atmospheric science and climatology research. It had higher performance sensors than the weather systems and was recommended to NOAA and DoD as an opportunity to improve their systems without developing expensive systems of their own. Integrating EOS with the weather systems was a horrifying prospect to the operators.[7] EOS churned out data at a rate that could clog the data transmission networks and prevent timely delivery of mission critical data. The EOS sensors were all experimental and focused on science requirements rather than weather ones. NASA operations procedures focused on

[4] "House Panel to approve joining DOD, civilian satellite programs", Aerospace Daily, 11/10/93
[5] National Security Decision Directive 42, July 14th, 1982
[6] Karras, Tom, et al, "NOAA O, P, Q—Phase A Report", January 24th, 1992, Goddard Space Flight Center.
[7] Author was a DMSP operator at that time.

preserving the satellite and science data and would put the satellite into safe mode even when it was possible to continue providing mission-critical data.

The NPR review was not kept secret from the agencies concerned or other interested parties. As the possibility of White House support for merging the systems grew more players began piling on. Senator James Exon (D-Neb.) led the charge. As a senior member on both the Commerce and Armed Services Committees he had influence on the funding for both DMSP and POES and didn't have to worry about other senators feeling he was intruding on their turf. He urged the merger of the two programs and suggested beginning by having DoD turn two satellites in storage over to NOAA for modification—the first of several "political solutions" being advanced in place of the existing technical solutions. He stressed that neither agency could afford major upgrades to their sensors and suggested cooperation with NASA could make sensor improvements affordable.[8]

Faced with having a new architecture imposed on them from the outside, the leaders of NOAA, DoD, and NASA formed a tri-agency study team in June of 1993. Trying to stay ahead of the cost-cutting wave they examined options for consolidating their systems.[9]

The Senate Armed Service Committee kept the pressure on by projecting that billions could be saved not just from a DMSP-NOAA merger but by reducing the size of the military system. The committee threatened to "mandat[e] that DOD drop from a two-satellite constellation to a one-satellite system", which would have sharply reduced the weather support to all of the missions DMSP supported.[10] A single satellite would allow gaps in coverage up to twelve hours long which was completely unacceptable to the DoD users. Given the end of the Cold War, this may have been an acceptable risk for national security, but avoiding that scenario gave the military a powerful incentive to cooperate in creating a sound merger strategy.

By the time the NPR was released in September the agencies had their story ready. The Air Force was willing to make concessions on DMSP—it was something of a "stepchild" program in Space Command, lacking the glamour of the Global Positioning System or the immediate utility of communications and warning systems. DMSP was already last in line for funds and personnel, and when Congress demanded a budget cut Space Command was willing to offer it up. The users of the system were kept happy by NOAA commitments that all national security requirements would be met.

The NPR report was released in September with a demand for combining DMSP, POES, and EOS: "Congress should enact legislation requiring these agencies to consolidate

[8] "What's Ahead in Aerospace—Merger Talk", Aerospace Daily 6/28/93, p527
[9] "Combined Polar Satellite Program Could Save $300 Million in Five Years", Defense Daily 11/10/93
[10] "SASC recommends $500 million in satellite deferrals, other space cuts.", Aerospace Daily 8/4/93, p193

their efforts into a single system, saving as much as $1.3 billion over the next 10 years."[11] Agency representatives testified to congressional committees that the merger could produce cost savings but weren't willing to commit to a specific long-term cost savings number. NOAA did predict that $300 million could be saved through combining the operations of DMSP and POES.

Sensing the opportunity for a major cost savings, Congress wasn't willing to let the agencies wiggle out of it. A November 1993 House Space Subcommittee hearing brought up the number of satellites the agencies were buying. Congressman Dana Rohrabacher complained about the backlog of 15 stored and planned DMSP and POES satellites, stating "I'm going to look into this closer." A closer look would have revealed that maintaining four satellites in orbit with lifespans of 2 to 4 years over the next decade or more would require just about that number of satellites, but as before "Perception is often more important than the truth". Chairman Ralph Hall said the $6 billion cost of DMSP, POES, and EOS over the next 10 years was something "which many members of Congress feel that the nation cannot afford."[12]

The agencies continued their study, now dubbed the "Convergence Study." Scheduled to complete in January 1994, the recommendations would be presented to the White House Office of Science and Technology Policy's convergence working group. DMSP and POES officials were examining the practical issues in operating the combined systems.[13] NASA was negotiating with NOAA to place its EOS-PM instruments on the POES satellites as the funding for the second and third PM flights began to look more precarious.

The dispute over which agency would have the lead on the converged system was settled in favor of NOAA. The House Science Committee added that to the Government Reform and Savings Act of 1993 with the proviso that it was "contingent on the provision of adequate resources to fully meet the national security interests of the United States."[14]

Forming the IPO—1994

The tri-agency study was submitted to the OSTP on schedule in January, which approved the plan for convergence and directed the agencies to finalize the division of responsibilities.

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[11] "NASA streamlining to save $2 billion, but White House doesn't say how", Aerospace Daily 9/8/93, p395
[12] "Combined Polar Satellite Program Could Save $300 Million in Five Years", Defense Daily 11/10/93
[13] The author's first connection with NPOESS was briefing the study delegations on DMSP mission planning
[14] "House Panel Approves Polar Satellite Convergence Plan", Space Business News, 11/23/93

The final agreement among the agencies was finalized through a Presidential Decision Directive issued on May 5th, 1994, labeled NSTC-2. The new converged system was to be procured and operated by an Integrated Program Office (IPO). The savings from convergence were projected at $1.5 billion over 15 years, with $300 million of that coming by 1999 from operations convergence.[15] Key posts in the IPO were allocated to specific agencies with NOAA having the System Program Director.

One other avenue for cost reduction was being actively pursued by NOAA head James Baker. European nations had formed a consortium called EUMETSAT to provide weather satellite coverage of their region. They were only planning on operating one satellite at a time but if that one was integrated into the American weather satellite system it could provide a high level of performance without requiring additional Congressional funding. Negotiations began with an American offer to provide high-performance sensors to be flown on the European satellite and access to the data provided by the American satellites.[16]

Technical work continued on finding a system architecture that would meet both the military and civil requirements. Requirements for different sun angles do not have obvious compromises as different types of data and coverage are provided. The military requirement for denying data to potential adversaries conflicted with NOAA's imperative to provide data to all users. The military demanded higher resolution imagery and faster delivery of data to the Centrals (user facilities). NOAA wanted more spectral bands to support scientific research. Neither agency wanted to pay for the other's more stringent requirements. Outside observers attributed these problems to "cultural" clashes but there were real technical problems with trying to meet both sets of requirements.[17]

A consensus design began to take shape. The system would consist of three satellites versus the four for DMSP and POES. One "METOP" satellite would be provided by the Europeans, reducing the American burden to only two satellites. The orbital planes were selected as 0530 (DMSP), 1330 (POES), and 0930 (DMSP, now supported by METOP). The new satellite design would be operational by 2004, leading to a savings over the decade of $1 billion or more.[18]

Study contracts were let for the new system using money that had been programmed for the DMSP follow-ons. Lockheed Sunnyvale and Martin Marietta (formerly RCA and GE) AstroSpace conducted the Phase 0 studies on the convergence architecture. Congress was not enthused by the new development effort and Sen. Ernest Hollings, Chairman of the Senate Commerce Committee, said money may not be available to support the converged design. NOAA and DoD continued to squabble about the cost

[15] "Pentagon, civilian agencies 'converge' on environmental satellites", Aerospace Daily, 5/11/94, p226
[16] Ibid.
[17] Asker, James R, "Weather Satellite Programs to Merge", Aviation Week, 5/16/94
[18] Ibid.

allocations with NOAA pushing for a 50-50 split and DoD wanting costs assigned in proportion to each agencies requirements on the system.[19] NASA was not a significant player in the architecture process as it was not in a position to offer funding for the new system.

NPOESS—1995

By May of 1995 the agencies had their Memorandum of Agreement worked out. The new system was named NPOESS—the National Polar-orbiting Operational Environmental Satellite System. NOAA and the Air Force would split the cost of the new system 50-50 averaged over five years:[20]

$Millions	FY96	FY97	FY98	FY99	FY00	FY01	Total
Budget	78.0	120.0	187.0	340.2	372.7	328.1	1426.0
DoC	54.0	78.2	131.4	146.5	162.5	140.4	713.0
DoD	24.0	41.8	55.6	193.7	210.2	187.7	713.0

NASA was given a role in providing technology support to the program but was not bringing cash. IPO head Robert Winokur stated clearly "No EOS requirement included in the NPOESS operational requirement set."[21] The Air Force provided leadership for the acquisition process, as the POES satellites had been acquired by NASA and NOAA lacked experience in that area. All satellite operations were led by NOAA. A Joint Agency Requirements Council was set up to approve the program requirements and settle conflicts between the different agencies, producing the Integrated Operational Requirements Document (IORD).

Plans for operating DMSP and POES from a single operations center were set with September 1997 as the official transfer date. The bulk of savings would come from closing the satellite operations facilities at Offutt AFB and Fairchild AFB and reducing the total number of operators.[22]

Preparations went ahead for procuring the new system. A draft RFP was released in May 1995 with incremental versions following. Proposals would have to cover all aspects of the system—satellite, sensors, command and control, and weather data processing—so potential bidders began forming teams with sensor and ground segment houses to cover the gaps in their own capabilities. Lockheed and Martin Marietta had an advantage in

[19] "Weather satellite cost-sharing unresolved; Hollings says funding tight" Aerospace Daily 6/15/94, p418
[20] Memorandum Of Agreement Between the Department of Commerce, Department of Defense, and National Aeronautics and Space Administration for the National Polar-orbiting Operational Environmental Satellite System (NPOESS), 5/26/95
[21] Robert S Winokur, "Status of NOAA's Satellite Programs and the National Polar-Orbiting Environmental Satellite Program", 11/15/95, briefing to National Academy of Sciences
[22] "Air Force to close satellite center" 11/13/95, Space News

this races as many potential teammates were already on board as part of the previous effort to win the DMSP Block 6 contract. TRW Space & Electronics Group and Hughes Space and Communications were also interested in competing. The Lockheed-Martin merger disrupted this process when the IPO decided that the two Phase 0 contracts could be completed but Lockheed-Martin would only be able to win one of the two Phase 1 contracts. Lockheed-Martin began choosing which contractors it would keep in each role while Hughes and TRW began their own negotiations. A government briefing to industry was held on December 13th, 1995, signaling the IPO's determination to proceed the with bidding to meet the 2004 launch availability date for NPOESS.[23]

By then James Mannen had taken over as the IPO System Program Director. One of the key concerns that the IPO discussed with the contractors was the exclusive teaming agreements that the prime contractors were setting up with their subcontractors. They were afraid that this would "limit potential design solutions" and "lead to pre-determined sensor selection based on business alignments." The IPO wanted unlimited competition and trades and the teaming agreements could prevent that. Contractors had to plan for EUMETSAT participation in NPOESS even though the negotiations to define METOP's role and capabilities were ongoing. The final RFP was to be released in April of 1996 with contract award expected in August.[24]

New System? Not Yet!—1996

Lockheed-Martin, TRW, and Hughes prepared for the proposal effort, with sensor houses teaming exclusively with each of the primes. The teaming negotiations were intense, as a prime which could not field a sensor for each of the required types would not be able to submit a qualified proposal regardless of how good the rest of the proposal was. Engineers at the worker-bee level studied the draft requirements documents and noticed that the Air Force and NOAA had not completely harmonized their requirements. Not only were some subtle conflicts present between requirements, but one requirement began with a statement that "one of the two following paragraphs will be selected" by the time the final RFP was released followed by descriptions of two completely opposite requirements.[25]

All this effort became moot as the IPO withdrew the procurement one month before the final RFP was due out! Two factors were key in the decision: the exclusive sensor contractor teaming agreements and the 2004 readiness date for the new system.

The sensor teaming agreements were preventing the government from getting an optimized system. This procurement was part of a new acquisition reform effort,

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[23] "Industry input sought for national weather satellite program", Defense Daily, 11/29/95
[24] "NPOESS Second Briefing to Industry", 13 December 95, IPO Briefing
[25] The author deeply regrets not having saved that page for posterity, but he was honestly quite shocked and has a vivid memory of the wording. Draft NPOESS Technical Requirements Document, 1995.

awarding a contract as prime to a contractor who would be responsible for all integration in place of the past practice of the government awarding separate spacecraft, payload, and ground segment contracts and then being responsible for integration itself. The savings in avoided interface problems and reduced government effort could be considerable. Unfortunately, the unintended consequence was to present them with proposals where the best visual sensor could be on one team and the best microwave sensor on the other. A cost-driven reform was preventing the government from procuring the best possible system—sometimes, "Political Problems Become Technical Problems."

Deploying NPOESS by 2004 was the earliest possible date that the new system with its improved sensors could be operational. This was attractive to the users wanting the higher-resolution data, but wasn't required by the expiration of the existing systems. DMSP and POES had enough satellites in the pipeline to continue operations to 2007 (or later, assuming no launch or other premature failures). Congress was not interested in spending money on a cost-saving effort when business as usual would be cheaper and not lead to disaster. NPOESS would provide better weather data than its predecessors but that was not enough to justify a new development.

The IPO regrouped and began developing a new acquisition strategy. By May of 1996 they were briefing the potential prime contractors on their new approach.[26] The primes would receive small study contracts to get their input during the wait for the full-scale development contract (and maintain their interest in lobbying for NPOESS funding). Government contracts would be let to develop sensors for the key NPOESS weather data products. The three study contractors would be downselected to two in 1999, with a final contract award in 2001. The first NPOESS satellite would be ready for launch in 2007. When the final prime contract was awarded the sensor contracts would become subcontracts to it. Delaying the development by 3-4 years was estimated to save $300 million in the near term. The IPO was actively seeking "buy-in" from the primes—keeping Lockheed-Martin, TRW, and Hughes as part of the coalition supporting NPOESS was crucial to maintaining support in Congress.

Four sensor competitions were sponsored by the IPO with downselects to follow in a few years to decide the final sensor designs. Ensuring that the highest possible quality data would be produced was need to keep the data users happy. These Centrals (NOAA's National Environmental Satellite, Data, and Information Service (NESDIS), Air Force Weather Agency (AFWA), and the Navy's Fleet Numerical Meteorology and Oceanography Center (FNMOC) and Naval Oceanographic Office (NAVO)) were the primary representatives of the user community, NESDIS representing the civil users and the rest the military. The support of the Centrals was essential to certify the legitimacy of NPOESS as a replacement for the DMSP Block 6 and NOAA OPQ follow-on programs. If NPOESS wasn't adding value to the mission Congress could have cancelled in favor of continuing the old programs with the same level of data quality, or even reopened the

[26] "Optimized Convergence—A Revised NPOESS Acquisition Approach", 13 May 1996, IPO Briefing

question of whether the weather mission was urgent enough for taxpayer funds and consider scaling back or canceling both the military and civil systems.

Convergence In Practice—1997 and 1998

By 1997 EOS PM had been reduced to only a single satellite and NASA's only hope for long-term data continuity on its climatology mission was to support NPOESS. NASA supported ATMS, one of the five sensor developments being kicked off for NPOESS. The IPO sponsored the VIIRS, CRIS, CMIS, and OMPS development competitions, which were all underway by July of 1997.[27] NOAA, USAF, and NASA all approved the new acquisition strategy.[28] The first stage in converging the operations of DMSP and POES was completed as the Air Force shut down the tracking station at Fairchild AFB.[29]

On May 29th, 1998 complete control of DMSP was transferred to NOAA and the 6th Satellite Operations Squadron at Offutt AFB was shut down after 35 years of continuous DMSP operations.[30] The government announced that $1.3 billion dollars would be saved by the consolidation through 2007, when the first NPOESS satellite would be launched.[31] The projected savings had stayed consistent with the original NPR savings forecast.

PDRR—1999

The downselect from three to two candidates for the prime contractor was scheduled for 1999. The decision was taken out of the hands of the IPO when Hughes decided to drop out of the competition for the prime contract and team with Lockheed-Martin. This left the IPO offering two contract awards with two bidders. The new contract was for Program Definition and Risk Reduction (PDRR), a set of detailed design studies to take the system to just short of Preliminary Design Review readiness. At the end of the 27 month study a final competition would be held to select the prime contractor. This schedule was needed to meet the timeline to have the first satellite ready by July 2008 (a one year slip from the 1998 schedule).[32]

The ground segment portions of the design would have to be more mature than the space segment as the winning contractor would have an additional responsibility above its support to NPOESS. NASA couldn't get the second EOS-PM satellite funded, and it wanted a continuous data set to provide a baseline for climatology research.

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[27] Ferster, Warren, "New Ozone Mapping Sensors Combined on One Spacecraft", Space news, 6/7/99
[28] Ferster, Warren, "NPOESS seeks bids for two contracts", Space news, 5/24/99
[29] McConnell, Don and Ted Zambos, "History of 4000th Satellite Operations Group", http://www.zianet.com/jpage/airforce/history/wings/4000th.html
[30] Ibid.
[31] "Merger of AF, NOAA weather satellite ops to save $1.3 billion" Defense Daily, 6/9/98
[32] Ferster, Warren, "NPOESS seeks bids for two contracts", Space news, 5/24/99, and Ferster, Warren, "Rivals Lockheed, Hughes Team Up on NPOESS Bid", Space news, 9/13/99

Unfortunately NPOESS was set to launch after the end of the design life for the EOS-PM (Terra) satellite. As a "bridge" mission NASA devised the NPOESS Preparatory Program. This would be a smaller satellite, procured separately, that would launch before the NPOESS satellites carrying some of the key sensors and provide an opportunity to the IPO to test the sensors in orbit and test data processing algorithms with real data before committing to the deployment of NPOESS. NASA would procure the satellite bus and launch vehicle and the IPO would provide payload and ground segment support. This required the ground segment to be ready before the 2005 NPP launch, at least three years before the first NPOESS satellite goes up.[33]

Contracts were awarded to Lockheed-Martin and TRW. The $20.6 million contracts would lead to a downselect for the full development contract for five satellites and multiple ground facilities, valued at over $1 billion.[34] These contracts are in progress at this writing. The procurement for the final downselect has been accelerated by the IPO by most of a year.

Work In Progress—2000

The IPO has been mostly spared technical problems during this process as not enough hardware had been built to have any spectacular failures. The first major problem came at the level of the system design. EUMETSAT was unwilling to place the all the American-made NPOESS sensors on the METOP 3 satellite, and the planned METOP sensors could not support the quality of data that NPOESS was trying to guarantee. As a stop-gap the IPO as added an "augmentation satellite" to its reference architecture, covering the time until the next generation METOP 4 satellite was launched. This was an effective technical solution but raised the question of whether the costs of interfacing with a completely different system were worthwhile.

This is a lose-lose situation for the IPO. Accepting the performance of METOP 3 would deprive the Centrals of the promised system performance. Depending on the Europeans would further weaken the program if they didn't live up to the current promises (the METOP schedule has slipped three years from previous plans). Deploying an NPOESS satellite in parallel with METOP keeps the users and Europeans happy but increases the system cost, which Congress may object to and is certainly in conflict with the intent of the program. Giving up on METOP and using NPOESS satellites for all three orbit planes would remove future cost savings from taking advantage of improvements in the METOP series, as well as possibly offending our allies in Europe and the US Government agencies who had participated hammering out the earlier agreements. Congress can be expected to take offense at being told that METOP isn't useful after

[33] Ferster, Warren, "ITT wins sensor contract for US weather satellites", Space News, 9/13/99
[34] "TRW team is awarded contract in US satellite program", Satellite Today, 12/22/99

funding the program on the assurance that the Europeans would carry a third of the burden.

While still a low-profile program NPOESS is filling an important need for its users and they continue to support it. The head of the US Naval Space Command stated the "need to continue to improve space-based weather sensors" as one of his highest priorities.[35] A follow-on to DMSP and POES must be available to replace them when the last of the existing satellites are launched in 2003 (POES) to 2009 (DMSP). The Clinton-Gore Administration is still committed to NPOESS as part of its Reinventing Government legacy.

A new constituency is trying to come on board NPOESS, trying to obtain support from the IPO that NASA can no longer afford to give them. Climate researchers want continuous data sets over long periods to detect changes in the Earth's temperature. One of the problems in analyzing satellite data is that it can be hard to compare the calibration of two sensors that were not in orbit at the same time. The typical practice of launching a new satellite on the imminent failure of the previous one allows very little time to compare the two sensors' views of the same scenes and find any differences. With the subtle data that climatologists study a small calibration difference can overwhelm actual trends in the Earth's temperature.

To provide the level of accuracy and precision desired by the global warming community would require a one-year overlap in operations between the old and new sensors during each replacement (the NPOESS sensors are already sufficient to meet their needs). Climatologist Frank Wentz said, "This would be a good message for Congress and the funding agencies: 'now is the time. NPOESS is still in its early stages. Build the infrastructure for a precise global monitoring system.' " Guaranteeing that much overlap would drive up the number of satellites required to cover the NPOESS mission, with resulting cost increases that would have little benefit to the other users of the system. The IPO's chief scientist, Steve Mango, responded to the suggestion by saying, "It's not just whether the technology is ready. It's whether you can afford it. [The one year overlap] unfortunately is an enormous cost driver."[36] The IPO has not been influenced enough to ask the contractors to look at the impact of this change, and no Congressional support has been aroused, so the climatologists are unlikely to become part of the NPOESS constituency.

[35] "Profile: Rear Admiral JJ Quinn", Space News, 11/27/00
[36] Iannotta, Ben, "Climate Researchers Push for Better Weather Satellites", Space News, 1/31/00

The Future of NPOESS

There is no doubt that the United States will maintain some capability for obtaining weather imagery from sun-synchronous orbits. World-wide coverage is not just useful for military and civil aviation but supports the forecasting models used to predict weather in the United States. The merger of the civil and military programs is probably irreversible at this point, as the shut-down of the old systems' production lines would require any new development to be from scratch, and that would be unlikely to reach operation before the existing systems run out of satellites. NPOESS will survive on momentum at least.

The key danger for NPOESS is cost growth. Congress is unlikely to tolerate overruns in a program founded on savings. The demands of the users for their follow-on programs has led to an increase in the data rate by over an order of magnitude. Combined with their rapid data delivery demands the cost of communications links may be a major driver in the program. Holding the line on data rates may require the IPO to reduce the quality of the weather data produced or increase the delivery delay which could endanger the Centrals' support for the program. Whichever solution is chosen for working around the METOP shortfalls may also drive up the program costs.

The IPO will need to maneuver carefully to maintain the strength of its constituency. Once the prime contractor downselect is made the NPOESS coalition will also be weakened as the losing candidate will no longer continuing lobbying to support the program. Conflict with EUMETSAT could weaken support by bringing other government agencies in to protect relations with Europe. If METOP's role in NPOESS is terminated Congress may be motivated to reassess the program completely with a possible reduction in scope. If some user requirements prove to be unaffordable the IPO will have to reject them which may cost support from some or all of the user community. The Clinton-Gore Administration had been the initiator of the project and a major backer but the Bush-Cheney Administration will mostly likely be indifferent to NPOESS, leaving the IPO to fight its battles without top-level support.

The NPOESS constituency was put together in a "shotgun wedding" but will probably hold together. Any faction vociferously objecting to the design would probably not get a program of its own but would instead get nothing, with its rivals receiving a downscoped NPOESS. This is the prime incentive for the military and civil users to stick together—not friendship but predator pressure (fear of Congress).

Summary—NPOESS and the Facts of Life

NPOESS is a clear example of the political "facts of life" because it has been politically driven during the entire program. Some systems might be small and useful enough to be

funded with minimal fuss and bother, but NPOESS was born in the political process and will never escape it. The discussion above mentioned a number of the facts of life in passing but this summary will show how they all come together.

Politics, not technology, sets the limits of what technology is allowed to achieve.

Before 1993 building a converged system was perfectly possible but forbidden by national policy. Common satellites or even a mix of common and dedicated military and civil satellites could have reduced cost while preserving mission performance.

The Senate Armed Services Committee's threat to reduce DMSP to a single-satellite system was a clear case of politics limiting technology, but even the two satellite system could have been expanded with more satellites to improve performance had funding allowed for it. When satellites suffered partial failures they were kept operating as long as possible to increase coverage with the remaining sensors.

The choice of three orbit planes for NPOESS was a political compromise between NOAA and the Air Force. The different user communities had desired sun angles and times for their data but Congress would not tolerate an increase in the number of satellites to satisfy everyone's needs.

COST RULES.

Merging DMSP and POES was driven entirely by the goal of cost reduction. Any performance improvements had to still leave the cost below that of the DMSP and POES follow-on systems. The leaders of this effort were prepared to accept reductions in mission capability if that's what it took to achieve savings—after all, the Cold War was over.

Asking EUMETSAT to take on a portion of the NPOESS responsibilities was also driven as a cost-saving move. Reducing the potential cost of the satellites and command and control by a third was a very tempting possibility, enough to make the IPO accept the difficulties of interfacing their system with an international one.

NASA's low profile in NPOESS's development has been a function of its steadily tightening budget. The cancellation of the EOS follow-on satellites left NASA looking for a new platform to perform its climate study mission with, but NPOESS will only support that as a by-product of its primary mission. If NASA had funding to support the mission the IPO would probably be open to new requirements to support NASA's needs.

A strong, coherent constituency is essential.

The weather satellite convergence effort started off with the support of one of the most powerful constituencies possible—the White House and Congress united toward a common goal. Integrating METOP into the program added more support from European governments and foreign policy groups. This gave the program a solid start but these supporters had higher priorities and were not going to pay much attention to NPOESS down the line.

The permanent constituents were the users and operators of the weather satellite systems. While they were limited in how much additional clout they could bring to support NPOESS, their opposition could be damaging or fatal to the program. The IPO had to keep these constituents content while producing the cost savings desired by Congress. The users were promised vastly improved weather data through the development of new sensors and algorithms for processing their data. The operating agencies were to have all their requirements met while only paying half the cost of the system. Everyone is happy and supporting the program as long as the IPO can keep its promises.

Technical problems become political problems.

METOP's shortfalls in meeting the NPOESS data requirements, and EUMETSAT's schedule slips and unwillingness to carry the American-made sensors, creates a technical problem that may have major political complications for the IPO. Accepting the limited performance would offend the users, eliminating METOP from the architecture would offend the Europeans and their American friends, and adding another satellite to the architecture would drive up costs, contrary to the program's primary goal. The IPO has chosen the third option in the hope that the cost increase will not be enough to inspire Congressional reaction.

Meeting all of the data quality requirements promised to the users may require higher sensor data rates, which have already increased significantly since the sensor development contracts began. This massive quantity of data will require more expensive spacecraft components and ground network services to meet the requirements for rapid delivery. Eventually the IPO may be forced to chose between breaking the promises on data quality or timeliness (angering the users) or driving up the cost of the program (angering Congress).

The best engineering solutions are not necessarily the best political solutions.

Numerous lovely technical concepts have fallen by the wayside as NPOESS has been driven to a politically acceptable low-cost architecture.

Grouping all 10 or so sensors onto a single satellite eliminates opportunities to customize each sensor's orbit to maximize the usefulness of its data. Some sensors are only useful at particular sun angles or would prefer different altitudes than the primary sensors. However, multiple satellites would increase cost and the complexity of command and control. Even if a cost-effective method of using many smaller satellites was found, Congressman Rohrabacher would probably find the quadrupling of the satellite count even more outrageous than the discovery of the old 15 satellite backlog.

The original plan for a 2004 deployment of NPOESS would have provided higher quality data sooner to the users, but short-term savings were preferred over the possible increased performance. Using up all the DMSP and POES satellites was necessary to provide a minimum-cost solution to Congress.

When the METOP Augmentation satellite was added to the NPOESS architecture the interfaces to METOP arguably became redundant. Only a limited portion of the METOP data would be applied to producing METOP products and adding another sensor to the augmentation satellite could eliminate that need, simplifying an overly complex system. Work is continuing on all the METOP interfaces as the political consequences of terminating that relationship could be damaging to the program, even it is no longer a significant contributor to mission performance.

Other Applicable Facts of Life.

Timing is everything: The IPO discovered their new system development was scheduled too early for Congress's tolerance and pushed the schedule back three years.

Political problems become technical problems: Determining which sun angles were acceptable for performing the key DMSP and POES missions was a technical problem arising from the directive to reduce the number of satellites.

Politics prefers immediate, near-term gratification: The savings advertised for the Convergence effort have come from combining the DMSP and POES operations centers. Much less interest has been paid to the savings from NPOESS compared to the Block 6 and OPQ follow-ons.

Perception is often more important than the truth: DMSP and POES were treated as having the same purpose even though there was little overlap in their primary missions. METOP will probably be kept as part of the architecture to provide the appearance of burden-sharing even if the "augmentation" satellite could do the job by itself.

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