REPORT OF THE DEFENSE SCIENCE BOARD TASK FORCE ON SPACE AND MISSILE TRACKING SYSTEM

AUGUST 1996

OFFICE OF THE UNDER SECRETARY OF DEFENSE
FOR
ACQUISITION AND TECHNOLOGY

WASHINGTON, D.C. 20301-3140

This report is a product of the Defense Science Board (DSB). The DSB is a Federal Advisory Committee established to provide independent advice to the Secretary of Defense. Statements, opinions, conclusions and recommendations in this report do not necessarily represent the official position of the Department of Defense.

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301-3140

DEFENSE SCIENCE
BOARD

3 Sep 96

MEMORANDUM FOR THE UNDER SECRETARY OF DEFENSE(ACQUISITION AND TECHNOLOGY)

SUBJECT: Report of the 1996 Defense Science Board (DSB) Task Force on the Space and Missile Tracking System.

Iam pleased to forward the final report of the DSB Task Force on the Space and Missile Tracking System (WITS). This Task Force was implemented for a quick turn-around response to support your upcoming acquisition milestones. This letter report addresses the three programmatic and technical issues regarding concurrency, feasibility of an accelerated SMTS launch, and technical trade-offs between a FY 02 deployment verses FY 06.

The Task Force believes there are no technical obstacles to proceeding with a near-term SMTS deployment decision. Concurrency is possible, particularly with the Flight Demonstration System and the Pre-EMD/EMD phase. After reviewing numerous accelerated program options, the Panel supports an FY 04 deployment program as the optimal balance between cost, schedule, and technical risk. Furthermore, the Task Force notes that if the Department proceeds with this option, it implies moving directly to a balanced SBIRS-High/Low architecture, originally envisioned by the 1994 OSD SBIRS Summer Study for deployment in FY 10. This in turn will demand a strong SBIRS architecture systems engineer (currently lacking) to ensure a proper balance between the Block One deployments of SBIRS-High and SMTS.

I concur with the Task Force's findings and conclusions and recommend you review and sign the tasking/release letter.

Craig I. Fields
Chairman

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301-3140

DEFENSE SCIENCE
BOARD

22 Aug 96

Dr. Craig Fields
Chairman, Defense Science Board
3140 Defense Pentagon, Room 30865
Washington, DC 20301-3140

Dear Dr. Fields,

Enclosed is the report of the Defense Science Board Task Force on the Space and Missile Tracking System (SMTS). The members of the Task Force worked expeditiously to address the technical and programmatic risks associated with the possible acceleration of the SMTS deployment prior to the baseline 2006 date.

We concluded that there are no technical obstacles to proceeding with a near-term SMTS deployment decision. Most significantly, the flight experiments of the FDS and Dem/Val programs do not have to be conducted serially with other pre-EMD/EMD activities, but can be conducted concurrently. Though not essential for program success, the flight experiments are extremely beneficial and the current on-orbit test plans are inadequate to fully exploit either the FDS or Dem/Val satellites. The Task Force recommends that additional dedicated targets and test time be added to both. Given the above considerations, and after reviewing numerous accelerated program options, the Task Force believes a FY 04 deployment provides the optimal balance between cost, schedule, and technical risk.

Furthermore, the Task Force notes that if the Department proceeds with this option, it implies moving directly to a balanced SBIRS-High/Low architecture, originally envisioned by the 1994 OSD SBIRS Summer Study for deployment in FY 10. This in turn will demand a strong SBIRS architecture systems engineer (currently lacking) to ensure a proper balance between the Block 1 deployments of SBIRS-High and SMTS.

I appreciate the extraordinary time and effort put in by Task Force members, government advisors, and the support staff on such short notice. We believe our recommendations will substantially assist restructuring the SMTS program.

For the DSB Task Force on SMTS,

Donald M. Kerr

Donald M. Kerr
Chairman

Enclosure

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301-3140

DEFENSE SCIENCE
BOARD

22 Aug 96

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE (ACQUISITION AND TECHNOLOGY)

SUBJECT: Defense Science Board (DSB) Letter Report on the Space and Missile Tracking System (SMTS)

This letter report responds to your July 10, 1996 tasking for the DSB to examine the Space and Missile Tracking System (SMTS) Program and assess the viability of accelerating program deployment prior to the baseline 2006 date. The report was requested by 1 September 1996.

The Terms of Reference (Appendix A) specifically asked us to address:

what level of concurrency is acceptable given the program technical risk?
if there is sufficient on-orbit testing and evaluation of the Flight Demonstration System (FDS) to support an accelerated SMTS deployment decision?
what are the trade-offs between early (2002) deployed version of SMTS and a more capable SMTS deployed in 2006?

Our report addresses these issues, provides a summary of the meetings and visits to applicable contractors and the concerned program offices as part of our information gathering, and details our findings, and recommendations. Task Force membership is shown at Appendix B.

The basis of the need for an improved space-based surveillance system is to replace DSP with a system that will satisfy new and expanded requirements for situational awareness. These are brought about by the increase of ballistic missile capabilities throughout the world and the proliferation of weapons of mass destruction. Of particular importance is the need to ensure an integrated space and ground system that will satisfy or contribute to four key mission areas as described below:

Missile Warning: Provide reliable, timely, and accurate missile warning information to the National Command Authorities (NCA), Unified Commanders In Chief (CINCs), and other users. This mission includes functional requirements to support strategic and theater ballistic missile warning, and the notification and implementation of passive defense and force posturing.

Missile Defense: Provide reliable, accurate, and timely information to defensive systems. This mission includes both national and theater requirements to support active missile defense and attack operations against hostile forces.

Technical Intelligence: Provide reliable, accurate and timely threat performance and infrared (IR) target signature data to warfighters and weapons developers. Provide target classification and identification profiles and algorithms for operational missions. Monitor activities and provide information to policy makers and other users on observed military tactics, new foreign technology development, arms control compliance, and proliferation activities.

Battlespace Characterization: Provide reliable, accurate, and timely data to enhance development of situational awareness, non-ballistic missile threat warning, decision support, battle damage assessment and intelligence information (for land, sea, air, and space) for the Unified CINCs, Joint Task Force (JTF) Commanders, and other users.

SMTS as the low altitude satellite component of the overall Space Based Infrared System (SBIRS) promises to provide a unique precision midcourse tracking capability for all four of these functions. Additionally, it should improve launch point detection, impact point prediction, and cueing support to other sensors. SMTS includes a Flight Demonstration System (FDS) program and a competitive Dem/Val program. FDS consists of two spacecraft, a ground test vehicle, and necessary ground station capability to support flight test activities. The Dem/Val program has a single spacecraft, a ground test payload, and necessary ground station capability to support flight test activities.

In examining the SMTS program, the Task Force met on separate occasions with leaders from USSPACECOM, the SMTS Program Office, the Aerospace Corporation, TRW, Hughes, and Rockwell, as well as with the planned operators of the system from Air Force Space Command. These meetings provided us with the necessary background information and technical data to develop our findings and recommendations. The assistance of Lt Col. James Martin from your Space Office as Task Force Executive Secretary and of Major Wynne Waldron (DSB Military Assistant) was particularly helpful in arranging the meetings with government and industry leaders on very short notice.

Findings

1. The program is substantially hampered by a problematic deployment decision now scheduled for FY 00. This results in a reduced corporate commitment to the program, fiscal vulnerability, lack of integrated systems engineering, and a distorted requirements allocation between SBIRS high and low components. An early commitment to the program is urgently needed.

2, There is no way to substantially speed up the IOC for SMTS while following the current procurement plan which demands flying FDS (3 years to launch), on orbit test (1 year) before a decision to buy the system, design and build the first production satellites (4 l/2 years to first launch), production and launch of the first constellation (2 l/2 years) or about 11 years. This scheduIe is already tight and can only be significantly shortened by leaving out or conducting concurrently some steps, not by squeezing them. We are certainly capable of putting up a SBIRS Low constellation in less than 11 years if we seriously want to.

3. The current SMTS plan lacks both an overall system designed for SBIRS and a system engineering organization to create such a design and integrate full system capability from signal acquisition to data delivery to the ultimate users. These deficiencies add confusion, time and risk to the program. Total system design must take into account cost schedule risk, balance between the elements, and a careful reevaluation of the requirements especially regarding how SMTS fits into the larger system of which it is a part. Deploying SMTS could affect the current planned configuration of SBIRS - High, Block 1, which was developed assuming SMTS would not be deployed in the near-term.

4. Establishing a credible alternative competitor to TRW/Hughes is essential. Following interviews with other contractor teams it was evident that a range of viable technical alternatives exist that should be pursued until EMD downselect. The Air Force should fully fund the competitive Dem/Val program to ensure the best candidate options are available for EMD.

5. The Task Force strongIy believes that ground demonstrations, tests, modeling, and simulations are critical to the success of the program. Flight demonstrations are important to developing CONOPS, serving as spacecraft integration "pathfinders", and forcing disciplined software development, but do not have to be accomplished before the deployment decision. On the other hand ground activities, particularly software development, will likely be the pacing elements of SMTS.

6. As far as we can determine FDS is neither a prototype (it would require major changes to serve as a first article unit) nor an experimental unit. It appears to be a mix of the two and not sufficient for either. The current limited bandwidth downlink and modest capacity data recorder preclude desired analysis of focal plane array (FPA) performance and possible anomalous behavior. Revisiting these limitations could provide a more robust capability to collect and analyze data.

7. The planned flight tests of FDS and the Dem/Val vehicles are considered to be overly success oriented and, in our opinion, do not have sufficient dedicated or cooperative targets. The FDS plan does not provide sufficient time for problem resolution and correction and does not seem to have adequate diagnostic data retrieval capability. At present there is only one dedicated target for FDS and none for Dem/Val test flights. (MSX has three dedicated targets for an equivalent one year period).

8. Technical Concerns / Issues

The Task Force encountered no technical impediments that would preclude design of the SMTS objective system. We were, however, in the course of discussions, made aware of several technical concerns that merit special attention.

Cryocooler Lifetime:

Experience with past IR satellite programs has shown that the operating life of the IR cooIer is an important determinant of satellite life. Mechanical wear, the primary cause of cryocooler failure, is a function of both sensor temperature and time in service. The SMTS may

potentially use FDS cryocooler designs; the Stirling cycle cooler has moving parts, the pulse tube design has none. Two Stirling coolers have been on test operation for 33 and 32 months respectively; the number of pulse tubes on test is uncertain. In view of the importance of these coolers, it is surprising how few coolers, especially of Stirling design, are undergoing life test. The Task Force urges that these and potential additional cooler designs be placed on life test to gain reliability experience with these critical components.

Contamination Control:

Experience with earlier infrared programs has shown the importance of contamination control during satellite fabrication, launch and operation. Failure to keep infrared optics clean significantly reduces sensor performance. This is particularly important for the objective SMTS which must maintain sensor performance for an eight-year mean mission duration. The Task Force urges that special attention be given to assuring contamination control.

Software:

The Air Force, contractors and the Task Force all agree that software is the riskiest aspect of the SMTS program. All the potential contractors for an EMD program face significant challenges in SMTS on-board processing and ground-based constellation management software. The members regard the development of reliable, operational software that meets performance requirements as the greatest technical issue in the SMTS program. As discussed in finding 5, the software risk can be mitigated through extensive use of system modeling and simulation with ground test hardware in-the-loop.

Radiation Hardened Components:

Depending on the altitude selected for SMTS deployment, satellite components may be exposed to unusually high total radiation doses. Integrated circuit electronic components such as SRAMS, E^2PROMs and A/D converters and processors are particularly sensitive to radiation exposure and must be specially designed and fabricated to be radiation hard. The supplier base for radiation hardened integrated circuits is small and declining; delivery times for radiation hardened SRAMS have been quoted to Aerospace Corporation to be 32 months after receipt of order. (An independent query on the part of the Task Force resulted in a 12 to 18 month quote dependent on quantity.)

Supplies of radiation-hardened integrated circuits are likely to remain tight for the foreseeable future; availability of these critical components could delay the construction of flight hardware. The Task Force urges that careful watch be kept on radiation hardened integrated circuit lead times and that steps be taken to reserve components needed to assure SMTS deployment, unless an early decision can be made to deploy at a lower altitude thus permitting the use of commercial components.

Recommendations

1. The Task Force recommends that the Air Force provide, either through an FFRDC or by contract, a system engineer for the entire SBIRS system of systems (See finding #3). Since SBIRS is intended to meet Joint requirements the system engineer should be supported by an advisory board drawn from the three services and staffed by qualified individuals drawn from MIT Lincoln Laboratory, JHU Applied Physics Laboratory, or other similar institutions. An immediate task for the SBIRS system engineer is to assess the trade-offs between SMTS altitude, cost, radiation hardness, and number of satellites. The degree of hardening needed has major effects on the use of available parts (especially COTS), cost, risk, producability, and schedule. Constellation altitude is a major cost determinant and should be thoroughly reviewed.

2. Systems such as MST1 and Clementine prove that affordable satellites can be built using new technologies. By exploiting the capabilities of both MSTI-3 and MSX, both already on orbit and operating successfully, a series of cooperative experiments could be undertaken which would go beyond the individual experiments currently planned for them using a very limited number ofAA targets The addition of cooperative experiments would demonstrate the essential elements of all stereo background and target phenomenology, as well as acquisition, handover, tracking and discrimination functions. With high feasibility and low marginal cost, such experiments would explore concept of operations issues surrounding the use of a distributed surveillance constellation.

3. As a result of our findings, the Task Force identified three (3) options for your consideration regarding the SMTS program. It is noted that the members unanimously expressed the strongest concern that no matter which option is chosen for program continuation, the designation of a "real" system engineer is required as soon as possible (note finding #3) and that all options require fairly stable funding, consistent requirements, and timely government decision making. The options proceed from a strictly sequential, current baseline deployment in FY 06 to an accelerated, higher risk program deployment in FY 02 that dispenses with any flight demonstration satellites.

Option 1:

This is the current baseline program which flies FDS and Dem/Val spacecraft, waits for data (if available), makes deployment decision in FY 01, and initiates deployment in FY 06 (risky schedule since FDS and Dem/Val flights are serial activities prior to EMD decision). See attached schedule.

Option 2:

Restructure the FDS and Dem/Val flights to be important experiments rather than critical path milestones supporting development of the EMD program. Expand FDS and Dem/Val on-orbit test period to permit operation up to third quarter FY 01. Deployment decision should be assessed at a DAB no later than third quarter FY 97. Pre-EMD proceeds in parallel with the flight demonstrations. This could lead to deployment in mid FY 04. See attached schedule.

Option 3:

Restructure the SMTS program to proceed directly into pre-EMD in FY 97. Provide no flight demonstrations. Nearly flight worthy hardware should be used in ground testing and simulation as well as support ground station software design. EMD would be in FY 98 with deployment commencing in FY 02. This would require termination of the current FDS and Dem/Val programs. See attached schedule.

The Task Force recommends Option 2 as the one most likely to balance technical, and budget constraints. It offers a lower level of risk and may be executable under current procurement plans, at a lower total funding level than Options 1 or 3.

Summary

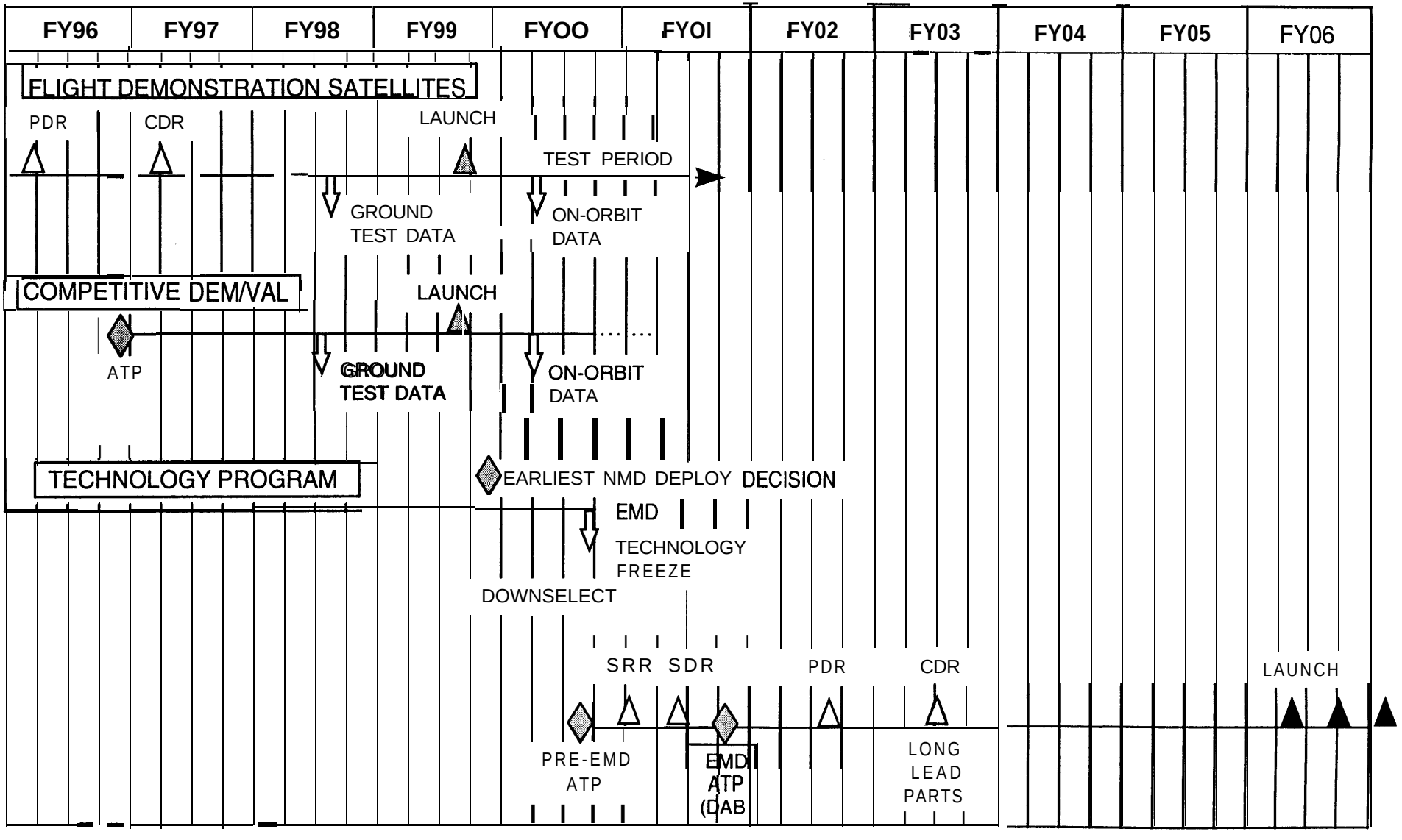
The Task Force believes there are no technical obstacles to proceeding with a near-term SMTS deployment decision. Most significantly, the flight experiments of the FDS and Dem/Val programs do not have to be conducted serially with other pre-EMD/EMD activities, but can be conducted concurrently. Though not essential for program success, the flight experiments are extremely beneficial and the current on-orbit test plans are inadequate to fully exploit either the FDS or Dem/Val satellites. The Task Force recommends that additional dedicated targets and test time be added to both. Given the above considerations, and after reviewing numerous accelerated program options, the Panel supports an FY 04 deployment program as the optimal balance between cost, schedule, and technical risk.

Furthermore, the Task Force notes that if the Department proceeds with this option, it implies moving directly to a balanced SBIRS-High/Low architecture, originally envisioned by the 1994 OSD SBIRS Summer Study for deployment in FY 10. This in turn will demand a strong SBIRS architecture systems engineer (currently lacking) to ensure a proper balance between the Block 1 deployments of SBIRS-High and SMTS.

I greatly appreciate the time and effort put in by Task Force members, government advisors, and the support staff on such short notice. It has been a pleasure to work with this talented group.

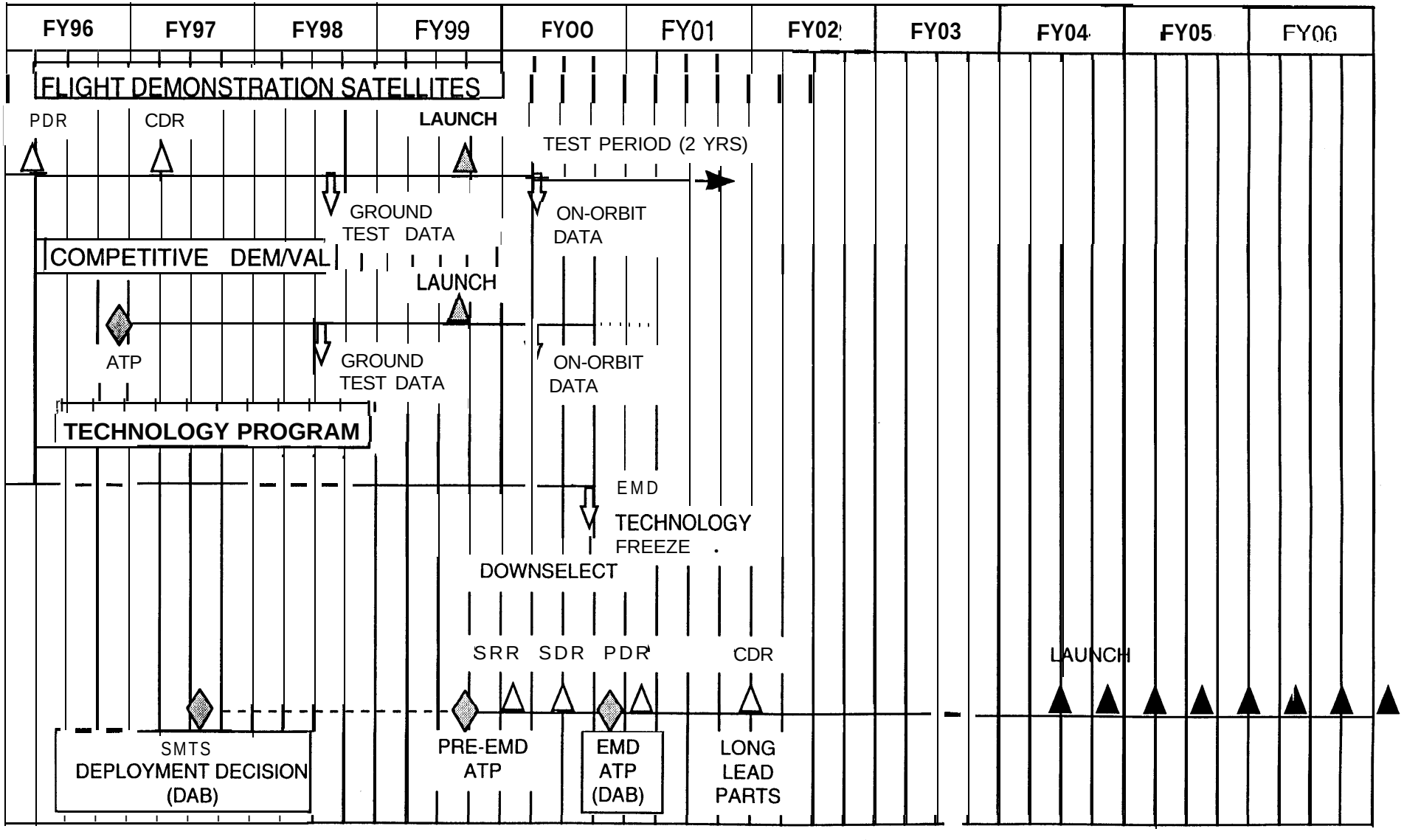
Donald M. Kerr
Chairman

SMTS OPTION 1: FY 06 FIRST LAUNCH



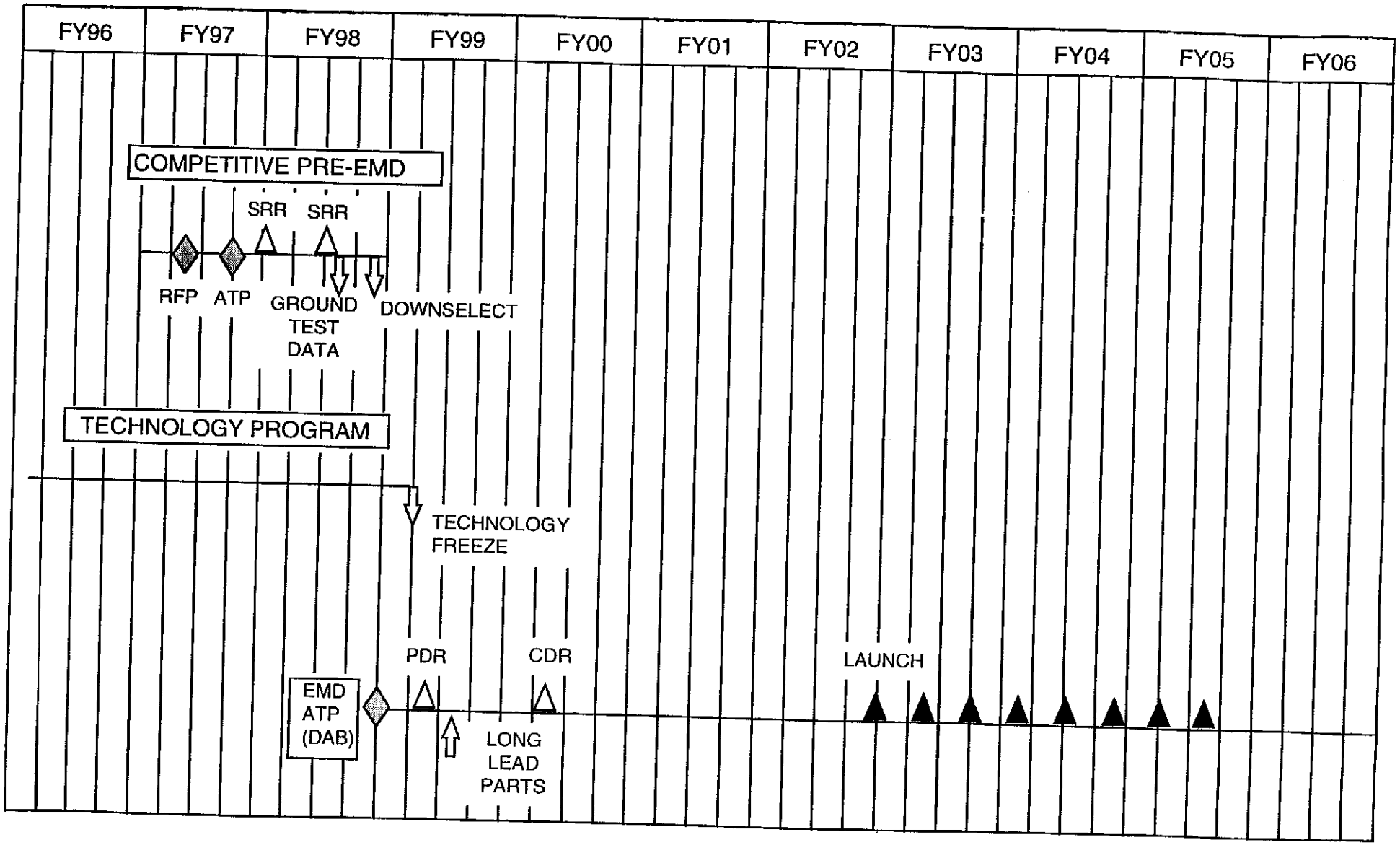
RAF/I-T328

SMTS OPTION 2: FY 04 FIRST LAUNCH



RAF/TT325

SMTS OPTION 3: FY 02 FIRST LAUNCH



RAF/TT327

THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON. D.C. 20301-3010

:QUISITION AND
TECHNOLOGY

JUL 1 0 1996

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

-SUBJECT: Terms of Reference--Defense Science Board Task Force on Space and Missile Tracking System (SMTS)

You are requested to form a Defense Science Board Task Force to assess the viability of accelerating the SMTS deployment prior to the baseline 2006 date.

The SMTS program has been funded to support initial deployment in 2006. However, the FY96 Defense Authorization Act directed a four-year acceleration with deployment beginning 2002 with a 2003 Initial Operational Capability--and reduced system requirements. Additional incremental funding would be provided for program acceleration. Recent experience with the Flight Demonstration System (FDS), precursor to an operational SMTS, indicates technical and integration risks may delay the launch schedule which could effect an aggressive deployment date. The Task Force should address the following:

- What level of concurrency is acceptable given the technical program risk?

Is there sufficient on-orbit testing and evaluation of the FDS to support an accelerated SMTS deployment decision?

- What are the trade-offs between early (2002) deployed versions of SMTS and a more capable SMTS deployed in 2006?

The Task Force should submit a report by 1 September 1996.

The DUSD(Space) will sponsor this Task Force. Dr Donald M. Kerr will serve as the Task Force Chairmen. Lt Co1 Jim Martin, USAF, from the DUSD (Space) will serve as Executive Secretary, and Maj Wynne Waldron, USAF, will serve as the Defense Science Board Secretariat representative.

Appendix 1

The Task Force will be operated in accordance with the provisions of P.L. 92-463, the "Federal Advisory Committee Act," and DoD Directive 5105.4, the DoD Federal Advisory Committee Management Program." It is not anticipated that this Task Force will need to go into any "particular matters" within the meaning of Section 208 of Title 18, U.S. Code, nor will it cause any member to be placed in the position of acting as a procurement official.

Paul Kaminski

Paul G. Kaminski

MEMBERSHIP

DEFENSE SCIENCE BOARD TASK FORCE

ON

SPACE AND MISSILE TRACKING SYSTEM

July 1996

CHAIRMAN

Dr. Donald M. Kerr *
Information Systems Laboratories, Inc,

MEMBERS

Mr William Howard *
Private Consultant

Mr Robert R. Everett #
MITRE

Mr Robert Graham @
The Defense Group, Inc

Mr Mark Albrecht @
SAIC

Professor Daniel E. Hastings @
Massachusetts Institute of Technology

Appendix E

Executive Secretary

Lt Co1 Jim Martin, USAF
ODUSD(**Space)**

DSB Executive Secretary

Maj Wynne Waldron, USAF'
OUSD(A&T)/DSB

* DSB Member
# Approved Consultant
@ Not Yet Approved DSB Consultant

Paul Kaminski
USD(A&t). Approved
JUL 2 5 1996
Date

SASD Coordination
July 30, 1996
Date