THE REPORT OF THE

DEFENSE SCIENCE BOARD

TASK FORCE

ON

CONCURRENCY AND RISK OF THE F-22 PROGRAM

(INTERIM REPORT)

DECEMBER 1994

OFFICE OF THE UNDER SECRETARY OF DEFENSE
FOR ACQUISITION & 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.

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OFFICE OF THE SECRETARY OF DEFENSE
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DEFENSE SCIENCE BOARD

26 DEC 1994

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE (ACQUISITION & TECHNOLOGY)

SUBJECT: Interim Report of Defense Science Board Task Force on Concurrency and Risk of the F-22 Program

I am pleased to forward the Interim Report of the Defense Science Board on Concurrency and Risk of the F-22 Program.

In response to your tasking, the Task Force examined the concurrency/risk in the F-22 program plan. Specifically, it reviewed the risks in each major area and identified those key events whose accomplishment was needed to provide assurance that the program was ready to move into significant production rate, from 4 to 12 aircraft per year. We found that the existing plan, if achieved, would provide such assurance. Further, each of these "events" has a series of preceding accomplishments which give adequate forewarning of potential problems.

We also, as requested, reviewed several studies that compared the F-22 schedule with that of previous fighter programs and concluded that the F-22 plan is consistent with and , in many ways, more conservative than these other programs.

Our conclusion, thus, was that the F-22 plan has acceptable overlap of development and production (Concurrency) and that the risks associated with premature entry into rate production are readily controllable through insistence on meeting the key "events" identified in this report.

As noted, this is our Interim Report. The Final Report will be a slightly expanded version and will be ready for formal DSB review in the 1st quarter CY '95. We do not expect any changes of substance.

Charles A. Fowler

Charles A. Fowler
Task Force Chairman

cc: Dr. Craig Fields
Chairman, DSB

DEFENSE SCIENCE BOARD
Task Force on F-22 Program
Concurrency and Risk

Interim Report

December 1994

OUTLINE

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- F-22 Schedule
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CHARTS

TASKING

- Are there any areas in the F-22 Program of excessive concurrency? What is the risk in each area?
- For any areas of identifiable high risk, are viable plans/options available that would mitigate the risk?
- What conclusions regarding F-22 concurrency and risk can be drawn by comparisons to previous fighter aircraft programs?

Terms of Reference: USD (A&T); Nov 1, 1994

The Terms of Reference (see Appendix A) included three tasks as noted above. The third task reviewing several studies comparing the concurrency in the F-22 program plan with that of other fighter aircraft programs, is covered in pages 10-20.

The first task, reviewing the program and determining and identifying the risk in each major area, is covered in pages 21-38.

The second task, relating to plans/options to mitigate risk in key areas, is covered on page 40.

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TASK FORCE SCHEDULE

3 November - Washington, D.C.
- Program Office Program Overview
- IDA Study on Concurrency

4 November - Washington, D.C.
- Program Office Detailed Briefings
  - Airframes, Engines, Avionics

16 November - Marietta, GA
- Lockheed Overview Briefings
- Hangar Tour & Demos

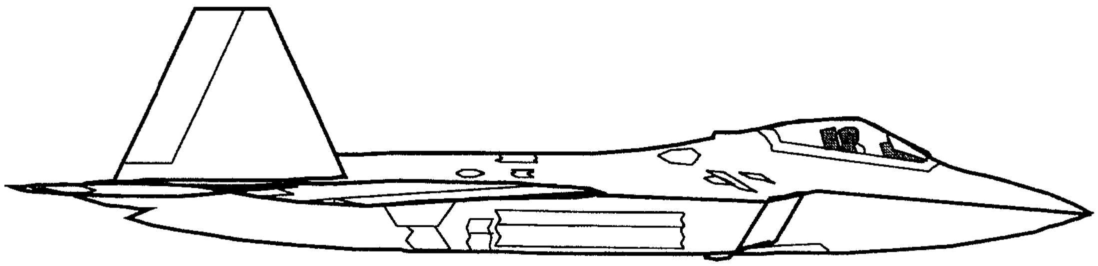
17 November - Marietta, GA
- Lockheed Detailed Briefings
- Individual Sessions

6 December - Washington, D.C.
- Task Force Discussions

7 December - Washington, D.C.
- Task Force Discussions
- Brief Findings to Director Strategic and Tactical Systems

The Task Force met with officials from the Air Force Program Office, the Air Staff, the prime contractors and major subcontractors. While the schedule was short, a critical technical and management review was conducted.

F-22 KEY FEATURES



Super Cruise

Vectored Thrust

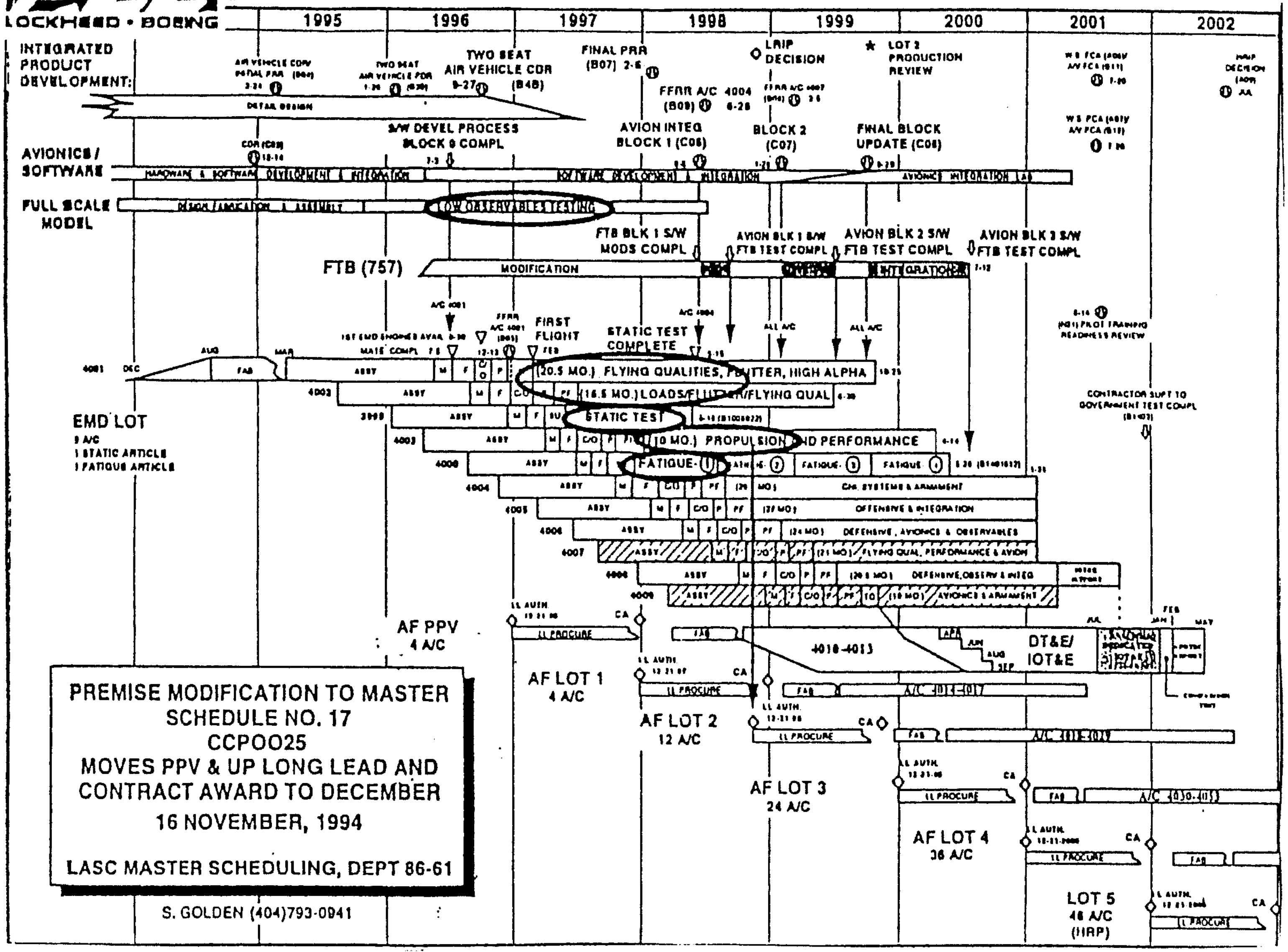
Stealth

Situation Awareness

Integrated Avionics

The F-22 is the next generation air superiority fighter scheduled for introduction in the first decade of the 21st century. Its primary role is to counter emerging proliferating worldwide threats, and to maintain the overwhelming air superiority advantage needed by a downsized and reshaped U.S. military force. The F-22 is designed to penetrate enemy airspace and achieve a first-look, first-kill capability against multiple aircraft targets. The features that will permit the F-22 to achieve this advantage are: a low observable highly maneuverable airframe extensive use of composites and low observable materials; advanced software-intensive integrated avionics providing improved situational awareness; and a new engine with a two-dimensional vectoring nozzle which is also capable of supersonic cruise without using afterburner.

F-22 PREMISE SCHEDULE



The DSB schedule concurrency and risk assessment was based upon the above F-22 program schedule resulting from the Air Force FY1996 POM submission.

TASK FORCE APPROACH

- Define Concurrency
- Compare F-22 development schedule concurrency metrics to experiences of earlier tactical aircraft developments
- Conduct top-level critical technical and management areas review of F-22
- Identify key decision points for each critical technical area
- Assess F-22 degree of concurrency and risk

The Task Force reordered the questions in the Terms of Reference (TOR) to address first concurrency metrics and then the technical review.

DEFINITION AND COMPARISONS OF CONCURRENCY

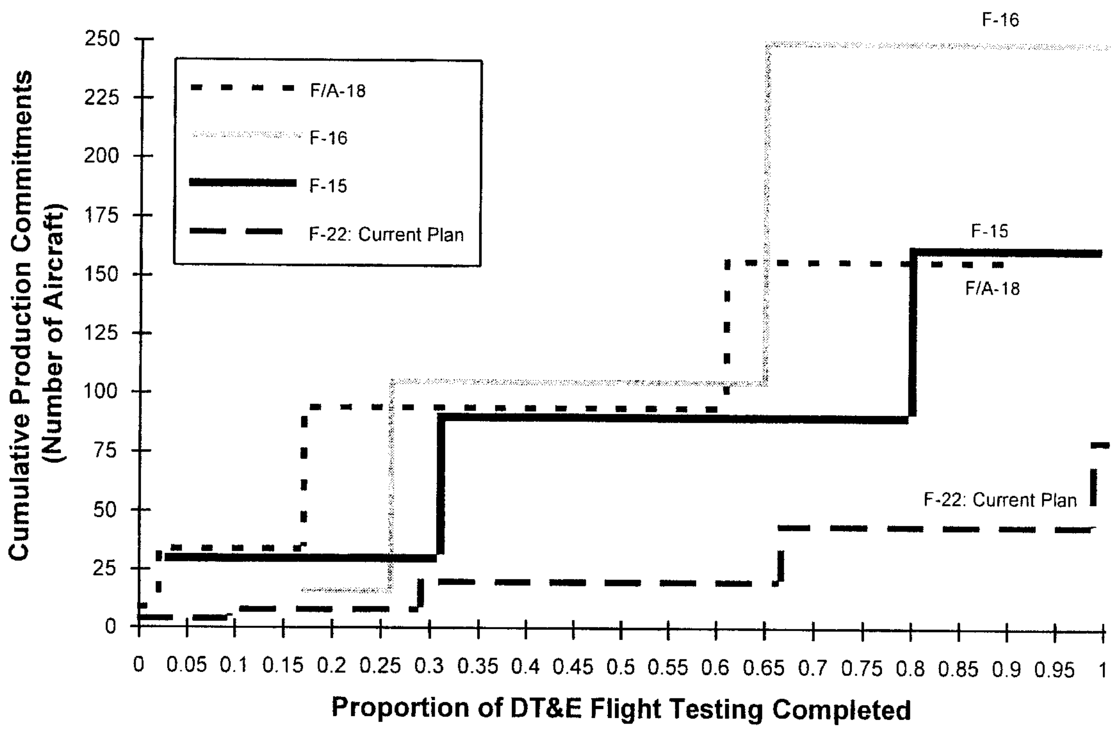
- Definition*
  - Concurrency is the degree of overlap between the development and production processes of an acquisition program. Structuring the overlap is a management judgment balancing:
    - » Risk of proceeding
    - » Cost of delay, work force inefficiency, design obscelescence
    - » Operational impact
- Comparison of F-22 concurrency with other relevant programs
  - IDA Study
  - RAND Study
  - Unpublished Source

* Source: DoD Report on Concurrency in Major Acquisition Programs; April 1990

In its report to Congress on concurrency in April 1990, DoD defined concurrency. The definition in that report is the definition the Task Force used.

It is important to note that concurrency is the degree of overlap, and degree must be measured in terms of the trade-offs and judgments of risk that must be made. To assist in this assessment of concurrency, the F-22 program was compared to previous fighter aircraft programs.

CONCURRENCY BETWEEN FLIGHT TEST AND PRODUCTION
IDA Metric 1: Number of Production Aircraft Commitment During DT&E

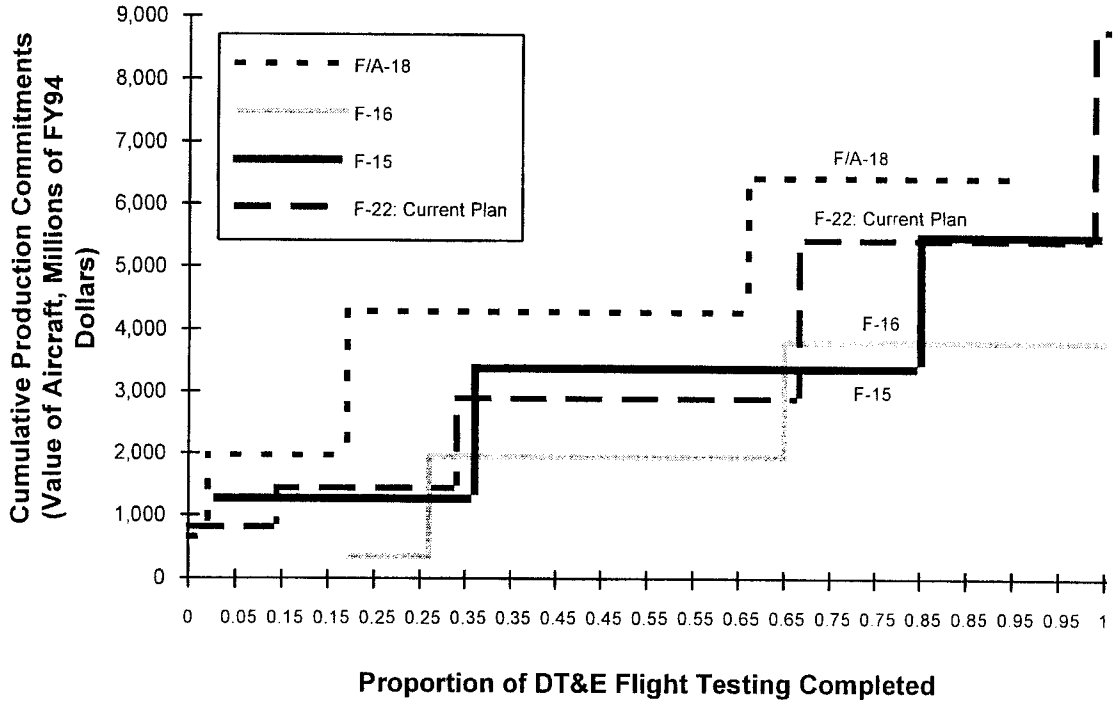


Source of Historical Program Data: IDA Paper P-2105, February 1989.
F-22 Data from Lockheed Premise Modification to Master Schedule, No. 17, dated 16 November 1994.

Continued

Our look at concurrency then, first compared the current plan of the F-22 with the three most recent fighter aircraft programs. IDA looked at several ways to compare concurrency in their 1989 report on "Assessing Acquisition Schedules for Tactical Aircraft". For this Task Force, IDA updated two measures of concurrency. The first, shown in this chart, compares the proportion of DT&E flight testing completed to the number of aircraft commited to production. As far as number of F-22s on contract when DT&E is complete in mid-2001, the 40 aircraft of Lots 1, 2 and 3 plus the Long-Lead items for another 36 aircraft (Lot 4) are scheduled to be on contract. This chart shows that fewer F-22 aircraft have been commited to production than with the other programs.

CONCURRENCY BETWEEN FLIGHT TEST AND PRODUCTION (Concluded)
IDA Metric 2: Value of Production Aircraft Commitment During DT&E



Source of Historical Program Data: IDA Paper P-2105, February 1989.
F-22 Data from Lockheed Premise Modification to Master Schedule, No. 17, dated 16 November 1994.
Historical Financial Data from Contractors/Program Office Sources.
F-22 Financial Data from F-22 SPO.

Looking at a different metric, IDA compared the proportion of DT&E flight testing completed to the amount of funding committed for the different fighter aircraft. The F-22 is more expensive per aircraft, but has a profile similar to the dollar commitments on the other programs.

LENGTH OF KEY PERIODS FOR FIGHTER/ATTACK AIRCRAFT

First Flight		EMD to First Flight (Months)	Static Test Duration (Months)	Fatigue Test Duration (Months)	DT&E/OT&E Flight Test Duration (Months)	EMD to LL Release for Lot #1 (Months)	First Flight to LL Release for Lot #1 (Months)	EMD to First Production Delivery (Months)
1972	F-15	31	8	15	44	34 (for 30 A/C)*	+3	59
1976	F-16A**	23	12	18	25	23 (for 16 A/C)*	+0	43
1978	F/A-18**	35	22	50	40	24 (for 9 A/C)*	-11	53
1981	AV-8B**	31	29	33	37	25 (for 12 A/C)*	-6	55
1997	F-22 (est)**	68	12	29	63	78 (for 4 A/C)*	+10	112

* Size of 1st Lot
** Also had prototype in program

Source of Historical Program Data: IDA Paper P-2105, February 1989.
F-22 Data from Lockheed Premise Modification to Master Schedule, No. 17, dated 16 November 1994.

This chart compares the F-22 to other aircraft, and shows the duration of testing. Static and fatigue durations are below average. However, flight testing is over a longer duration—twice the average, giving time to correct problems. Time from EMD to first production is also longer than average, giving time to correct problems. Long-Lead release for Lot 1 is after first flight. Thus in these categories, the F-22 time lengths seem reasonable compared with other programs.

FLIGHT TEST DATA COMPARISONS

	Number A/C	Air Vehicle Test Hours	Avionics Test Hours	Armaments Test Hours	R&M	Total Flight Hours	Average Hours/Flight	Average Hours Per A/C Per Month
F-15 A/B	20	1,664	819	372	-	2,856	.94	10.9
F-16	10	1,638	489	174	280	2,581	1.24	16.5
F/A-18	12	2,365	591	952	1,013	4,922	1.43	16.2
AV-8B	5	1,037	478	523	-	2,038	1.05	13.9
F-22	9	2,426	2,765	-	-	5,191	1.8	23.3

Source of Historical Program Data: IDA Paper P-2105, February 1989.
F-22 Data from Lockheed Premise Modification to Master Schedule, No. 17, dated 16 November 1994.

This chart shows how the scheduled F-22 flight test hours compare to other programs. The average hours per flight and per aircraft are higher than other programs because of the high number of flight hours using 9 test aircraft. The 1.8 hours per flight does exceed the 1.6 hours per flight average in the YF-22 test program—there is a planned heavy use of in-flight refueling. The 23.3 hours per month is a calculated value—Lockheed plans approximately 25 hours per month. (Even at 19 hours per month—on average—20% of the flight test hours would be accomplished by the time Lot 2 long-lead items are procured. However, it should be noted that this depends on achieving the high flying hour rates scheduled early in the flight test program.) The F-22 program does have an accelerated maturation, which the Program Office attributes to Demonstration/Validation (D/V) benefits as well as integrity program benefits. (The higher number of test aircraft for the F-15 might be explained by the fact that there was no prototype.)

RAND STUDY ON F-22 PRODUCTION DECISION
(1989-1991; Updated Nov 94)

Issue:
- When should production commitments be authorized?

How much system maturity is enough?

Approach:
- Link decisions to development flight test results
- Distinguish between kinds of problems
  - Potential program killers
  - Troublesome but manageable
  - Routine

Examine data base of prior programs

Whether the timeline, number of aircraft, and funding commitments are consistent with other fighter aircraft programs, the question remains, "how much testing is enough to reduce risk to an acceptable level before committing to production?" A RAND project memorandum "Use of Flight Test Results in Support of F-22 Production Decision" of November 1994, discussed this issue. They examined the type of problems found during flight testing. They categorized problems in the three areas shown here and examined prior programs. Using this past history, RAND estimated ways to link production commitments to flight test results. It should be noted however, that arguments for reduced concurrency usually focus on reducing the risks of not achieving financial, technical, and operational performance for programs, rather than whether programs may or may not get cancelled.

RAND STUDY ON F-22 PRODUCTION DECISION: RESULTS

Findings:

- When major problems occur, it is usually within first 10-20% of full scale system development test
- No instances where major problems were first revealed in later phases of development test program

Conclusion:

Unlikely that keying production decisions to completion of IOT&E testing would substantially reduce technical risk

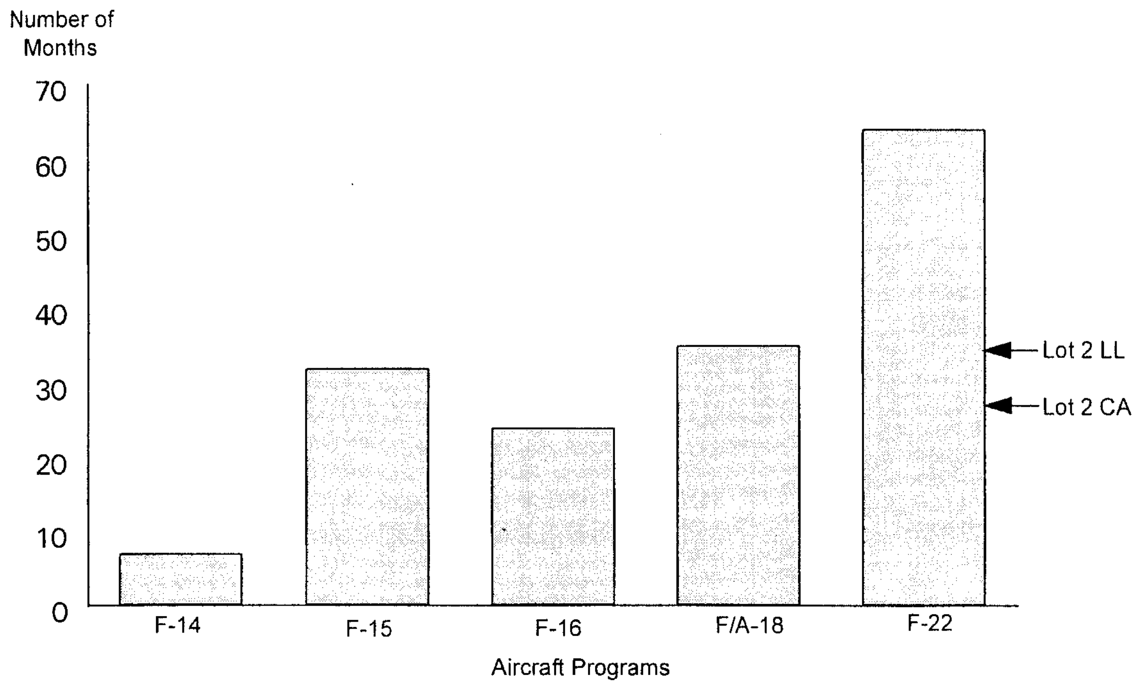
RAND found the results shown here. To put this in perspective, we looked at the current schedule of the F-22, and the time at which 10%-20% of full-scale system development testing would be completed. Looking at the F-22 flight testing, if one excludes the flight test experience in the YF-22 in Demonstration/Validation (D/V), Lockheed estimates approximately 400 hours of flight testing scheduled to be completed by December 1997, which does not represent 10%-20% of testing being completed before Long-Lead Procurement for Lot 1. In addition, this accumulation of flight test hours in this time period appears optimistic in comparison to previous flight test experience. The Lockheed schedule calls for approximately 25 hours per month for 10 months, averaging 1.5 aircraft over this time period. The YF-22 D/V is excluded because there are differences between the prototype and the EMD aircraft under contract.

Another milestone is the Lockheed estimated 1,400 hours (27%) of flight test hours scheduled for completion by December 1998 (using 4 aircraft). At that point, only the Long-Lead items for Lot 1 (4 aircraft) will have been procured with decisions pending at Lot 1 Contract Award and Lot 2 Long-Lead. Again, the accumulated flight test hour estimate appears optimistic. However, if a more modest accrual of flight test hours occurs, the Task Force believes that 1,000 flight hours could be achieved, which is still in line with the RAND 10%-20% factor. (To reach 20% of flight test hours, the F-22 would have to reach 1,040 hours.)

A large portion of testing on the F-22 is testing of the avionics. Some 20% of avionics flight testing is scheduled for completion by the first quarter of 1999. While that may not cover some important avionics subsystems hardware and software integration, it should cover significant portions of the radar, CIP, CNI, and EW functions. At that point, long-lead items for Lot 2 (12 aircraft) and Contract for Lot 1 should have been awarded.

Further, it appears that keying production decisions to Lot 2 Long-Lead—or conservatively—Lot 2 Contract Award, would provide sufficient risk reduction. Given the amount and duration of testing, it seems unlikely that keying production decisions to completion of IOT&E testing (February 2002) would substantially reduce technical risk.

NUMBER OF MONTHS THE START OF PRODUCTION IS SCHEDULED TO BEGIN PRIOR TO THE END OF IOT&E
Other Metric 1



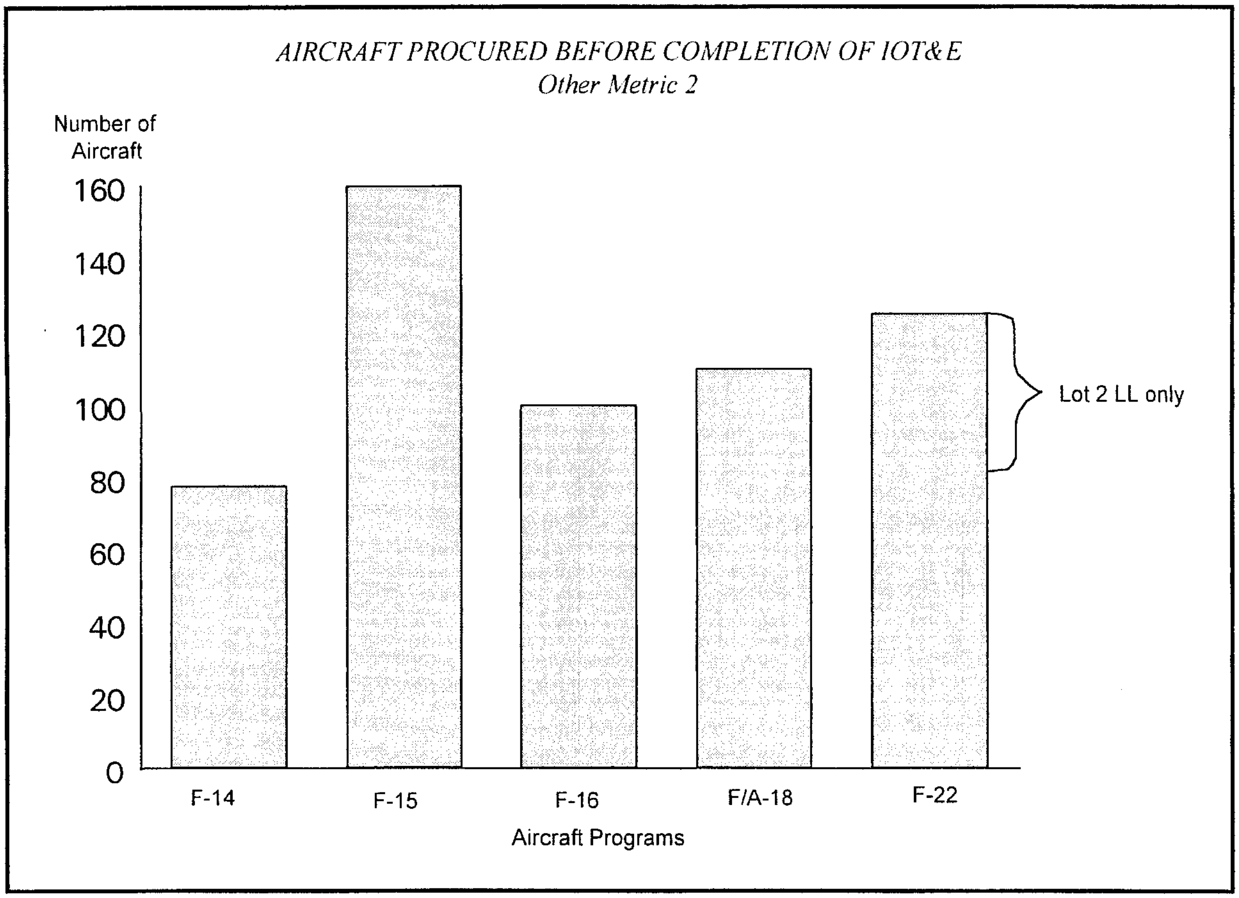
The IDA study focused on DT&E and the RAND study assessed the likelihood of problems occuring within DT&E and IOT&E. The DSB Task Force also had available for its review comparison data from an unpublished source that suggested two other possible concurrency metrics which focused on the end of dedicated IOT&E as the basis for production decisions. IOT&E is currently scheduled for completion approximately 8 months later than completion of DT&E, or February 2002.

First, it should be noted that the F-22 test program is longer and more thorough than other programs. This stretch out represents, inter alia, risk reduction (more testing with more time to make improvements), funding shortfalls, and the trend toward longer procurement cycles (which acquisition streamling initiatives are meant to reverse).

The chart above plots one of the other metrics which is the number of months from initial production to completion of dedicated IOT&E. The Task Force has plotted on this chart the Lot 2 milestones, since we believe that Lot 2 Long-Lead and Contract Award are critical milestones.

It is important to note that the historical aircraft development programs considered in this sample used Full-Scale Development (FSD) aircraft for IOT&E testing. The F-22 program will use PPV aircraft to conduct IOT&E testing. Therefore, unlike the historical programs, the later F-22 production decisions will be based on IOT&E data accumulated on real production aircraft, not FSD aircraft.

The DSB chose to use F-22 Lot 2 as a benchmark for comparison purposes, the reason being that this was the transition point from the 4 per year to 12 per year production rate. Also, using the results from the RAND Study it was determined that Lot 2 was a better milestone upon which to judge production decisions. The two arrows on the F-22 bar show two different milestones for the F-22 program: Long-Lead (LL) award for Lot 2 production aircraft, and Contract Award (CA) for the Lot 2 buy. Using this benchmark, the chart shows that the F-22 compares favorably to historical fighter aircraft developments in terms of the time at which major commitment to production aircraft is made prior to the completion of the IOT&E test phase.



A second concurrency metric suggested in the unpublished source is the comparison of the number of aircraft procured prior to the completion of IOT&E. As the chart shows, a total of 80 aircraft (the 4 PPV aircraft <u>required</u> for IOT&E, plus Lots 1-4) are to be contracted for before completion of IOT&E. In addition, the Long-Lead procurement for another 48 (Lot 5) aircraft is scheduled to take place in December 2001, two months before the scheduled end of IOT&E. Again, in comparison with the other programs, the degree of concurrency does not appear unusual.

SUMMARY FINDINGS REGARDING SCHEDULE CONCURRENCY METRICS

- F-22 Degree of Overlap
  - Conservative compared with other tactical fighters
- Risk of Proceeding
  - Key date is long-lead for Lot 2, by that point 20% of flight test program is scheduled for completion
  - Cumulative cost for Lot 1 and 2 long-lead items plus Lot 1 (with support and training equipment) is approximately $1.3B
- Cost of Delay
  - SPO estimate of $8-10B over program for multi-year extension of LRIP
  - Contractors estimate of $2.3B if Lot 2 is reduced from 12 to 4 aircraft
- Operational Impact
  - F-22 IOC is now planned for mid-2004

In summary, we looked at aspects of concurrency in a number of ways.

The IDA metrics showed that the degree of overlap is conservative compared with other programs.

The technical risk of proceeding is evaluated using the RAND metric. Using the RAND 10%-20% factor, and the amount and duration of testing, it seems unlikely that keying production decisions to completion of IOT&E would substantially reduce technical risk.

We also looked at cost risk—costs provided by the F-22 SPO and contractors Lockheed and Pratt and Whitney are shown here. The cost of delay provided by the F-22 SPO is $8B-$10B over the life of the program due to loss-of-learning, inflation, and further EMD stretch-out of testing and low rate production for three additional years of LRIP. In addition, Lockheed and Pratt and Whitney estimate that reducing Lot 2 from 12 to 4 aircraft would add $2.3 billion (assuming a 4% inflation rate).

Finally—operational impact. There are a number of foreign aircraft developments underway which reportedly will soon produce aircraft with capabilities similar to the F-15 and F-16. IOC for the F-22 is now planned for mid-2004.

TASK FORCE EMPHASIS

- Review of various concurrency metrics did not portray complete picture
- Task Force conducted a brief, but aggressive top-level critical technical and management review
  - Does program recognize key technical challenges?
  - Does a plan exist to monitor and manage these risk areas?
  - Is testing and demonstration early enough to assess program production readiness?
  - What is effect on combat capability if some or several goals are not achieved?
  - Can decisions regarding production lot quantity buy be deferred until later in EMD?
- Lot 2 (12A/C) Long-Lead and especially Contract Award considered critical milestones
- Key decision points identified for each critical-technical area
  - Airframe
  - Engine
  - Low Observables
  - Radar
  - Passive Surveillance and Electronic Warfare
  - Sensor Control/Sensor Fusion/Pilot Interface
  - Flight Control/Vehicle Management
  - Software

To assess the concurrency of the F-22 program in isolation does not give a complete picture of the potential technical or programmatic risks in the program. Therefore, the Task Force conducted a review of the technical and management status of the program in several key areas. This was done in an effort to relate concurrency and technical risk.

The costs of concurrency risks within the F-22 program are directly related to the following four types of changes:

- Major structural/engine Long-Lead changes (most expensive)
- Fixed hardware/database Long-Lead changes (expensive)
- Changes to existing LRUs
- Software changes only (may be expensive in terms of labor but no impact on production costs)

Lot 2 Long-Lead and Contract Award were chosen as the critical milestones to balance schedule and cost commitment, while insuring the fielding of the system in a reasonable time.

AIRFRAME

Status:
- Weight excess of the order of 1,000 lbs. (relative to proposal)
- Combination of airframe and engine excess weight and excess SFC result in decrements in specification subsonic and ferry ranges and sustained load factors
- Extensive wind-tunnel and YF-22 flight tests provide confidence on engine-inlet compatibility and stability/control characteristics
- Extensive structural component and materials testing programs for risk reduction

Concerns:
- Weight control
- Extensive use of new materials and fabrication processes and new applications of materials
- Higher than average-temperature/time durations for composites in supersonic flight legs
- 1st lifetime fatigue test scheduled completion
  3 months before Lot 1 contract authorization and Lot 2 Long-Lead procurement

Key Events:

• Static Test Complete	May 1998
• 1st Lifetime Fatigue Test	Sept 1998
	Lot 2 LL Commit 12/98
• 2nd Lifetime Fatigue Test	March 1999
	Lot 2 Contract Award 11/99

Status:
Current estimates put the airframe weight at the order of 1,000 pounds above the proposed weight, and estimates may not yet have stabilized. Special efforts are under way to control weight - a "Tiger Team" is due to report in mid-December.

Extensive structural and materials testing (and corresponding manufacturing development work) has been conducted to reduce risks in these areas.

Wind-tunnel and YF-22 prototype flight tests provide confidence on the generally satisfactory nature of engine-inlet compatibility and stability and control characteristics. Also validated to some degree were aerodynamic drag and other parameters estimating methods.

The current estimate of airframe and engine excess weights together with the estimated excess engine specific fuel consumption results in estimated decrements from specification values of subsonic mission and ferry ranges and sustained load factors.

Concerns:
There is a continuing concern over weight control and whether projected weight reductions through redesign will be achieved, and whether new estimates of excess weights of other parts and equipment will stabilize. The "Tiger Team" on weight control is currently reviewing this problem and is due to report in mid-December.

There is extensive use of new materials and processes as well as new applications of established materials, including both composites and cocuring processes as well as welded metal castings and large forgings. While the materials and structural component testing for risk reduction have been comprehensive and all aspects of design and testing conform to Air Force Structural Integrity Program standards, only full-scale static and fatigue tests can provide a sufficient degree of confidence in the structural integrity of the production configuration of the aircraft to warrant moving toward high-rate production. Completion of the static test and 1st lifetime of the fatigue test in September 1998 precedes by only 3 months the initiation of Lot 2 Long-Lead Procurement.

In terms of lifetime durability the higher average temperature-time durations for supersonic flight mission segments are more severe than in prior composite applications, although these temperatures are not in excess of allowable as determined in laboratory materials tests.

Key Events:
The key events are listed on the chart together with Lot 2 Long-Lead (LL) and Lot 2 Contract Award (CA) dates.

ENGINES

Status:
- Excessive vibratory stress levels found in fan and high pressure turbine
- Specific fuel consumption (SFC) too high - 15% for subsonic mission
- Fixes for stress problems require redesign of overstressed components and adjacent components (stress drivers)
- Fixes for excess SFC include several component efficiency improvements - major contributors - turbine and exhaust nozzle
- Estimated excess SFC of improved engine is 1.8%
- Estimated excess weight of improved engine is 120 pounds

Concerns:
- Large amount of "fixing" required
- Late in program to be working large performance deficiencies
- Unlikely to meet all performance/durability goals prior to first flight
- Program provides for fall back using interim engines in early flight test

Key Events:

• First Test of Flight Test Engine Core	July 1995
• First Test of Complete ISR* Configuration	Oct 1995
• Initiate Durability Test of Flight Test Engine	Dec 1995
• Begin Flight Test Engine Assembly	Mar 1996
• First Flight Test Engine Delivery	Sept 1996
• IFR** Milestone	Dec 1996
• FFR*** Milestone	Dec 1997
• ISR* Milestone, LRIP Decision	Dec 1998
• First PPV Lot Engine Delivery	Mar 1999

* Initial Service Release
** Initial Flight Release
*** Full Flight Release

Status:

The engine has excessive vibratory stress levels in the hollow-blade fan, and also in the high pressure turbine. Fixes have been found involving both the critical component designs and revisions in the configurations of adjacent components to change the vibratory forcing functions. There may also be durability issues in other hot section parts if temperatures are raised to meet performance goals.

The engine is also deficient in performance at a number of significant operating points. One of the most critical in operational terms is the subsonic cruise mission at which the specific fuel consumption (SFC) is 15% too high. The proposed fixes would result in an estimated subsonic SFC that is 1.8% above the current specification. These fixes involve design changes to improve component efficiencies and reduce flow losses at several locations in the engine. However, the largest projected improvements are in major redesigns of the turbines and the exhaust nozzle. These significant component redesigns will not be incorporated in an all-up test engine until the summer of 1995. The current estimate of engine weight incorporating the fixes is 120 pounds over the target weight originally specified.

Concerns:

The number and extent of the engine design changes needed to correct performance deficiencies is considerable. For fighter engines of this type, the components tend to be closely coupled as elements of the propulsion system. Design changes in one area may cause unanticipated effects in other areas of the engine.

It is highly challenging to be correcting significant shortfalls in performance at this time in the development cycle, particularly if EMD engines are to be available in time for installation in the first flight test aircraft in September 1996. Normally, at this stage of development, engineering and test efforts would be devoted primarily to solving problems of reliability and durability in the near-final configuration of the production engines.

Key Events:
As shown on chart.

Conclusions:
In view of the compressed time available for test validation and refinement of the modified engine (July 1995 availability of the core engine for test and October test availability of a complete engine including redesigned nozzle), it appears that it would be desirable to consider possible program alternatives in the event that unanticipated events preclude availability of currently planned redesigned engines in time for installation in the earliest flight test aircraft. It is understood that the SPO has a checkpoint for this purpose scheduled for mid-1995. Alternatives range from acceptance of an EMD engine with greater than 1.8% excess SFC based on trade-offs of operational effectiveness, cost, compatibility with force modernization phase, and other factors, to adopting an interim engine for some of the flight test aircraft and revising schedules. Schedule adjustments affecting concurrency may also be made at this decision point, if considered necessary.

LOW OBSERVABLES

Status:
- Many LO design and manufacturing challenges exist
  - Radar antenna, radome, nose integration
  - Gaps, cracks, seals, drains, etc.
- Program has plans to insure that problems are identified early
  - Full scale RCS pole models (aircraft, inlet, canopy)
  - Production RCS imaging facility
  - Early LO flight test (EMD a/c #4)
- Infrared signature receiving proper emphasis based on F-22 capability and likelihood of encounter

Concerns:
- Program must maintain emphasis on testing full scale articles built with production components/processes

Key Events:

• Full-scale aircraft RCS pole model testing complete	6/98
	Lot 2 LL Commit 12/98
• Early RCS LO flight tests complete	3/99
	Lot 2 Contract Award 11/99

Conclusions:
- No unacceptable concurrency risk exists

Status:
During DEM/VAL the program constructed a full-scale RCS pole model and demonstrated that the design could yield very impressive radar cross-section signatures. During EMD this design must be further refined with attention to integration of critical components as well as development of the manufacturing processes which are required to yield a low signature vehicle.

Many challenges exist. Two of the bigger ones are integration of the radar antenna and radome into the aircraft and attention to the details related to gaps/cracks/doors/seals and drain holes. These and other challenges are acknowledged by the program office and plans have been instituted to reduce risk.

The program will be conducting low observable testing throughout the EMD schedule. Full-scale RCS test fixtures, to include a full-scale aircraft model, will be used for these tests. The testing of full-scale hardware, and in many cases full-scale production hardware (antennas, leading edges, radome, canopy, etc.) will significantly reduce the development risk. Several programs which experienced problems either did not or could not test at full-scale. Full-scale RCS pole model testing will take place late 1995 through mid-1998.

The F-22 production line at Marietta, GA, will have a radar cross-section measurement system. This system will allow for each EMD and production aircraft to be measured (ground diagnostic RCS imaging). This will allow for an early evaluation of production manufacturing processes and their ability to achieve a low observable aircraft.

Low observable flight testing will commence with EMD aircraft #4. These tests are critical as they will demonstrate the achieved radar cross-section of a flight vehicle built using the actual production line process. The initial results of these tests should be available in early 1998.

The infrared signature is secondary in importance to the radar cross-section of the F-22 in view of the current threat definition. This area is receiving proper emphasis and a similar plan has been developed to refine the design and develop production processes.

Concerns:
It is critical that the program maintain and, where possible, increase emphasis on full-scale test articles which are built with production components and processes. Changes to the current low observable program schedule or a reduction in the reliance on production components or processes for testing will significantly increase the risk of concurrency.

Key Events:
In relation to the Lot 2 Long-Lead and contract award decisions, two low observable related significant events exists. Full-scale RCS pole model testing will be complete before the Lot 2 Long-Lead decision in 12/98 and early low observable flight testing will be complete before the Lot 2 contract award date of 11/99. Data from these events will allow the F-22 program, the Air Force, and OSD to evaluate the current status of the low observable design and manufacturing process. Data from these events can be used to support go-ahead decisions or alternative decisions to delay or reduce the Lot 2 quantity.

Conclusions:
No unacceptable concurrency risk exists in the F-22 low observable area. Reducing the Lot 2 production quantity at this time will not reduce the risk. Significant test data will be available prior to Lot 2 Long-Lead and contract award to more thoroughly evaluate program risks.

RADAR

Status:
- Components developed, performance said to be acceptable
- CIP throughput and memory demands within allocation
- Recently had "very successful" CDR

Concerns:
- Clutter rejection still to be demonstrated
  - Antenna/radome sidelobe performance said to be adequate
  - Vibrational effects on clutter rejection to be tested January 95
- RCS of antenna "a little high" - candidate fix to be tested February 95
- T/R modules - can contractors meet schedules of both F-22 and GBR?

Key Events:
- First complete radar ~4/96
- Block I software tested in flying test bed (FTB) ~9/98
- First radar flight in EMD A/C ~10/98

Lot 2 LL Commit 12/98
Lot 2 Contract Award 11/99
- Block III software tested in FTB ~7/00

Conclusion:
- Assuming near-term tests successful, radar hardware development proceeding well

Status:
The F-22 radar is a solid state electronically scanned multi-mode radar. Although quite different from any operational radar, it builds on a legacy of work on solid state transmit/receive (T/R) module development and the multi-mode nature of radars like that in the B-1B. The radar has also benefited from the long period since its initial design for the YF-22/YF-23, and the preceding Ultra Reliable Radar (URR) program. Even in the YF-22 program hardware, the issues were largely those of cost, especially of the T/R modules, and not of feasibility or producibility. The radar signal processing is done in the common integrated processor (CIP). It requires substantial amounts of throughput and memory, but this is said to be within CIP allocations. The real time control of the multiple modes is being worked in the mission software design and development. The reliability projection is so good that even a substantial shortfall would still result in a very maintainable system.

Concerns:
The Task Force has two performance concerns. The first arises from the requirement to detect low RCS targets against a clutter background. This requires very good sidelobe control of the antenna/radome combination. We were told, but did not verify, that the sidelobe performance was adequate. Such target detection in clutter also requires very stable reference oscillators. It is yet to be demonstrated that the requisite stability is achieved in the vibration environment of the aircraft. The second performance concern is that the contribution of the radar antenna to the aircraft RCS is above spec. This is a matter of precision in antenna impedance matching. The contractor has an approach to improving the performance that will be tested soon.

There is also a potential production concern that should be investigated by joint meetings between the relevant project offices. The F-22 radar and the BMDO Ground Based Radar (GBR) both make demands on one of the contractors, Texas Instruments, for T/R module production. Assurance should be obtained that both programs are comfortable that the potential impact of the other on their program schedule is negligible or acceptable.

Key Events:
The event schedule shows that the radar hardware will be delivered and installed prior to Long-Lead commitment to Lot 2 and will fly in an EMD aircraft before Lot 2 contract award. Thus, there appears to be little risk in the radar hardware concurrency.

Conclusions:
Assuming near-term tests will be successful, radar hardware development is proceeding well.

PASSIVE SURVEILLANCE AND ELECTRONIC WARFARE

Multiple (15-20) sources of passive surveillance designed to:

- Provide situational awareness
- Minimize active (radar) emissions
- Provide identification
- Cue defensive measures - weapons, EW, flares

Status:

- CNI and EW Critical Design Reviews (CDR) successfully completed
- Fusion algorithms prototyped, sample scenarios simulated, critical antennas prototyped

Concerns:

- Major advances in automated sensor management, multi-source integration and ESM system performance
  - Integrated architecture helps
  - Can back-off on performance of selected inputs
  - Must achieve integration
  - Potential antenna aperture problems is a concurrency concern
- Algorithms to deal with all the signal complexities, variabilities, and unexpected or conflicting events and parameters will be a significant challenge

Key Events:

- Proof of implementation progress will come during
  - Block 3 Avionics Integration - Aug-Dec 1999
  - Flying Test Bed & Aircraft Testing - Oct 1999-March 2000
- This is after Lot 2 Long-Lead and coincident with Lot 2 Contract Award

Conclusions:

- Very challenging area with the attendant risks
- Proceeding well and being carefully managed

The F-22 has many means of passively receiving situation awareness information from both its own sensors and external sources. The intent is to allow the pilot to see the threat situation while minimizing use of the active radar. These inputs will also help in identifying the threats and providing cues to the weapons, electronic warfare systems and flares.

The system includes many stressing performance requirements. Most are well beyond anything previously accomplished on an airborne platform regardless of size. Particular areas of advance include automated sensor management, multi-source integration, and electronic support measures (ESM) system performance, and target handling capabilities. These are major steps forward with the attendant risks.

Failure to achieve the current full specified performance in any one passive subsystem would not be fatal since so many potential information sources are involved. In the worst case, the active radar could be used more. However, that would increase the aircraft's observability against sophisticated threat systems.

To be successful, the integration of the multiple sources must be achieved. Presented individually, the data would clearly overload the pilot.

Status:

The current approach, progress, and plans appear sound. There are early efforts to identify, track and address the key risks. Prototyping of the most stressing areas has begun. Fusion algorithms have been written and are being tested under different scenario loads. Testing and simulation is planned in dense emitter environments. Green Flag testing would stress the system considerably.

Concerns:

The primary risk relating to production concurrency appears to be from problems with the antenna apertures. If the system experiences field-of-view/obstruction problems, lacks sensitivity, or has co-channel interference, fixing the antennas could be very expensive - given the aircraft would already be in production, and the observability testing that would have to be redone.

There will likely be numerous software related problems found during integration and testing, particularly related to dealing with the variability of real emitters. These software problems however, should not have an impact on the production concurrency issues being addressed here.

Key Events:

Key events in the integration of the passive surveillance and EW systems are in the Block 3 ground-based integration in August-December 1999 and then on the Flying Test Bed and aircraft early in 2000. These events occur after Long-Lead is released on Lot 2 and coincident with Contract Award for Lot 2.

Conclusions:

The requirements for this area are a major step forward in both ESM system performance and automated processing. Good progress is being made in the design, and the program is being carefully managed. This area must receive continuing close attention due to the potential risks and rather late scheduling of the key tests relative to Lot 2 production.

SENSOR CONTROL/SENSOR FUSION/PILOT INTERFACE

Motivation:
- Complex set of sensors in single seat aircraft
- Computer control necessary to manage workload

Status:
- Control and fusion algorithms being developed and tested against simulated threats/scenarios
- Cockpit simulator built; being used for interface evaluation

Concerns:
- Breaking new ground in pilot/sensor interface
- Software must work in all scenarios:
  - Accommodate changes in enemy tactics
  - Provide easy response to threat evolution
- Will require long evolutionary software development
- Pilot interface will also evolve - could necessitate hardware changes (probably not beyond LRU level)

Significant Events:
- First flight of complete avionics in EMD aircraft ~10/99

  Lot 2 Contract Award ~11/99
- First software (Block III) with significant levels of sensor control and fusion tested in FTB ~7/00

Conclusion:
- An extended program in developing and updating mission software will be required; pilot interface hardware may need to be changed. This will probably not be known by Lot 2 Contract Award

The F-22 incorporates a large number of sensors, many with an assortment of operating modes. It has a single part-time sensor operator (the pilot). These circumstances dictate that 1) the real time management and control of the sensors must be automated, 2) the data on each target from all relevant sensors must be correlated and its meaning extracted by a computer, 3) the reduced data must be presented to the pilot in a "user friendly" way, and 4) the required reaction of the pilot facilitated by good engineering of his controls and switches. These tasks will be done on the F-22 by computer, to a degree unprecedented, at least in tactical aircraft.

The result should be an impressive and very useful capability. Reaching that end will require mission software development process of 1) identifying threat signatures and tactics, both nominal and plausible variations from nominal; 2) crafting the procedures and algorithms to be used for situational awareness, threat assessment, and weapons control; and 3) generating and debugging the continuing software evolutions. This is well recognized throughout the F-22 organization. They hope and believe that the evolution can be confined to the software.

We caution that it seems likely that as large numbers of pilots learn the F-22, there may arise pressures to change displays and switch function/locations. Doing so may involve more than software changes, despite good efforts to provide system flexibility.

Conclusion:

The issues of control/fusion/interfaces are not thoroughly tested until the Block 3 software is available, at least to the Flying Test Bed (FTB). The Block 3 FTB tests finish about 6 months after the Lot 2 contract award. It seems very likely that further changes in software will be required and quite possible that cockpit hardware changes may be desired. Hopefully and most likely, these could be contained to the LRU level.

FLIGHT CONTROL/VEHICLE MANAGEMENT

Concerns:
- None - Risks are low

Status:
- Stability and Control flight tests occur early with few production commitments
  - Testing is 60% complete with eight aircraft
  - 100% complete with 20 aircraft

Conclusions:
- Success can be reasonably expected
  - Design based on proven FBW technology
  - New features demonstrated on prototypes
    - » aerodynamics, supercruise, RCS
    - » pitch thrust vectoring
    - » high-alpha maneuvering
  - Important lessons learned from FY-22 mishap
    - » more rigorous, reliable EMD design process
    - » better integrated aero/thrust vectoring

Status:

The basic design approach uses proven fly-by-wire (FBW) concepts from previous programs. The major differences are a) somewhat unusual aerodynamics due to RCS and supersonic cruise, b) integrated pitch-axis thrust vectoring, and c) maneuvering at high angle-of-attack.

The new elements of the system have been previously demonstrated in Demonstration/Validation (D/V) on the prototype YF-22 aircraft. For example, aerodynamic stability and control characteristics, which form the essential data base behind the control system design, are accurately predicted for the prototype by computational models and wind-tunnel tests. Since the F-22's external planform is substantially similar to the prototype, we can expect the same high modeling fidelity in EMD. Thrust vectoring and high-alpha maneuvering were also demonstrated on the prototype, although vectoring was not as well integrated into the rest of the control system as it will be on the production aircraft.

The EMD flight control design approach effectively incorporates important lessons learned from a mishap in the Demonstration/Validation (D/V) program. One of the prototype vehicles exhibited severe pitch oscillations on a max power go-around, resulting in a "gear-up landing" and subsequent fire. Post-accident investigations confirmed that this incident was not caused by hardware failures. Instead, the prototype's flight control algorithms made the closed-loop aircraft PIO-prone (PIO stands for pilot-induced oscillations—a misnomer, since the aircraft is really at fault, not the pilot). Transients changes in thrust vectoring and gear settings on the specific go-around triggered the oscillation event. It turns out that several analytical control metrics exist which predict PIO-tendencies, and better control algorithms can readily be designed. The modified EMD design approach makes good use of these metrics and is, in general, a much more rigorous and reliable process for designing the flight control system. It also includes an elegant integration of the aerodynamic control and thrust vectoring features of the aircraft, which is much improved over the prototype.

Conclusions:

At the bottom line, the flight control/vehicle management system appears to be in good shape.

SOFTWARE

Observations:
- Common Development Process/Tools
- Good Digital Architectural Design
- Available Core Hardware and Software
- Four Major Block Releases of Software
- Extensive Ground and Flight Test
- Early Block Releases Address Greatest Production Risks
- AFOTEC Operational Assessments Concurrent With Development Flight Test
- Software Block Schedules Must Be Met to Achieve Production Schedule

Common Development Process/Tools:
A common software development process and software engineering environment have been imposed for use in the F-22 program. Contractors have accepted this uniform approach and have made provisions for the corresponding requisite training to ensure consistency in implementation.

The software development process, which represents a tailored DoD-STD-2167A approach to software development, consists of methods that were defined by the contractor Integrated Product Team (IPT). Compliance to this process is monitored by a robust set of software metrics, as well as software tools that automate some aspects of the process.

The use of the common Software Engineering Environment (SEE) enhances team communication and facilitates system integration. The environment is comprised of both commercial off-the-shelf (COTS) software products as well as team developed software tools. The SEE has been baselined and modifications to its various components are subject to configuration control. In addition, the use of a common interface database ensures interface consistency throughout the development process.

Good Digital Architectural Design:
An open systems approach has been applied to the design of the digital architecture. The hardware architecture has been designed in a modular fashion that enables the addition of processing components to the backplane without requiring any software modifications.

Similarly, the modular approach to the design of the software enables the inclusion of additional functionality without adverse impact to the current design/capability.

Available Core Hardware and Software:
Core hardware and software (including the common operating system and SEE tools) are now available for use, providing the basis for development of the application specific aspects of the program.

Four Major Block Releases of Software:
An evolutionary approach to software development is implemented via four block releases (0-3) each of which provides greater functionality by building on the previous release.

- Block 0 provides the flight control software, full IRS functionality, all operating systems, stores management and basic CNI functions.

- Block 1 provides mission data edit and event dates, single sensor control and display, initial radar functionality, additional CNI capability and fusion.

- Block 2 provides additional radar and CNI capability and initial functionality in EW and weapon stores management.

- Block 3 represents the extension and integration of functions provided in the previous blocks, in addition to an embedded training capability.

Extensive Ground and Flight Test:
The F-22 program provides ample opportunity for detecting potential software problems through an extensive incremental process that includes both ground and flight test. The stages of this process are:

- *Software Testing.* This stage includes all aspects of testing during the actual software development process (i.e., code and unit test, integration test, quality assurance test, IV&V, etc.).
- *Sensor Stand Alone Test.* This stage enables testing of the software with actual sensor input.
- *Avionics Integration Lab.* This stage facilitates integration testing of the software within the full avionics system, supported by simulation as required.
- *Flying Test Bed.* This stage enables testing of the software in a "near" real-time environment, facilitated by exercising and fusing actual sensor data.
- *Flight Test Aircraft.* This stage provides an operational test environment in which to fully exercise within as realistic environment as possible the full software functionality, including error detection, and system bounds.

Early Block Releases Address Greatest Production Risks:
The costs of concurrency risks within the F-22 program are directly related to the following four types of changes:

- Major structural/engine Long-Lead changes (most expensive)
- Fixed hardware/database Long-Lead changes (expensive)
- Changes to existing LRUs
  - New LRUs must be developed, or existing LRUs modified
  - More existing LRUs must be built for added processing power (less expensive impacts on production)
- Software changes only (may be expensive in terms of labor but no impact on production costs)

With regard to F-22 software, testing of Block 0 will address the major structural issues (most expensive types of changes.) Blocks 1-3 will address the remaining categories of potential changes. Block 3.1, which will address software-specific issues only, is unlikely to surface any changes other than those that impact the software directly. Accordingly, the greatest concurrency risks should be identified by the early block releases. The last block release should have little, if any, impact on production aircraft.

AFOTEC Operational Assessments Concurrent With Development Flight Test:
During the software development and testing process, AFOTEC will be conducting operational assessments. The results of these assessments should identify potential IOT&E problems long before the official IOT&E occurs. In fact, AFOTEC input will be taken into consideration prior to the LRIP decision currently scheduled for December 1998.

Software Block Schedules Must Be Met to Achieve Production Schedule:
A basic assumption used in the formulation of the software observations is that the schedules currently planned for software development must be met, and that the functionality to be provided within each of the Blocks as currently defined, must be retained. If a slip occurs within the software development schedule, the resultant slip may adversely impact production.

SOFTWARE (Continued)

Status:
- Requirements reasonably solid
- CDR currently underway
- Contractors moving into code/unit test stage

Concerns:
- Maintaining the software schedule

Key Events:
- Release of Block 3 software to flight test (29 Sept 1999) should precede the Contract Award for Lot 2 production

Status:
The mission software requirements including interface requirements are reasonably solid having used the automated requirements and top level design methodology (ADARTS). All contractors are using these common tools. Detailed design is well underway and at the time of this writing (7 December 1994) the vehicle Critical Design Review is in progress. The contractors have begun to move into the code and unit test phase of the mission software.

Concerns:
The major software concern is that of maintaining the block release schedule with the functionality planned. With over 30 contractors contributing to the 1.4 million source lines of code, it is important to have enough of the proper resources applied to assure that the delivery schedule can be met without compromising the discipline of a good development process.

Key Events:
A key milestone event is the release of Block 3 software to flight test (29 September 1999). It is important that this event precede the Lot 2 production Contract Award scheduled for late 1999. A review (discussed later) must validate the observation that Block 3 flight test will have minimal impact on the Lot 2 production configuration.

SOFTWARE (Concluded)

Conclusions:

- The software block releases are such that the earlier releases test those functions with the highest cost risk to production changes
- A review of Block 3 functionality reveals a low likelihood of any significant cost impact on production aircraft that would not have been identified by earlier ground or flight test or by operational assessments by AFOTEC
- The software development among all the contractors must be carefully planned and replanned to keep critical paths through the development on schedule
- A review of the following is prudent prior to Lot 2 Contract Award for Production to assess the concurrency risk:
  - Block 1 & 2 flight test results
  - Block 3 Avionics Integrated Laboratory results
  - AFOTEC operational assessments/plans

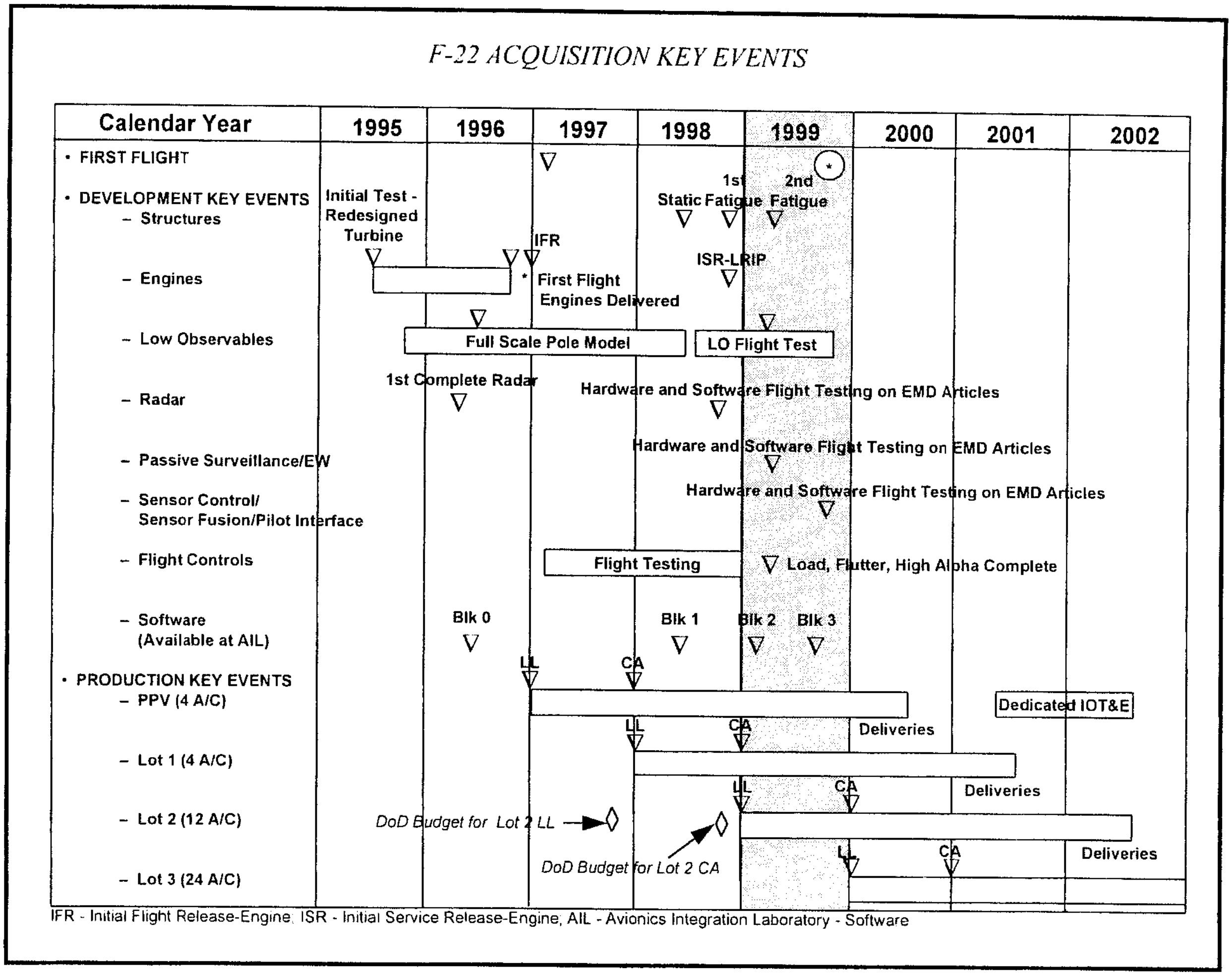
Block 0 software release in mid-1996 essentially permits the flight test program to validate major structural, aerodynamic and safety objections early in the flight test program. The results along with static test and fatigue test results should feed into the LRIP decision in late 1998 which influences the Lot 2 aircraft Long-Lead procurement decision.

The flight test of Block 1 and 2 software functionality should exercise the avionics hardware to demonstrate most of the individual functions the hardware is to perform. Any major hardware changes should become evident during this phase.

Block 3 functionality essentially integrates the functionality that has been previously tested. Avionics Integrated Laboratory (AIL) testing and earlier testing should have identified any major hardware changes. The flight test of Block 3 would most likely point to software changes, or the need for more processing capability. Changes of this sort would have only very minor cost impacts on the production aircraft. It is important to know that the testing has been in the right "ball park" concerning OT&E. One can rely on concurrent "operational assessments" being conducted by AFOTEC to make this latter assessment.

An activity net of all the key software development tasks among all the contractors with their detailed planning would be useful in determining the critical path through all the contractor activities that determine overall schedule. Since the process is dynamic, the critical paths must be reassessed frequently with the objective of identifying key problems, finding resources across the IPT to resolve those problems, and containing critical path extensions without compromising a good engineering process. A central design and implementation focus on the software progress would be very useful.

A key review should be held prior to the Lot 2 Production Contract Award after reviewing Block 1 and 2 flight test results, Block 3 ground test results, and the AFOTEC operational assessments and plans. This review can verify the observation that there are only minor production cost impacts in proceeding with Lot 2, if that is the case. If not, then a more optimal Lot 2 buy could be made. The review point is shown during late 1999 by the asterisk on the top line of the present schedule chart on Page 8 and the key events chart on the next page.



The F-22 Acquisition Key Events as determined by the Task Force are presented on this chart. First flight, development key events and production key events are displayed. The critical milestones for Lot 2 Long-Lead and Lot 2 Contract Award span the year 1999, which is shown shaded in the chart. For each technical area, there are several key test events prior to Lot 2 Long-Lead and Contract Award for production which can be used to measure progress.

GENERAL OBSERVATIONS:

- Short time/limited effort by Task Force: 6 days total, 2 at contractors
- Overall program appears well structured and managed
- Top government and contractor people impressive
- The "spec" system provides major advances in capability across the board
  - Hence, less then spec performance in certain areas will still result in very capable system
  - As program progresses, this permits performance to be traded for cost/schedule

The Task Force had a limited amount of time to carry out its work. A total of six (6) days of meetings were held; two in Washington, D.C., receiving briefings on the program and relevant studies; two at the contractor's plant reviewing the major subsystems in detail; and two in Washington, D.C., reviewing findings and drawing conclusions. There was also much additional data gathering and consultation by individuals.

In spite of this limited effort, the Task Force believes it gained sufficient understanding of the program to be confident its findings are sound.

The overall program appears well structured, sound, and well managed. We were favorably impressed by the knowledge and objectivity of both the government and contractor staff with whom we interacted.

The "spec" F-22 system provides significant advances in every important aspect of a tactical aircraft. "Less-than spec" performance, if encountered in certain areas, will still result in a system that will be a large step ahead of current U.S. and likely opponent capabilities for a long time, and will thus continue the "overwhelming superiority" of U.S. forces in this area.

As the program progresses, any shortfalls in sub-area performance can be reviewed and appropriate trade-offs made with cost and schedule.

PLANS/OPTIONS TO MITIGATE RISKS

- No completely independent alternative approaches for big ticket items (e.g., engine/radar) exist nor are any recommended
- Alternate approaches in parts/sub areas are being pursued in some cases and more are doable within the program plan
- The general approach should be to handle problems by accepting some reduced performance, slipping schedule or both, depending on risk/cost trade-offs

The Task Force was tasked to address the issue of viable plans/options available to mitigate high risk areas.

We found that there were no alternative completely independent approaches being pursued for the major subsystems (such as the engine or the radar) and we concluded that such alternate approaches were neither practical nor needed.

There are, of course, alternate approaches being pursued or reviewed at the part/component level (e.g., turbine blades), and others (e.g., LO, CNI antennas) can be accommodated within the program's plan and schedule.

We concluded that the best approach to handling problems that do arise is to seriously consider accepting some reduced F-22 performance, slip in the schedule, or some combination of both. As has been noted elsewhere in this report, F-22 performance in many areas, if it fell short of that specified, would still represent a major increase in military capability. Rigid adherence to the current specifications and goals would generally be unproductive and very costly.

SUMMARY CONCLUSIONS

- The program is very ambitious technically
- For each risk area there are significant achievements that should be demonstrated before release of funding for Lot 2 (12 aircraft) Contract Award
- The engine and the passive surveillance avionics are the highest risk areas
- In the event of inadequate progress, the program can be slipped by staying at the 4 aircraft per year rate
- Stretching the program in this way may reduce risk but can create cost, manpower and obsolescence problems
- There is no risk-concurrency reason to introduce such a stretch at this time

With its many "first time" features for a fighter (super cruise, vectored thrust, stealth, passive location system, integrated avionics), the F-22 is one of the most challenging developments undertaken in recent times. The overall program, starting with the prototype in the Demonstration/Validation Phase and related R&D efforts, has been structured to address all these areas in an orderly, appropriate way and much has been accomplished.

From the standpoint of risk/concurrency, the critical point in the program is the ramp-up in the production program from 4 aircraft to 12 aircraft per year (Lot 2).

The Task Force identified for each risk area specific significant events whose accomplishment should take place before release of Contract Award (and to a lesser degree Long-Lead) funding for Lot 2, the 12 aircraft buy.

It should be noted that, at this time, the engine and the Passive Surveillance avionics subsystem have the greatest number of uncertainties. Consequently, if there are changes in the program plan, emphasis on these two areas should receive special attention and continued support

If there are significant delays in accomplishment of these key events or if the performance levels achieved are unacceptable, the program could be adjusted by staying at the 4 aircraft per year production rate for an additional year.

It is noted that, while stretching a program may reduce risk, if stretching is not necessary it can result in increased total costs, possible loss of key manpower and suppliers, and earlier technical/operational obsolescence.

After careful review of the program plans and accomplishments, the Task Force concluded that there are appropriate future milestones on which to judge readiness for production ramp-up. Thus, there is no reason based upon risk/concurrency to introduce a schedule stretch at this time.

APPENDIX A

TERMS OF REFERENCE

THE UNDER SECRETARY OF DEFENSE

3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

ACQUISITION AND
TECHNOLOGY

November 1, 1994

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference -- Defense Science Board Task Force on Concurrency and Risk of the F-22 Program

You are requested to establish a Defense Science Board Task Force to assess the degree of concurrency and risk in the F-22 program in accordance with SASC Report 163-282, dated June 14, 1994. The scope of your assessment should be based on the most recent rephasing of the F-22 program. Work should begin as soon as possible with the Task Force providing an interim report by 15 December 1994 and a final report by 31 March 1995.

The Task Force should address the following questions:

Are there any areas in the F-22 program of excessive concurrency? What is the risk in each area?

For any areas of identifiable high risk, are viable plans/options available that would mitigate the risk?

What conclusions regarding F-22 concurrency and risk can be drawn by comparisons to existing data (e.g., an ongoing IDA study) on previous fighter/combat aircraft programs?

The Director, Tactical Warfare Programs will sponsor the Task Force, providing funding and other support as necessary. Mr. Charles Fowler will serve as Chairman of the Task Force. Mr. Dean Gissendanner and Colonel George DeFilippi of the Office of the Director, Tactical Warfare Programs, will serve as the Task Force Co-Executive Secretaries. Lt Col Keith M. Larson, USAF, will be the Defense Science Board Secretariat Representative.

It is not anticipated that the work assigned to this Task Force will cause any member to be placed in the position of acting as a procurement official.

Paul G. Kaminski

Paul G. Kaminski