RAND Research Brief

Developing an Affordable Fighter for the Future

The Air Force has embarked on a course to replace the most numerous and versatile fighter aircraft in its inventory, the F-16. The Joint Strike Fighter (JSF) may evolve from the tri-Service Joint Advanced Strike Technology (JAST) Program to replace the F-16 and perhaps other Air Force ground-attack aircraft, as well as air-to-ground fighters for the Navy and Marines. As the JAST Program proceeds to a hardware demonstration phase, the Air Force is drafting statements of mission needs and operational requirements for the new aircraft.

The Air Force asked RAND to analyze fighter inventory levels, affordability, and mission needs for the new fighter, to augment Air Force and contractor studies. The RAND study, documented in a forthcoming report, found that the constraints of future budgets will severely circumscribe Air Force options for the JSF. Without a sharp reversal in defense budget trends and/or allocating more of the Air Force budget to fighter modernization, the JSF will need to be a relatively low-cost, moderate-performance aircraft to fit within Air Force budget constraints. The good news is that an aircraft with a combat radius of 650 nmi, moderate stealth, and a turn-rate comparable to that of today's multirole aircraft can probably meet most of the Services' needs in future regional conflicts.

WHEN AND HOW MANY?

The projected exhaustion of the F-16 attrition reserve early in the next century (2001) sets the timing for the introduction of an Air Force JSF. It is already too late to develop a new fighter design in time to offset these losses completely, but deliveries of a new operational aircraft could begin during the second half of the next decade.

The Air Force will need large numbers of JSFs—on the order of 1,400 to 2,300 airplanes, depending on the specific airplanes the JSF replaces in the fighter force structure. Similarly, JSFs will need to be procured at high rates—probably in excess of 120 aircraft per year—as F-16s are retired in large numbers. Accommodating the budgetary impact of such procurement rates within the constrained Air Force budgets of the future represents a major challenge.

Methods for adjusting the required introduction date of the JSF include retaining Cold War–era aircraft longer than currently planned or buying more F-15Es and/or F-16s today. Accepting force structure reductions below 20 wings—perhaps with compensatory actions, such as improved weaponry to mitigate capability impacts—is a third method. Such options must be assessed for their effects on force capability and on the industrial base for combat aircraft.

AFFORDABILITY

What the Air Force can afford to pay for a JSF depends on the budget it can allocate to fighter modernization, the mix of F-22s and JSFs it buys, the cost of F-22s, and the size of the fighter force structure. The interplay of these factors is shown in Figure 1. The three graphics in the figure assume different budget shares for fighter procurement, given a future Department of Defense (DoD) budget estimate of $227 billion. Even an average share of this budget for fighter procurement—shown in the middle graphic as $4 billion annually—is not assured, given the pressure future DoD budgets will be under, the competition fighter-modernization accounts will face from other systems, and the fact that operation-and-maintenance and personnel accounts are currently taking more than their historical shares of the budget.

The figure illustrates how the cost of the JSF the Air Force can afford varies with the size of the fighter force structure (16 to 20 wings) and the percentage of that force that is F-22s (10 to 30 percent). For this example, an F-22 flyaway cost of $80 million is assumed, which incorporates an expectation of some future cost growth beyond current cost estimates as the aircraft goes through its full production life. The graphic in the middle of the figure, for example, shows that if the Air Force has a $4 billion fighter-procurement budget and holds to its objective of

20 fighter wings with 20 percent F-22s, it could afford a JSF costing slightly less than $26 million. Affording a $30 to $40 million JSF—a plausible cost range for a new airplane—could require either an increase in the fighter-procurement budget or some combination of force structure cuts and changes in the mix of F-22s and JSFs.

Figure 1 underscores the importance of not overstating JSF requirements. That imperative shaped our assessment of the key mission needs the JSF would have to satisfy, in that we looked for ways to use weapon capabilities and support from other assets to moderate the stringency of design requirements for the JSF platform.

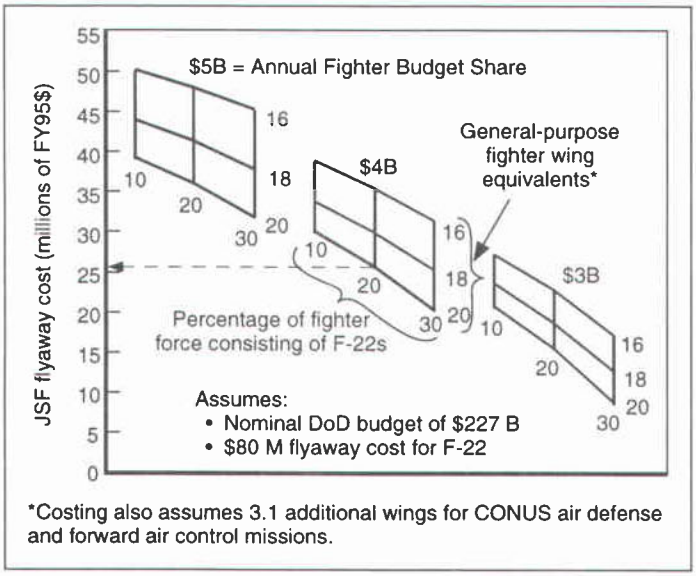

Figure 1—How Fighter Budget, Force Size, and Force Mix Influence Allowable Cost of JSF

DESIGN CHARACTERISTICS

We examined mission needs in several key areas that strongly influence aircraft cost, including

- combat radius
- stealth
- maneuverability
- compromises for design commonality.

Combat Radius Needs

The combat-radius requirement for a fighter aircraft exerts a strong influence on the size, and therefore the cost, of a new aircraft. The RAND analysis calculated radius requirements for

- three theaters
  - —Iran
  - —Iraq
  - —North Korea
- three basing options
  - —optimistic (close to the theater)
  - —fallback (in the rear to avoid attacks by tactical ballistic missiles or enemy ground forces)
  - —off-shore (flying from Japan for operations in North Korea or from carriers for operations against Iran)
- three in-flight refueling options
  - —two-way
  - —one-way
  - —none
- three levels of support from other assets in the theater
  - —no support
  - —three days of heavy bomber sorties and cruise missiles from one carrier battle group
  - —seven days of bomber sorties and cruise missiles from three carrier battle groups.

With favorable basing, an aircraft having a 650-nmi radius can hold at least 70 percent of the targets at risk in any of the three theaters without refueling. The same percentage of targets can be held at risk with a 650-nmi radius and less-favorable basing if some in-flight refueling support is available. Aircraft radius would have to increase to 800 nmi or more to reduce the dependence on in-flight refueling significantly. In contrast, decreasing the aircraft radius from 650 nmi to 600 nmi would increase dependence on in-flight refueling significantly. With support from sea-based attack assets and bombers and with some in-flight refueling, a 650-nmi radius is probably sufficient for a JSF.

Stealth and Standoff Weapon Trade-Offs

The principal reason that the Air Force and the Navy may want a new aircraft rather than a derivative of an existing aircraft is stealth. It is very difficult to modify an existing design to achieve the same level of stealth as a new design. The stringency of stealth requirements will probably determine whether derivatives of the F-15E, F-16C, and F-18E/F can compete to satisfy the JSF need.

The RAND analysis assessed how various degrees of radio frequency stealth—combined with weapons having various standoff ranges—influence an aircraft's ability to attack targets from medium altitude with impunity in three different theaters (Iran, Iraq, and North Korea) and with four different levels of support from other assets in the theater. Results showed that moderate stealth, coupled with some degree of standoff and advanced countermeasures, is probably sufficient for survivability in regional threat environments. Derivatives of existing designs may be viable and should not be excluded from consideration because of survivability concerns.

Maneuverability and Armament Trade-Offs

Turn-rate requirements exert a strong influence on wing selection and size and on the overall aerodynamic performance requirements of fighter aircraft. High turn rates can help a fighter aircraft dominate close-in air-to-air combat engagements. The RAND analysis suggests, however, that the advent of high-performance, short-range, air-to-air missiles (AIM-9X or ASRAAM) and associated targeting aids may permit some relaxation of aircraft turn-rate requirements in the interests of affordability while still retaining a level of superiority in close-in combat comparable to that which the Air Force has historically enjoyed.

Compromises Associated with Design Commonality

If the JSF is a new aircraft design rather than a derivative of an existing fighter, it is likely that it will be derived from a platform common to the three Services, motivated by the desire to achieve economies of scale in production. Each Service will tailor the platform to meet its particular needs, paying some weight and performance penalties in comparison with an aircraft designed to meet the needs of a single Service exclusively.

This analysis assessed the range and gross-weight penalties the Air Force could incur from buying a derivative of a short take-off vertical landing (STOVL) or a conventional take-off and landing (CTOL) aircraft suitable for operations from aircraft carriers (see Figure 2). Compared to a land-based design, an Air Force derivative of a carrier-suitable CTOL design paid a 15-percent range penalty (6.1-percent gross-weight penalty). The range penalty for an Air Force derivative of an STOVL design was less—9 percent (3.8-percent gross-weight penalty). Using the STOVL rather than the CTOL as a basis for the JSF has two other advantages: The STOVL design would provide additional fuel capacity in place of the engine (or fan) and would not impose the structural-weight penalty of an aircraft designed for catapult launches and arrested landings.

This research also examined a three-way modular design, which would allow each Service to develop its own aircraft from a common baseline. Assuming normal

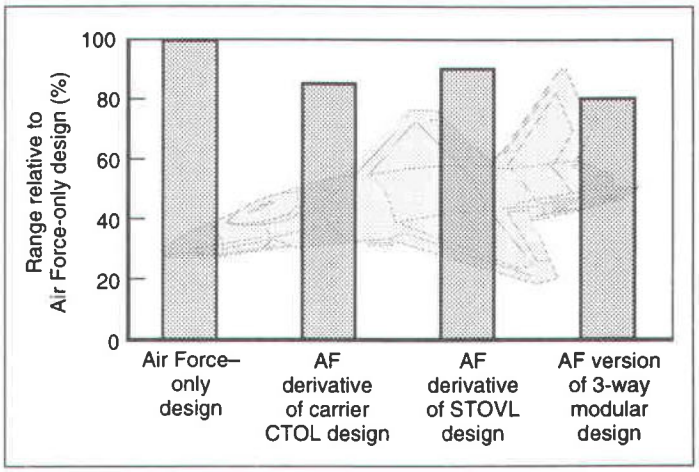

Figure 2—Impact of Commonality Approach on Range of Air Force JSF

design practice, the analysis found that the Air Force version would suffer a 20-percent range penalty, as shown in the last bar of Figure 2. However, the as-yet-unproven "cousins" approach, in which similarly shaped parts are built with different thicknesses for different aircraft, may recover some of the weight and range penalty.

CONCLUSION

The new environment, featuring regional threats rather than a superpower competition, may provide some relief from the stringent requirements that drove up costs during the Cold War. A total force perspective will also be essential for setting affordable design parameters: Other assets, such as standoff weapons, advanced air-to-air missiles, and heavy bombers, can complement the JSF to permit some relaxation of its design requirements.

Nevertheless, the Joint Strike Fighter will be the most versatile multirole fighter ever built, and making it affordable will be a serious challenge. Affordability will have to be an ingredient in the design trade-off process. The Air Force will also have to devote an increased share of its budget to fighter acquisition to meet current force structure and force mix goals. Even with rigorous cost controls, challenges lie ahead in introducing a JSF without creating an unaffordable budget bow wave as the Air Force acquires several new systems at the same time after the turn of the century.

RAND research briefs summarize research that has been more fully documented elsewhere. This research brief describes work done for RAND's Project AIR FORCE; it is documented in The Next-Generation Attack Fighter: Affordability and Mission Needs, *by Donald Stevens, Bruce Davis, William Stanley, Daniel Norton, Rae Starr, Daniel Raymer, John Gibson, Jeffrey Hagen, and Gary L. Liberson, MR-719-AF, 1997, ISBN 0-8330-2497-3, available from RAND Distribution Services (Telephone: 310-451-7002; FAX: 310-451-6915; or Internet: order@rand.org). Abstracts of all RAND documents may be viewed on the World Wide Web (http://www.rand.org). Publications are distributed to the trade by National Book Network. RAND is a nonprofit institution that helps improve public policy through research and analysis; its publications do not necessarily reflect the opinions or policies of its research sponsors.*

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