Chapter 9
Other Options for Competition

In Chapter Four, we outlined an overall analysis strategy encompassing four categories of competition that might be applied to the JSF program. The figure depicting those categories is repeated here as Figure 9.1. The majority of the analysis, reported in Chapters Five through Eight, focused on options for near-term competition within the JSF program. In this chapter, we discuss options in the remaining three areas depicted in Figure 9.1.

![Figure 9.1—Other Near-Term and Long-Term Competition Options Within and Outside the JSF Program](image)

<table>
<thead>
<tr>
<th>Near-term</th>
<th>Long-term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create second source to compete on production contracts</td>
<td>Invest enough in alternate sources to create a credible threat of introducing competition in the future</td>
</tr>
<tr>
<td>Assess possible alternatives to JSF</td>
<td>Encourage and guide development of alternatives to JSF</td>
</tr>
</tbody>
</table>

Within JSF program

Outside JSF program

Actions to take
Options for Long-Term Competition Within the JSF Program

The production phase of the JSF is expected to extend over a period of roughly 25 years, during which some 3,000 aircraft will be delivered to the U.S. services. If history is a guide, we can expect several new variants to be introduced during that time as mission needs evolve and new technologies become available. The timing and exact content of those upgrade programs cannot be defined at this time. However, it seems likely that they will offer opportunities for competition in both design and production activities. It seems useful to look ahead and project as best we can the nature of such future competitions and to identify how they might affect the JSF program and any near-term actions needed to enhance the effectiveness of those options in the future.

In principle, any competition option examined in the preceding chapter could be applied in the future. However, history suggests that aircraft vehicle configurations do not evolve radically throughout the life of a fighter aircraft design. Such airplanes typically grow in gross weight, and modest refinements are made in aerodynamic performance and in details of structure design, but the basic vehicle design remains relatively static. Furthermore, the analysis of the vehicle structure and major subsystems described in Chapters Five and Six showed little promise of breaking even financially through introduction of a second production source, and there is no apparent reason to expect that fact to change in the foreseeable future. We therefore see little opportunity to introduce competition in the future for production of vehicle structure and major subsystems.

Mission equipment presents more opportunities for future competition. The most important reason for this expectation is that mission system components are likely to undergo relatively rapid evolution in both mission needs and enabling technologies. By the time the JSF enters operational service, roughly ten years from now, there is a strong probability that the operational concept will have changed somewhat, redistributing emphasis on the various elements of the electronics suite of sensors, displays, and associated computation methods. Further-

---

1 Our analysis of the JSF mission equipment described in this section drew extensively on an ongoing U.S. Air Force-sponsored RAND Project Air Force study of JSF avionics cost-estimating relationships and cost-reduction initiatives.
more, the relevant technologies are advancing rapidly, thus enabling improvements in capabilities over the suite now being developed for the initial variants of JSF.

For these reasons, we expect that new designs for mission equipment will emerge over the next decade. Does it make sense to introduce a second source that could compete for design and production of that new mission equipment suite? Consideration of a second source is justified because the potential improvements in JSF mission effectiveness through upgrades in mission equipment are so large that they justify the stimulus to technical innovation that is believed to be achieved through competition. The argument does not have to rely entirely on potential cost savings; some increase in cost might be justified as investment in improved mission capability through technological innovation.

To devise an overall concept for competition in design and development of future mission equipment, we need to examine three issues:

1. Can individual elements of the mission equipment suite be competed or must such competition encompass an entire avionics suite?
2. Should the second source compete on the basis of BTP or FFF?
3. What should be done in the near term to enable future competition?

We examine each in turn, drawing on features of the mission equipment designs being offered in the present JSF competition.

**Integrated Design Versus Separate Subsystem Design**

Mission system avionics will perform a variety of functions in the JSF. They will

- control the plane
- monitor its resources
- provide information that pilots need to perform their missions and to control and/or guide weapons to targets
- provide communication links to report mission status.

---

2 In our analysis, we examined individual elements of the mission system in detail. Due to proprietary constraints, that analysis cannot be fully reported here.
In the past, contractors working on conventional aircraft programs typically have developed discrete requirements for each avionics subsystem. But with the JSF, each prime has analyzed the JSF mission operational requirements and has developed an integrated mission equipment package in which traditional subsystems take on nontraditional functions. Driven both by the JSF’s complex mission requirements and by desires to save costs, contractors are using combinations of subsystems to accomplish tasks heretofore performed by single subsystems. For example, traditionally, radar functions have been performed by a single stand-alone subsystem. Contractors have parceled out some of the JSF’s radar functions among the integrated core processor (ICP), electronic warfare (EW) components, and other subsystems. Moreover, the EW and the communications/navigation/identification friend or foe (CNI) subsystems share antennas, an integrated core processor—which replaces most of the separate processors in each subsystem—and common support electronics.

Each of the two prime contractors working on the JSF expects that such integration of mission system avionics will enable it to significantly reduce these components’ cost and weight and boost their performance. However, the two designs differ in how functions are distributed across different hardware and software elements and in how they are integrated into the flight vehicle. The differences vary from minor to major, directly affecting the ability of a subsystem vendor to enter into a future competition against the firms participating in the initial production program. Given the design strategy being employed, traditional methods of fostering avionics competition may not be effective.

Reverting to a conventional federated, or stand-alone, subsystem design would facilitate future competition at a component level. However, with such a conventional design, the overall program cost would be greater than with an integrated mission system package. This does not mean some level of traditional competition for each avionics subsystem is futile. What it means is that a detailed assessment of each subsystem is required before the decision to compete the subsystem (or a part of it) can be made. The decision is not whether another vendor could make its subsystem fit in the winning team’s design. Rather, a hy-
A hypothetical decision to fit a competitor’s component into the existing JSF design would need to be assessed on the following factors:

- How much would it cost to make the new design fit?
- What innovations would the proposed new design bring to the existing mission system?
- What else would be needed to foster competition for the entire avionics package?

Our preliminary analysis of these issues indicates that the Defense Department should consider a new approach to fostering competition for the mission system at a future upgrade: Compete the entire mission system package.

The integrated systems approach enables significant cost, size, and weight savings for the mission system package. Competing at the mission system level would empower the competitor to be innovative and develop systems that enhance mission performance while minimizing cost. In addition, it would help preserve the avionics integrator industrial base.

**Should Competition Be in FFF or BTP Mode?**

In Chapter Five, where we examined near-term opportunities for competition, we considered options in which the second source would competitively build a component or subsystem using the original source’s design (Build-to-Print) or design and manufacture its own variant that would fit into the existing overall system (Form-Fit-Function) as a direct substitute for the original source’s design. Which approach should be followed by our suggested second source for future mission equipment?

In principle, it should be possible for the prime to design a follow-on mission equipment suite, then a second source could compete for production on a minimum-cost basis. However, we argued earlier that a major future benefit from a mission equipment second source would be to encourage innovation and exploit advances in technology. The advantage being sought here is different from that of the near-term competition modes examined in Chapter Five; here, we are primarily seeking design improvements, not just reductions in manufacturing.
cost. To achieve such benefits, it would be necessary for the second source to create its own design for all or parts of the mission equipment suite.

Such an FFF strategy would require close cooperation between the overall system prime and the competitive second source for mission equipment, because the second-source design would have to fit into the existing flight-vehicle and overall-weapon-system design.

What Near-Term Actions Should Be Taken to Support Future Competition for Mission Equipment?
One strategy the DoD could employ would be to wait a few years until changing mission needs and evolving technologies justify an upgrade in mission equipment, then evaluate the option of introducing a competitive second source. However, that might not provide the maximum benefits. Near-term stimulus might not be available to support appropriate technology innovation at the desired rate, and some key firms might have left the industry. Thus, we want to consider sustaining a second source at a level less than full EMD but sufficient to ensure technology advances and retain a vigorous industrial base to support future competition.

How might such a sustainment phase be structured? We suggest some guidelines. Following the arguments outlined above favoring an integrated design approach, it would be appropriate to organize a “shadow mission system design team” to develop a next-generation mission system. A shadow team would have as its strategic goal to create a strong competition to the JSF prime contractor team for design and production of the second-generation mission equipment suite. The strength of that competition would depend on how well the shadow team used available resources to develop critical technologies, nurture the firms best capable of providing such technologies, and integrate the results into a next-generation design concept.

How much might such a shadow team cost? We can draw on some related research in which RAND researchers examined the minimum size at which an aircraft design team must be sustained through lean times in order to be competitive on the next design competition. That study (Drezner et al., 1992) identified five categories making up the overall activity needed to sustain a vigorous design capability:
• Technology development
• Engineering and management staff
• Facilities
• Financial support
• Institutional structures and management organizations.

RAND’s survey of several aircraft-development firms over several cycles of lean and full business activity suggested that “the historical minimum size that design organizations reached (was) characterized by about $100 million in annual funding and 1,000 people in engineering and technical management.”

We have not conducted a similar survey of modern military avionics development firms, but we have no reason to believe that a team preparing to compete for development of a future mission equipment suite for the JSF would be larger than an equivalent aircraft design team. Thus, we estimate that the annual sustainment cost for such a team would be roughly $50 to $100 million, depending on the range of system elements subject to vigorous development activities.3 This investment rate would equal some 10–20 percent of the annual cost of full-scale EMD for the mission system.

Assuming that such a shadow competitor might be sustained for five years before deciding whether to implement a full competition for an upgraded mission system (and hence the need to invest in a full EMD for the competitor) would yield a total investment of maybe $250 to $500 million, or roughly 10 to 20 percent of full EMD cost. But that would not necessarily represent a net outlay. It seems reasonable to assume that the suppliers of mission system equipment to the JSF program would view such a program as a threat of future competition, and they might consequently work to reduce their own prices and, hence, be better prepared to meet such future competition.

How large would such price reductions have to be in order to cover the shadow competitor costs? Making a limit-case assumption that the price reduction would affect the entire production run of mission system equipment, we obtained the results shown in Table 9.1. Of course,

---

3 Some believe that, because of the need to keep 6–10 individual contractors active, our cost estimates are too low.
if the price reduction affected only a later segment of the production, the required reductions needed to break even would be greater. But even if the recouped cost was less than the amount necessary to fully cover the investment in the shadow competitor, the benefits of having a full design competition for the next upgrade appear to justify the investment.

The government would get four benefits from such an annual investment:

- It would be assured of continued development in technologies and system architectures directly relevant to the JSF. Having such a program in place would provide the institutional structure necessary to support and guide appropriate development work.
- It would be able to selectively support a few key firms that might otherwise leave the business of developing fighter aircraft mission equipment, and thus strengthen the industrial base for future programs.
- The shadow competitor would serve as a backup in case the prime developer of mission equipment “stumbled” in some important way.
- The existence of such a program might provide to the prime developer of mission equipment a sense of impending future competition in this important area, thus improving the quality of the main JSF development program.

<table>
<thead>
<tr>
<th>Investment in shadow competitor (percent of full EMD)</th>
<th>Prime cost reduction needed to break even (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 9.1
Production Savings Needed to Break Even on Investment in Shadow Competitor

RANDMR1362-T9.1
The complete implementation of such a strategy has not been fully examined in the present study. This option deserves careful consideration, but its size, scope, and structure will depend on more-detailed examination.

Options for Competition from Outside the JSF Program
There are many near-term and longer-term options for competition from outside the JSF program. However, a very quick survey of these options suggests that none is particularly attractive, for a variety of reasons.

Near-Term Options
In the near term, modifications or upgrades of some existing aircraft could in some ways be viewed as competitive with the CTOL variant of the JSF. On the one hand, a multirole air-to-ground variant of the F-22 Raptor, now completing EMD, could certainly equal or surpass the JSF CTOL in most performance areas. On the other hand, a variant of the large, two-engine F-22 would undoubtedly be considerably more expensive than the JSF CTOL, assuming the JSF program achieves its URF cost goals. An upgraded variant of either the F-16D Block 60+ or the F-15C or F-15E, including JSF avionics subsystems, also might equal or exceed the JSF CTOL in many performance areas. Indeed, an advanced F-16 is already being developed for the United Arab Emirates and includes the latest AESA radar technology and other advanced avionics, as well as conformal fuel tanks added to the fuselage for greater range. However, both F-16 and F-15 upgrades would likely fall well short of the JSF CTOL in low-observability (LO) characteristics, as well as in other areas. Furthermore, an F-15 variant would probably surpass the stringent JSF URF cost goals.

For carrier use, an upgraded variant of the F/A-18E/F now going into production is an obvious alternative to the JSF CV. Indeed, the Navy is already adding an advanced AESA radar and other improved avionics to the existing F/A-18. However, this option suffers from the
same problems as the CTOL alternatives: The two-engine F/A-18 variant would likely be more expensive and would lack the LO characteristics of the JSF CV variant.

There is no plausible near-term alternative to the JSF STOVL variant. The only possibility would be a major developmental program to upgrade the existing subsonic AV-8B Harrier, an aircraft developed in the late 1970s. Of course, such a variant would also probably lack the LO characteristics of the JSF STOVL design.

Perhaps most important, these options would mean the loss of the substantial cost-improvement curve benefits of producing large numbers of variants of the same basic design that is at the heart of the cost savings approach of the JSF program. Instead of all three services procuring essentially the same basic airframe design and the same mission avionics, three separate modification and upgrade programs of different existing aircraft would have to be undertaken, each resulting in the procurement of far smaller numbers of unique designs. Thus, the economies of scale sought in the JSF program would be lost.

Variants or upgrades of foreign fighters currently under development or in production could also be considered possible alternatives to the JSF, although probably only for foreign customers. Possible alternatives for the JSF CTOL variant include the UK-German-Italian-Spanish Eurofighter, which is now just entering into production; the French Dassault Rafale, also just entering production; and the Swedish Saab Gripen. The Eurofighter and the Rafale, high-performance modern fighters, show some of the same disadvantages of the F-15 and the F/A-18: They are both expensive two-engine aircraft with poor LO characteristics relative to the JSF designs. The Rafale was designed from its inception for both land-based and carrier options. The first-production Rafale is the Rafale M variant for the French Navy, which could be considered as an alternative for the JSF CV. However, the problems mentioned above for U.S. fighters apply to the Rafale M. Already in production, the Gripen is a smaller, lighter, less capable F-20-class fighter whose design does not possess the basic performance and LO characteristics of the JSF designs. No STOVL candidates exist in Europe, other than a major upgrade of the existing subsonic Harrier GR.7. Finally, none of these aircraft would provide the
benefits of the huge economies of scale sought in the JSF program by using a single basic design to meet all services' needs.

**Long-Term Options**

In the longer term, more radical modifications of the already-mentioned existing fighters could be considered as alternatives to the JSF. However, the scale of modifications necessary to be truly competitive with the JSF would amount to developing essentially a new aircraft. Thus, no particular advantage would necessarily be gained from taking this route.

In the long term, radical alternatives such as Unmanned Combat Air Vehicles (UCAVs) might be substituted for some missions envisioned for JSF. Indeed, the U.S. Defense Department recently awarded a contract to Boeing to continue development of its UCAV design. Other radical concepts such as mounting larger numbers of smart standoff munitions on aerial missile launch platforms such as existing or future bombers, or even modified commercial wide-body airliners, might appear attractive. The type of munitions that could be used might be something like an upgraded Joint Air-to-Surface Standoff Missile (JASSM) with an active target-recognition sensor for greater accuracy against high-value targets, even when launched hundreds of miles from the target area. The JASSM is currently in full-scale development for the Air Force.

An even more radical concept might be to place weapon-launching platforms in space and launch precision-guided munitions from there against land and sea targets. This, as well as many other similar suggestions, is obviously an option that might become available only far in the future.

The problem with most of these radical options is that the ultimate effectiveness and capabilities of such future systems are not known at this time. The UCAV and JASSM are being developed, but real capabilities and effectiveness of even the first-generation systems that are currently under development are not known. No well-developed doctrine or operational concepts exist for the substitution of air-breathing or space-based smart-munition launch platforms for the traditional combat missions assigned to fighter-attack aircraft such as the JSF. Fur-
Furthermore, the ultimate cost competitiveness of such systems with the JSF cannot be calculated at this time.

**Conclusion**

We conclude, therefore, that if the JSF program achieves its system performance and URF cost goals, no realistic competitor exists, at least in the short term. Existing stealthy aircraft that might be competitive are too expensive, whereas existing nonstealthy aircraft will lack the operational capabilities of JSF. However, if JSF URF costs begin to escalate, other platforms might become feasible alternatives, especially for the CTOL JSF variant. The most obvious would be a downgraded ground-attack variant of the F-22 or an upgraded F-16 Block 60+. An enhanced variant of the F/A-18E/F would probably be the most likely candidate for the CV of the JSF.

If JSF costs begin to escalate, careful and extensive combat modeling must be conducted to determine the cross-over point between cost and effectiveness, at which candidates such as an upgraded F-16 or a downgraded F-22 become viable substitutes. At this stage of the JSF program, competition from outside the program appears to be limited.