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REPORT

Evaluating the Desirability of Navy F/A-18E/F Service Life Extension Programs (SLEPs)

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Prepared for the United States Navy

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Summary

This report resulted from a U.S. Navy request to the RAND Corporation to assess the cost-effectiveness of prospective service life extension programs (SLEPs) on F/A-18E/F fighter jets and C-2A transport aircraft. The Navy's request and the methodology we present in this report assume that a SLEPed aircraft and the potential replacement aircraft have comparable capabilities.

SLEPs are complex depot-level overhauls in which an aircraft is extensively inspected, cracked or worn materials are repaired or replaced, computer systems are upgraded, and mechanical function is ensured. When a SLEP is undertaken, it is assumed that a number of extra years of operation are added to an aircraft's life. Likewise, one might hope that a post-SLEP aircraft performs better, e.g., has greater availability levels or lower maintenance costs.

However, many key parameters are uncertain, e.g., the cost of the SLEP, the additional years of service provided by the SLEP, the cost of the alternative new aircraft. Given this uncertainty, we assess which parameters are most crucial to decisionmaking and present ranges of their values that favor versus oppose undertaking SLEPs.

Making the Cost-Minimizing Choice Between a Service Life Extension Program and a New Aircraft

One can estimate the discounted sum of total costs associated with a SLEP versus a new aircraft. However, these summations are not directly comparable, since a new aircraft will presumably last longer than the number of extra years of operation provided by a SLEP.

One way to correct for this problem would be to annuitize each approach's cash flows and to choose the approach (SLEP versus new aircraft) with the lower annuitized cost. Annuitization translates uneven cash flows (e.g., an up-front procurement or SLEP payment followed by lower year-to-year maintenance costs) into a single, equal-sized annual payment. Annuitization is appropriate if technology is static, i.e., the Navy's options upon the expiration of the once-SLEPed aircraft are neither better nor worse than they are today.

Unfortunately, choosing the approach with the lower annuitized cost does not consider aircraft availability issues.

Consideration of Aircraft Availability Trends

As aircraft age, we expect their annual maintenance costs to increase and their annual availability levels (the fraction of the fleet that is operator possessed and mission capable) to decrease. Selection of the cost-minimizing option between SLEP and aircraft replacement ignores prospective aircraft availability declines.

Keating and Dixon (2003) suggested use of average cost per available year to account for age-driven availability declines. While the average-cost-per-available-year metric is tractable and intuitive in how it adjusts for changing availability, it is not a standard, agreed-upon metric. One must accept a priori that average cost per available year is the right metric to minimize.

A different methodology would be to assume that Navy valuation of an aircraft increases linearly in its availability level, i.e., net benefit equals $k \times a(t) - c(t)$, where $a(t)$ denotes availability in year t and $c(t)$ denotes cost in year t. One can then annuitize net benefits of both new aircraft and a SLEP and choose the option with the greater annuitized net benefit.

Introduction of an availability valuation parameter k has its own challenges, however. We can only bound, not specifically identify, k.

If we assume that the new aircraft has net benefit, the new aircraft's k must be greater than the new aircraft's average cost per available year. On the other hand, the new aircraft's k must be small enough that it is optimal to operate the new aircraft for its assumed lifetime (and not retire it sooner). The result of these two constraints is a range of possible k values. How should one interpret, for instance, a SLEP being worthwhile if k is at its minimum value but not if k is at its maximum value? There is no clear way to assess the Navy's value of k.

F/A-18E/F Context

The Navy asked RAND to evaluate the desirability of a prospective SLEP on F/A-18E/F fighter aircraft. F/A-18E/Fs will be due for a SLEP or for retirement sometime late in the 2010 decade or early in the 2020 decade.

Our models need an estimate of the cost of the SLEP, as well as the additional years of operation it allows. One also wants to know the life-cycle costs associated with the replacement aircraft alternative to doing an E/F SLEP. If aircraft availability trends are to be considered, one would also need to estimate the levels of aircraft availability associated with both a post-SLEP F/A-18E/F and its prospective replacement.

Unfortunately, an F/A-18E/F service life assessment program only recently commenced. So, many of the parameters we need are not known and can only be estimated with a high degree of imprecision.

Based on insights from Navy experts, analysis of Navy data, and literature review, we make the following assumptions:

- The alternative to undertaking E/F SLEPs is to acquire the F-35C carrier variant of the Joint Strike Fighter (JSF).
- An E/F SLEP would add ten years to the aircraft's life. (We refer to a SLEP that adds ten years to an existing aircraft's life as a *ten-year SLEP*.)
- This SLEP would cost $26 million (fiscal year [FY] 2009 dollars) per aircraft.

- F/A-18E/F maintenance and modification expenditures per aircraft will grow at 3 percent per annum in real terms.
- A ten-year SLEP would "pull back" annual expenditures per aircraft to the level seen when the aircraft was 11 years younger (ten years of pullback plus the year spent in the SLEP).
- F/A-18E/F aircraft availability will follow the downward trend observed in the F/A-18C/D fleet and a ten-year SLEP will return the aircraft's availability to its level seen 11 years prior.
- A JSF will have a 30-year lifetime and a procurement unit cost of $80 million.
- JSF maintenance and modification costs will be the same as an E/F's at the same age, but JSFs will not require a SLEP after 20 years of operation.
- JSF availability will equal assumed E/F availability through age 20, then stabilize.

F/A-18E/F Service Life Extension Program Desirability Analysis

Minimizing either the cost metric or the average-cost-per-available-year metric, we find that a $26 million SLEP that adds ten years to the life span of an F/A-18E/F is desirable relative to buying a new JSF.

Use of the average-cost-per-available-year metric consistently finds results more favorable to a new aircraft than use of the cost metric. With our baseline parameters, the differences are moot. Both methodologies favor the SLEP. But the average-cost-per-available-year metric, because it considers aircraft availability, has a lower SLEP cost cutoff ($30.9 million versus $33.6 million), a greater SLEP year cutoff (nine extra years versus eight), and a greater JSF procurement unit cost cutoff ($67.9 million versus $62.1 million).

Net benefit maximization also favors ten-year $26 million E/F SLEPs with our baseline parameters. But now one attains a range of SLEP cost cutoffs (between $28.2 million and $30.9 million), JSF procurement unit cost cutoffs (between $68.4 million and $74.6 million), and SLEP year cutoffs (nine or ten). These cutoff ranges emanate from uncertainty in the valuation parameter k, a parameter we can bound but not identify.

If the Navy attributes even moderately greater military value to a JSF than to a SLEPed E/F, our generally pro-SLEP findings can reverse. The Navy must therefore examine the extent to which it might put greater military value on JSFs. Such an inquiry is beyond the scope of this analysis.

Conclusions

This report applies three different methodologies to assessment of the desirability of an F/A-18E/F SLEP. With our baseline parameters, all three methodologies favor undertaking the SLEP.

Minimization of average cost per available year and net benefit maximization consider aircraft availability levels. Cost minimization does not.

While the average-cost-per-available-year metric is tractable and intuitive in how it adjusts for changing availability, it is not a standard, agreed-upon metric. One must accept a priori

that average cost per available year is the right metric to minimize. The net benefit maximization approach assumes that Navy valuation of an aircraft increases linearly in $a(t)$.

We conclude that an analysis of repair-replace decisionmaking should start with cost-minimization calculations. Most notably, if a new aircraft is found to be less costly, there is little need for additional calculations assuming the typical result of newer aircraft having greater availability and capability levels. If, on the other hand, the repair approach is found to be less costly, we then recommend explorations of both net benefit maximization and average-cost-per-available-year minimization to see how much additional availability or capability and the value placed on them it would take to offset the higher cost in decisionmaking.