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REPORT

Options for and Costs of Retaining C-17 Aircraft Production-Only Tooling

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Summary

The U.S. Air Force (USAF) asked the RAND Corporation to analyze the desirability of storing government-funded, production-only tooling when production of the C-17A cargo aircraft ends. To address this question, we focused on weapon system–specific production-only tooling, i.e., tooling not used in weapon system sustainment and useful only for producing C-17s, that is, not readily convertible for use on a different weapon system.

Immediate disposal of weapon system–specific production-only tooling is usually the less costly option, but retention of this tooling gives the government the option of restarting production in the future without having to procure all-new tooling.

The possible restart scenarios include someday resuming C-17A production, starting up production of a tactical variant Boeing has proposed (which it refers to as the C-17B), or starting up production of the so-called C-17FE (*FE* standing for fuel efficient).

Future production of C-17As, C-17Bs, or C-17FEs is highly speculative. There is considerable uncertainty as to what sort of restart the USAF might want in the future, when, and in what quantities. Or, of course, C-17 production may never be restarted.

Tooling Issues

Boeing provided us a tally listing 53,910 government-funded tools currently used in C-17A production. These tools were distributed across nine tool types with more than half (31,025) being what Boeing terms *other fabrication tools*.

We assumed retention of any tooling currently being used in production that would also be needed for C-17A sustainment. Given that, of the total number of tools, we recommend retaining 9,761 for C-17A sustainment and that this set include all master models, hard masters, and stretch blocks (three of Boeing's nine types of tools) and/or their associated data.

The remaining 44,149 production-only tools appear to have little value for sustainment but may help reduce the cost of a prospective restart or future production of a variant. Thus, a key question became how much the tools would be worth in the event of a restart, in terms of the cost differential between retaining them and making new ones.

We assumed that, in case of a production restart, a tool would be worth its original acquisition cost, escalated into fiscal year 2011 (FY 2011) dollars, after adjusting for the cost of making the tool ready for production following a period in storage.

If we knew each tool's physical attributes, estimating the cost to pack, ship, and store that tool would be straightforward. Unfortunately, although the information Boeing provided us sorted each tool into one of the nine types based on its usage in production, it did not include

the physical attributes of individual tools. To overcome this lacuna, we used the cost of each tool to associate it with one of three size gradations (small, medium, and large) within its tool type. Each of the resulting 27 categories was then assigned a typical weight and dimension based on discussions with Boeing experts. We estimated the costs to package, transport, and store each tool from these weight and dimension estimates.

Production Restart Costs

To assess how production restart costs would differ with and without retained C-17A production-only tooling, we analyzed three different scenarios: restarted C-17A production, a startup of C-17B production, and a startup of C-17FE production.

According to our estimates, the nonrecurring new facility and tooling costs for a C-17A restart would be about $1.4 billion (in FY 2011 dollars) with tooling retention and about $1.9 billion without it. This suggests that tool retention reduces nonrecurring tooling costs by about $540 million. Other nonrecurring costs for a C-17A restart, most centrally nonrecurring airframe engineering labor, would cost somewhere between $760 million and 1.34 billion. In total, therefore, the nonrecurring costs for a C-17A restart would be $2.1 billion to 2.7 billion with tool retention and $2.7 billion to 3.3 billion without it. See Table S.1.

Also, a production break leads to loss of learning, which imposes recurring cost penalties. These penalties would range from $8 million to 45 million per aircraft, with the largest penalty for a small restart quantity.

The costs for starting up production of a C-17 variant would be even higher (Table S.1). We estimated that the nonrecurring costs for a C-17B variant would be $4.6 billion to 6.4 billion with tool retention and roughly $450 million more without it. We estimated the nonrecurring costs for a C-17FE variant would be $6.2 billion to 7.0 billion with tool retention and roughly $300 million more without it.

We estimated that recurring costs for the C-17B would be slightly higher than those for the C-17A. Those for the C-17FE might be slightly lower or somewhat higher than those for the C-17A.

Ultimately, tooling costs are not a major cost driver. Tooling retention could reduce program acquisition unit cost by about 1.5 percent for a C-17A restart and about 1 percent for a variant startup.

Table S.1
Estimates of Nonrecurring Costs

Scenario	Estimate With Tool Retention		Increment Without Tool Retention ($M)
	Low ($B)	High ($B)	
C-17A restart	2.1	2.7	+540
C-17B startup	4.6	6.4	+450
C-17FE startup	6.2	7.0	+300

NOTE: All dollars in FY 2011 terms.

Tooling Retention Analysis

Clearly, the decision on retention must occur before determining whether to restart production. Other things equal, the higher the perceived probability of production restart, the greater the desirability of retaining production-only tooling. So, we developed a methodology for assessing the desirability of retaining C-17A production-only tooling.

We defined the *breakeven probability* of a production restart for a tool as the probability at which the decisionmaker is indifferent between retaining the tooling and not retaining it. If the decisionmaker's perceived probability of a restart is greater than the breakeven probability, he or she should retain the tooling and conversely. Breakeven probabilities are lowest, i.e., retention is most desirable, for high-value, low-volume tools that are inexpensive to retain but valuable at a restart.

Removing the master models, hard masters, and stretch blocks—all tools in these types are needed for sustainment—we estimated 18 different breakeven probabilities, three sizes for each of six types of tools. The lowest breakeven probability, of around 2 percent, is for the category of large other fabrication tools. On the other extreme, it would cost more to retain small handling fixtures and dollies and small workstands and storage racks than they are worth; tools in these two categories should not be retained even if restart is certain.

We are not prescribing or suggesting the actual probability of a C-17 restart. That subjective probability is a decisionmaker's choice. Conditional on making that choice, we have cataloged which categories of production-only tools should be retained and which should not.

Not surprisingly, there are diminishing returns on investments in tool retention. The first few millions of dollars of investments retain a considerable number of high-value tools. As more tools are retained, additional investments are less productive on the margin.

Tooling retention is more desirable when production restart comes sooner, although the optimal tool retention decision is only moderately affected by the restart year assumption. If tools' values decline while in storage, tooling retention is less desirable.

We assumed that a C-17FE would have less tool commonality with the C-17A than would a C-17B variant. Therefore, more tools should be retained if a C-17B startup is expected rather than a C-17FE startup.

Conclusions

Barring unforeseen changes to the C-17A program, production will end in 2014 or 2015. Once C-17A production in Long Beach ceases, any resumption of production would incur sizable costs. Even Table S.1's most optimistic C-17A restart case would have at least $2.1 billion in nonrecurring costs. The magnitude of the cost of restarting C-17A production or starting up production of a variant gives pause with respect to tooling retention. One could interpret these sizable cost estimates to suggest the probability of a future production restart is quite small. Without some probability of eventual C-17 restart, there would be no value in retaining C-17 production-only tools.

Our estimate of the nonrecurring cost of retaining production-only tools, net of the cost of near-term disposal, ranges from zero (if no production-only tools are retained) to about $70 million if nearly all tools for a C-17A restart were kept. To put tooling costs in perspective, if the entire population of C-17A production-only tools ($860 million worth) had to be repro-

cured for a restart of 150 C-17A aircraft, the program acquisition unit cost saving attributable to the retained tools would be about $6 million per aircraft or between 2 and 3 percent of the unit cost.