COST AND SCHEDULE IMPLICATIONS OF MULTINATIONAL COPRODUCTION

Michael D. Rich, William L. Stanley
John L. Birkler, and Mary E. Vaiana

July 1984

P-6998

The Rand Corporation, 1700 Main Street, P.O. Box 2138, Santa Monica, CA 90406-2138

COST AND SCHEDULE IMPLICATIONS OF MULTINATIONAL COPRODUCTION

Michael D. Rich, William L. Stanley,
John L. Birkler, and Mary E. Vaiana

The Rand Corporation
Santa Monica, California

July 1984

Originally published in *Defense Management Journal*, Vol. 20, No. 2,
Second Quarter 1984.

COST AND SCHEDULE IMPLICATIONS OF MULTINATIONAL COPRODUCTION

The United States and its European allies continue to consider multinational collaboration as a means for acquiring tactical weapon systems. And although the cost, schedule, and program management implications of collaboration are not always well-understood, interest in the approach remains high for several reasons:

- The ever-rising costs of developing and producing weapon systems.
- A desire to standardize weapon systems used by North Atlantic Treaty Organization nations.
- A desire on the part of European members to improve their defense industrial capabilities.
- The pragmatic requirement for an equitable balance of defense hardware trade between the United States and Europe.
- The growing number of European firms that have technical capabilities commensurate with those of American firms.

Coproduction, or international collaboration during production of a major weapon system, is one of the more complex forms of multinational cooperation, and the Rand Corporation has completed a comprehensive investigation into some widely held beliefs about such arrangements. The purpose of the analysis was to assess the impact of coproduction on acquisition costs and schedules and to identify ways to maximize its advantages while sidestepping its pitfalls. (For details of this Air Force-sponsored study, see Michael Rich, William Stanley, John Birkler, and Michael Hesse, *Multinational Coproduction of Military Aerospace Systems,* Rand Corporation, R-2861-AF, October 1981.)

Researchers were particularly interested in determining whether European collaborative programs are credible guideposts for predicting the outcomes of U.S.-European programs, whether collaborative programs experience more schedule slippage than do uninational programs, and whether coproduction imposes a cost penalty on the United States. The Rand team examined a wide variety of uninational, U.S.-European, and European collaborative aerospace development and production programs, both completed and ongoing, including the largest and most complex U.S.-European collaborative effort to date, the F-16 fighter aircraft program.

Requisite to an understanding of U.S.-European efforts is an awareness of the differences between the United States and its allies in designing, developing, and producing weapon systems. Multinational European programs often serve as paradigms for predicting the results of collaborative programs in which the U.S. participates. Thus, to make credible predictions about joint U.S.-European efforts, one must first distinguish the effects of collaboration per se from the effects of European weapon acquisition practices. Two areas of special concern are program length and schedule slippage.

To investigate program length, Rand researchers compared three critical intervals across 20 U.S. military aircraft programs, 13 European national programs, and six European multinational programs. The intervals measured were those between design start and first flight, between first flight and initial operational delivery, and between design start and first delivery. Though program length is not necessarily a good measure of program merit, differences in length can reflect systemic disparities that may have implications for joint ventures. Figure 1 depicts the varying intervals between design start and first flight and between first flight and initial operational delivery for European multinational, European national, and U.S. national programs.

Variations from program to program gave rise to questions about the significance of these differences. The two statistical techniques used to compare U.S. and European program lengths yielded the same results: weak evidence that European programs take longer from design start to first flight, but strong evidence that they take longer from first flight to initial operational delivery and from design to delivery. Although one can always identify particular collaborative programs of excessive length, statistical differences between the Rand samples of European national and multinational program lengths were not

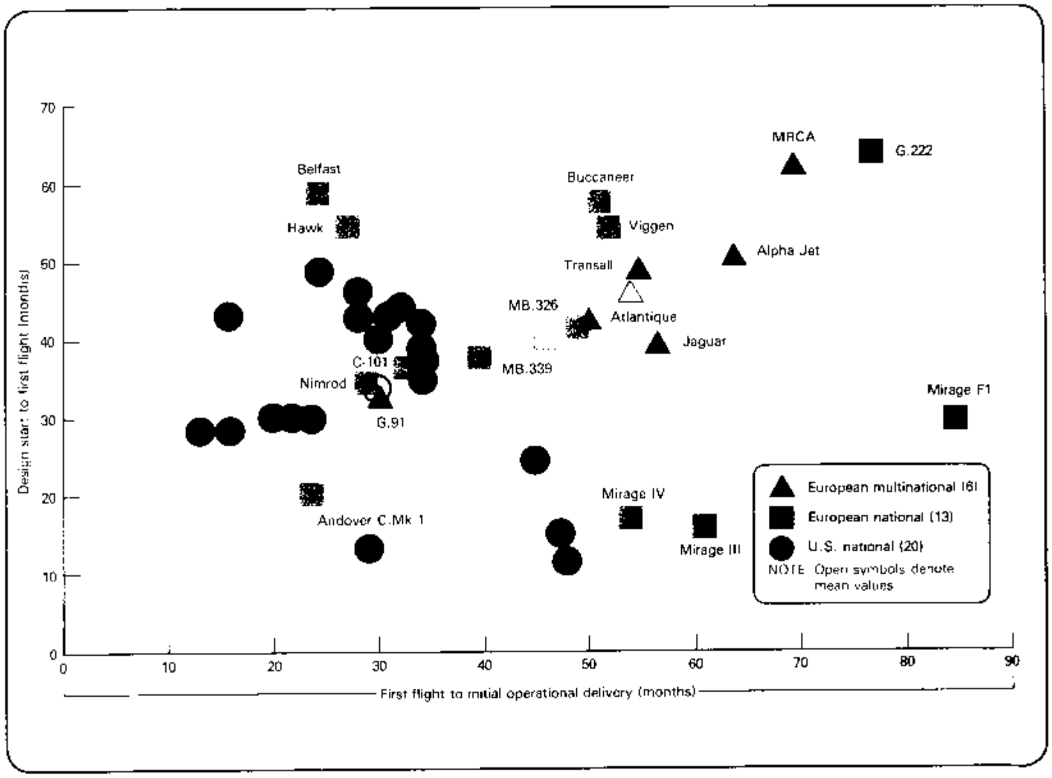

Fig. 1 -- The varying intervals between design start and first flight and between first flight and initial operational delivery for European multinational, European national, and U.S. national programs

significant. Hence, the longer duration of these programs seems more attributable to the European acquisition setting than to the inherent nature of collaboration.

For any number of reasons, including many unrelated to collaboration, program schedules may slip or change. Whatever the cause, adjustments due to schedule slippage are burdensome and costly. Capital investments optimized for a particular schedule become less than optimal. Overhead expenses can mount. Older weapon systems may have to be refurbished to fill the void that was to have been filled by the slipped system. Moreover, changes in employment commitments, particularly in Europe, can be very costly.

Comparisons of several recent U.S. aircraft programs--the A-10, F-111, F-14, F-15, and F-16--with several European multinational programs--Atlantic, Transall, Jaguar, Alpha Jet, and Tornado--also revealed that U.S. and European slippage patterns differ. The European programs were much more likely to experience schedule slippage before first delivery; in four of five programs examined, time lags ranged from 34 to 43 months. Slippage in U.S. programs before first delivery never exceeded eight months. However, after initial delivery, both types of programs experienced considerable delays--from 24 to 64 months for some European programs and from 30 to 40 months for U.S. programs. Clearly, these dramatic differences must be reconciled if collaboration between the United States and European nations is to be successful.

The European acquisition setting is one factor that significantly affects program length and schedule trends. Three principal characteristics color and shape that environment:

- The scale and breadth of defense activities.
- Work force policies.
- Design, development, and manufacturing methods and practices.

In gross economic and industrial terms, NATO Europe is roughly comparable to the United States. However, U.S. defense expenditures are almost twice those of NATO Europe, and this disparity reflects substantial differences in defense industry activity and capabilities, including breadth of product areas, extent of the industrial infrastructure, continuity of production, and size of programs. The diversity and scope of national industrial activity in turn affect schedule length and slippage.

The most salient of U.S.-European differences affecting collaborative programs is management of the work force. The goal of long-term work force stability dominates European employment practices. Shorter work weeks, longer vacations, worker antipathy toward overtime, and restrictive policies governing layoffs and use of temporary workers combine to constrain the ability of European firms to expand the labor force to meet schedule or production commitments. Similarly, these factors make it more difficult for European firms to overcome temporary obstacles in order to stay on schedule or to catch up once a schedule has slipped. Recently, though, European civilian programs such as Airbus have shown some willingness to accommodate business opportunities by using multiple shifts to stay on schedule.

This emphasis on work force stability and a generally smaller scale of operation are two key reasons why European manufacturing processes are often more labor-intensive than the United States'. Although European and U.S. industries are introducing more production automation, the heavier European reliance on labor-intensive methods--methods tailored to smaller production runs and constrained funding profiles--has hindered technology transfers between the two.

Understanding the fundamental reasons for discrepant schedules permits more effective structuring of collaborative programs. It is particularly important in planning U.S.-European collaborations, to which efforts the United States brings its larger production base and more flexible work force policies. Even so, and despite the considerable assets that the United States can bring to a coproduction program, various other challenges remain. For example, multinational decisionmaking requires meticulous planning to accommodate each country's particular system needs; it thus provides rich opportunities for delay. Negotiation of preferred delivery dates and reconciliation of radically different national acquisition approaches may be necessary. Contractors in turn may have to adjust to the practices and management procedures of their collaborators. Also, distribution of work (and consequently of benefits as well) may be delayed if qualified contractors are hard to find or difficult negotiations are necessary. In addition, multiple final assembly lines can complicate scheduling and increase the possibility of schedule slippage.

The F-16 program is one of the most ambitious coproduction efforts ever attempted. It entails the concurrent production of airframe, engine, and avionics components in five countries and aircraft final assembly in three.[1] Although the program has enjoyed generally favorable

---

[1] The number of countries assembling F-16s will grow to four when Turkey begins assembly activities.

results, it nonetheless provides an excellent example of how the complexity of coproduction can affect schedule. It also shows how the addition of U.S. industrial capability to the collaborative equation can improve schedule outcomes.

European participation in the F-16 program introduced scheduling considerations that influenced all program phases. Some of the more important considerations were:

- **Early delivery requirements.** Dutch and Belgian plans for early replacement of their aging F-104G aircraft increased the pace of the program.
- **Start-up delays.** Resolving differences in acquisition procedures, finding qualified contractors, and negotiating the division of work all delayed start-up.
- **Longer lead times.** European work force policies discouraging surges in labor contributed to longer lead times for European parts. The longer lead times pushed the United States to an earlier-than-usual production decision, causing considerable development and production concurrency in the schedule. Also, the differences in lead times impeded incorporation of changes and complicated scheduling for final assembly.

The program's ambitious pace--as dictated by the early delivery requirements--coupled with European production start-up delays and work-force policy constraints, forced U.S. contractors to alter their production schedules. To keep initial deliveries on schedule, U.S. firms had to supply additional parts and subassemblies to European manufacturers. General Dynamics, for example, accelerated its tooling schedule and dipped into its management reserve to produce some aft fuselages originally scheduled to be produced by a Belgian firm that ran into financial difficulties. In effect, the ability of U.S. manufacturers to produce each aircraft component provided insurance against disruptions in the flow of components from European contractors.

Figure 2 summarizes F-16 schedule experience during the early stages of production. Although coproduction has made scheduling more complex, the combined efforts of U.S. and European producers prevented

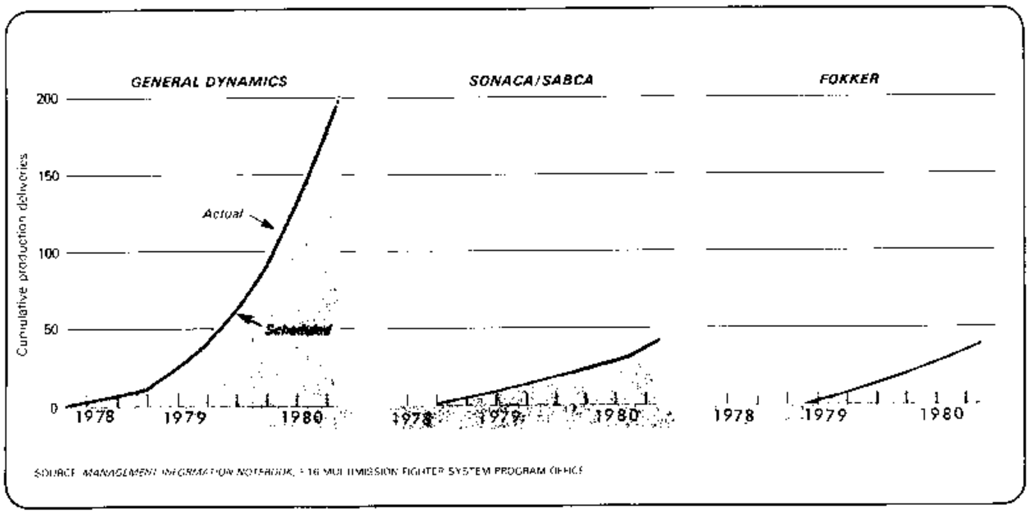

Fig. 2 -- Summary of F-16 schedule experience during the early phases of coproduction

program delays that have marred a number of purely European collaborative efforts. Moreover, the F-16 production schedule and funding profiles have been significantly more stable than those of typical domestic programs, a feature due largely to congressional and DoD recognition of the extensive commitments made by the producing nations.

There is no simple answer to the question of whether collaborative programs cost more. The cost implications of any program are very complex and depend critically on the participants, the product, and the perspective from which one is evaluating cost. An analysis of F-16 costs suggests that from the U.S. point of view, which is actually a composite of Air Force, DoD, and U.S. government perspectives, the F-16 program has had a generally favorable cost outcome for a coproduction effort.

Coproduction of the first 650 U.S. F-16s is expected to increase costs to the Air Force by about $170 million (in 1975 dollars), approximately 5 percent of total program expenditures. Estimates indicate that coproduced items are likely to cost the Air Force more than the same items produced domestically, because of the higher cost of subcontracting in Europe (see Figure 3). But sale of F-16s to the Europeans also led to a larger production volume for most U.S. contractors, thus offsetting some of the additional costs incurred by the Air Force.

In meeting the European requirement for F-16 airframes, for example, General Dynamics manufactured the equivalent of 144 airframes over and above the 650 airframes it produced for the U.S. Air Force. This increased volume benefited the traditional manufacturing learning curve and therefore this increased volume yielded significant savings in labor costs as well. Moreover, Air Force programs requiring the same

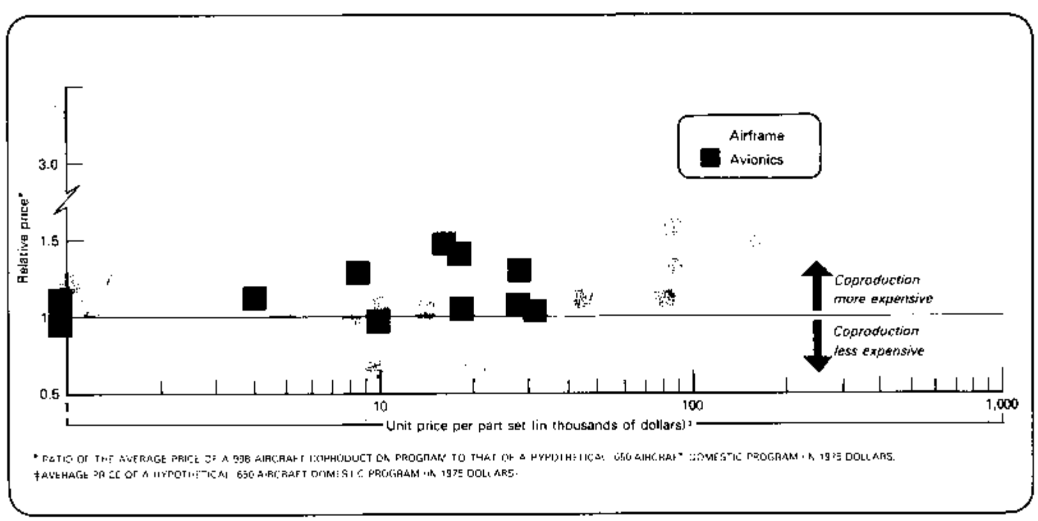

Fig. 3 -- Estimated effect of coproduction on the cost to the Air Force of selected airframe and avionics part sets

equipment or components used in the F-16 benefit from savings due to increased volume as well. The F-15 program, which uses the same F100 engine that powers the F-16, is one example.

Expanded volume can also lower overhead costs at U.S. production plants, thus potentially lowering further the costs of components for the F-16 and other Air Force programs. Contractors can pass on overhead savings achieved at F-16 plants to other DoD production efforts at those same facilities. Like the Defense Department, the U.S. government reaps benefits from F-16 coproduction too. The U.S. Treasury is receiving $163.5 million (in 1975 dollars) from participating European governments for research and development fees, and the increase in European sales translates into additional U.S. tax revenues.

This quantitative focus on costs is of course too narrow. It ignores hard-to-quantify but significant benefits such as NATO standardization and improved European management, manufacturing, and maintenance capabilities. In fact, assessing coproduction cost implications from the European point of view even more strongly demonstrates the importance of perspective and nonquantifiable benefits in the total cost equation.

The participating European governments could have purchased their collective requirements of 348 F-16s directly from General Dynamics. By choosing coproduction over direct purchase, they appear to have accepted a 34-percent cost penalty. But such a strictly monetary comparison ignores many other important factors that color European thinking on the costs and benefits of coproduction. Specifically, collaborative programs offer opportunities for industry capitalization, development of an indigenous aircraft support capability, technology transfer, employment stability or growth, improved political relationships and military capability, standardization, and cost recovery of domestic spending through taxes.

From the European perspective, a realistic evaluation of the F-16 program must address more than incremental increases in program costs due to the coproduction arrangement. Eloquent proof of that assertion is Belgium's decision to supplement its initial F-16 procurement by building 44 additional F-16s domestically rather than purchasing them directly off the U.S. production line. Belgian officials admit that direct purchase would be about 10 percent cheaper. However, domestic production of the F-16s will provide Belgian jobs for at least ten years and secure orders worth the equivalent of about $472 million for Belgian industry. The government of Belgium estimates that it can recover nearly $280 million in taxes from these sales. Thus, on net, the country will save about $206 million by opting for domestic production over direct purchase. And that figure does not reflect savings in unemployment benefits that would otherwise have to be paid to jobless aerospace workers.

The cost comparisons made so far have not been adjusted for differences in quantities produced or for costs charged by a prime contractor to administer subcontracts. Figure 4 depicts the theoretical relative price competitiveness of European and U.S. contractors for selected F-16 aircraft and avionics part sets when price is adjusted for these factors. As the figure indicates, European prices are competitive

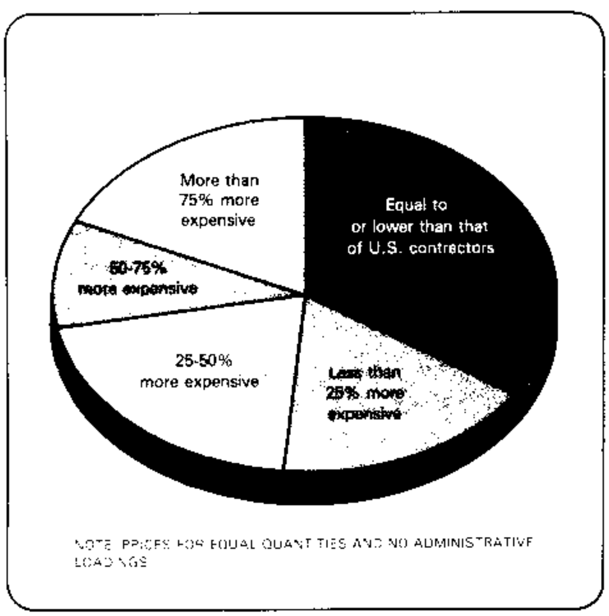

Fig. 4 -- Price competitiveness of European airframe and avionics contractors in the F-16 program

with U.S. prices for only about one-third of the part sets in the sample. Constrained by a not-to-exceed cost target and by pressures to achieve equitable distribution of work across the consortium, F-16 program management sought to overcome the cost competitiveness problem by identifying the strengths of European industry, structuring work packages that exploited those strengths, and using volume production to bring down costs.

To the extent that it can serve as a paradigm for assessing the costs and benefits of collaborative programs, the F-16 program suggests some guidelines for lessening the inherent difficulties of collaboration. In particular, managers of coproduced weapon systems should:

- Recognize differences in U.S. and European acquisition settings and environments and plan accordingly.
- Exploit unique U.S. and European industrial capabilities as well as U.S. advantages in scale, work force flexibility, and production redundancy in order to cope with program adversity.
- Involve foreign producers as early as possible in order to facilitate technology transfer.
- Use quantity production to reduce the costs of less efficient coproducers.

As these highlights of Rand's research efforts make clear, multinational coproduction of a major weapon system is a delicate and complex undertaking, the outcome of which is largely determined by the distinctive capabilities and industrial milieu of each participant. While the above guidelines are hardly an inclusive, surefire formula for success, they do nonetheless represent a solid point of departure.

RAND/P-6998 COST AND SCHEDULE IMPLICATIONS OF MULTINATIONAL COPRODUCTION Rich, Stanley, Birkler, Vaiana