BASELINING AND BENCHMARKING

Management Tools for the 21st Century

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In 1979, after failing to obtain a temporary freeze on government regulations or a refundable tax credit, the Chrysler Corporation was forced to do the unthinkable and go to the perennial source of funds, the U.S. government, to obtain loan guarantees. Having been ravaged by recession, the energy crisis, government regulation, and poor management, Chrysler had to follow the footsteps of the City of New York and Lockheed Corporation. Fearing that government involvement accompanying incipient loans would ruin the company, Chrysler management had to convince itself and Congress that the loan guarantees were the correct thing to do.

With approval of the loans in December 1979, Chrysler was given a unique opportunity to reinvent itself. The team assembled to save Chrysler needed to employ a host of cost-saving techniques and improved manufacturing skills to survive. Marketing strategies had to be initiated for the near and far term. In addition to common platform technology, Chrysler targeted markets and manufacturing quantities. The idea of adapting "benchmarking" was born.

V-22 Osprey Combat Assault

Benchmarking is a management tool that enables businesses to borrow existing proven techniques from successful companies and adapt them to companies needing change. Rather than reinvent new management principles and implement them to an existing business, managers look outside the immediate organization for help in self-improvement. At a minimum, benchmarking is a form of validating and verifying how the business of an entity is conducted. Like any management tool, benchmarking success strongly depends on how receptive management is to change. Encountering resistance from the established and entrenched organizational hierarchy is not unusual.

At Chrysler, management had no choice. They had to adopt the techniques that worked best for other large corporations. After

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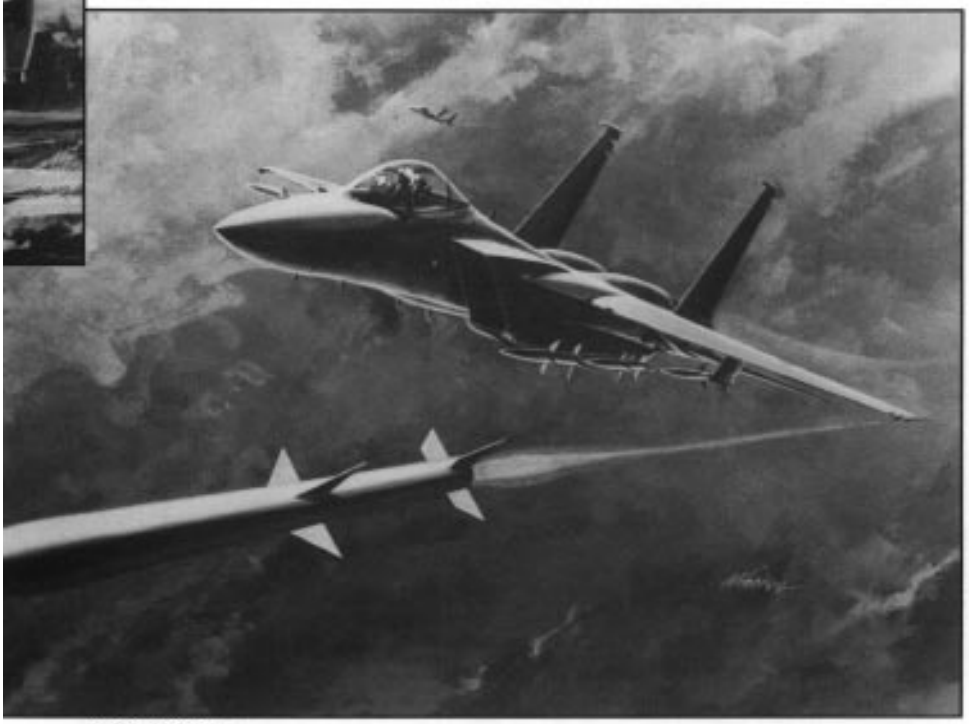
implementing numerous improvements, Chrysler excelled at making cars and at measuring the success of their benchmarking performance. Using proven efficiency improvement processes perfected by Honda and General Electric, Chrysler went one step further and measured effectiveness by using cost-benefit analysis. With its employees oriented toward measuring performance on a continued basis, benchmarking continues to be used by Chrysler as a way of improving the manufacturing process.[1]

Illustration courtesy Bell/Boeing Tiltrotor Team

The Military Connection

A military connection to benchmarking does exist — the baseline, a term widely used throughout current regulations.[2] Establishing the *development baseline* requires effective interaction among the requirements generation, acquisition management, planning, programming and budgeting systems. *Configuration baselines* are used to ensure an orderly transition from one major commitment to the next. *Program baseline* thresholds are established to determine when a program has breached its acquisition level. *Performance measurement baseline* describes the time-phased budget plan against which contract performance is measured. Baselining, therefore, is a term that describes the process of maintaining baselines consistent and current throughout the program acquisition cycle.

The Fall/Winter 1986 edition of *Amphibious Warfare Review* contained numerous articles concerning the V-22 Osprey program. In addition to topics assessing the mission capabilities, reports addressed the management issues for the 913-aircraft acquisition. Senator John H. Glenn highlighted a number of management innovations to reduce risk and control costs. Lt. Gen. Bernard E. Trainor, USMC (Ret), and Col. John J. Grace, USMC (Ret), espoused such factors as a good design, new materials and manufacturing techniques, and modern technology in all components will make the entire system as efficient and reliable as possible.



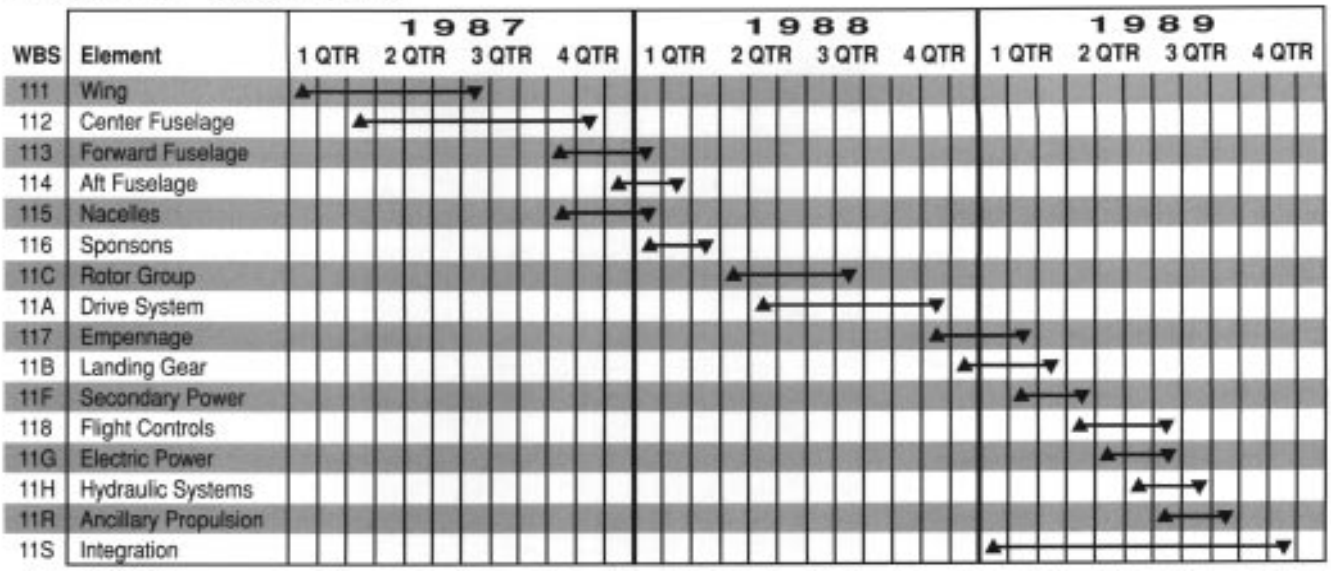
AMRAAM F-15

Though the program enjoyed a tremendous amount of support from Congress and the aviation community, the Naval Air Systems Command program office, tasked with managing the Osprey program, realized this program faced many hurdles before production could begin. Since the aircraft would incorporate many new technologies such as tilt-rotor and composites, inherent questions existed about feasibility of production and affordability. An increased emphasis also was being placed on work measurement for performance measurement using MIL-STD 1567A[3] and should-cost studies on military programs.[4] The program office was determined to consider innovative methods to estimate and manage the V-22 program.

Historically, the process of estimating a new airplane program is straightforward. Early in a program's concept formulation phase, when the design of a proposed aircraft is unknown, detailed cost estimates cannot be calculated. However, estimates are necessary to establish resource planning requirements and perform cost and operational effectiveness analysis on weapon system alternatives. Since detailed designs are not available, cost estimates are developed using gross parametric relationships or by comparing the new aircraft program with known costs of a past program. These estimates then form a budgetary threshold for the program.

As the design of an aircraft becomes defined, more precise estimates can be developed. The earlier estimates, based on broadly applied cost-estimating relationships (CER) and parametric estimates, can be replaced with more accurate estimates based on specific subsystem designs for the new aircraft. The problem, however, is that program estimates are calculated using historical information, at

FIGURE 1. RMCB Plan



least until the total design is solidified. This technique assumes that historical experiences can be a good predictor of the future. But, when a program involves drastically new technology, such as the extensive use of composites for both primary and secondary structures, the confidence level decreases with the use of existing cost information that lacks relevant data.

Basing future costs on past experiences does not consider any improvement to the manufacturing processes used on older aircraft programs. This approach to costing corroborates the past as acceptable and uses the information to form a standard for future performance measurement. Old manufacturing processes, together with historical cost information, are extrapolated and adjusted for technology to form the basis for the new program. Because of the perceived acceptability of the past, production design decisions may not reflect the state-of-the-art production technology — new techniques are often believed to have a greater risk than older, proven processes.

In August 1984, Deputy Secretary of Defense William Taft IV directed the Under Secretary of Defense (Research and Engineering) (USD)(R&E) to lead a joint-Service review of contractor overhead costs. The objective of the study, in addition to identifying contractor cost-reduction incentives, was to improve government oversight of defense contractors. Mr. Taft established 10 principles to improving government oversight. One of the principles, Discrete Cost Analysis, stated that, "Pricing methods that place undue emphasis on historical costs must be avoided."[5] Similarly, J.T. Kammerer, Deputy Assistant Secretary of Defense (Cost and Audit) (July 1985) stated that cost-monitoring activities performed on a continuing basis might be a better approach in the long run than a full-scale should-cost over the relatively short period of a proposal review.

To satisfy the Defense Department's senior management's quest for an improved methodology to estimate and manage programs, the program office established an objective to develop an independent, in-depth cost "baseline" for the V-22. The monitoring program would have to be structured to enhance the ability to identify and challenge uneconomical and inefficient practices, to quantify those findings in terms of cost impact, and to establish a program for eliminating such practices in future follow-on production. By benchmarking a program used successfully by the Air Force on the Advanced Medium Range Air-to-Air Missile (AMRAAM) program, the V-22 program office identified an existing process that could meet its rigid criteria.[6]

Entitled "Recurring Manufacturing Cost Baseline" (RMCB), the program office implemented a system for evaluating and measuring efficiency in the manufacturing environment. The system was detailed sufficiently to satisfy regulation requirements and major milestone reviews, while at the same time adaptive to design changes. Although the intent of the program was stressing commonality in variant aircraft, changes due to Engineering Change Proposals (ECP), Value Engineering Change Proposals (VECP), and manufacturing initiatives were anticipated. The evaluation and measurement system would account for all design configurations.

The principal philosophy underlying RMCB is the development of a model that estimates cost, using work measurement techniques. An impor-

tant step in the process applies learning improvement at the part/assembly level rather than the program level, thereby yielding a more accurate estimate. The validity of this application can be substantiated and documented easily. When first documented, the learning effect was based on a reduction of labor hours. Soon after, costs were examined for many operations, and learning was evident. In analyzing this observation, it was discovered that different learning rates existed, and they were task-dependent. For example, a machine shop operation has a different learning rate than an assembly operation, even though both are from the same program. This is because the machine-dependent operation improves relatively little, since a machine does not learn through repetition while the assembly operation, which is labor-intensive, improves dramatically.

The RMCB is the ultimate cost-management tool to satisfy the DoD requirement for ensuring a reasonable price for aircraft. The RMCB avoids the potential pitfalls of using historical data, since it is not dependent on analogous systems cost. Rather than base estimates on parametric or CER data, RMCB calculates cost from a "bottoms-up" approach. Similar to zero-based budgeting, every manufacturing process and component is reviewed for efficiency and cost-effectiveness. New manufacturing techniques are simulated and analyzed to determine their effect on the bottom-line cost.

Numerous features to the RMCB program exist. Most importantly, it provides an independent review of the program and documents analyses in order to support conclusions. Alternative manufacturing processes are considered and their impact assessed. Because RMCB was being performed during full-scale development (FSD) (as opposed to a "should-cost" study that would be performed at the conclusion of FSD), it could influence the manufacturing plan and design before many of the investment decisions are made. Last, but not least, it provides a single repository for production cost data.

How Baselining Works

The RMCB program was established to develop a recurring cost baseline for production aircraft. This was to be accomplished by collecting data during the FSD phase, such as standard hours, processes, realization indices, etc., and using this data as a basis to project production costs. The RMCB was expected to develop and maintain an independent non-parametric estimate of recurring manufacturing cost, based on the determination and evaluation of: work to be performed, the effort required to perform it, and the frequency of occurrence.

The effort begins by identifying major assemblies of the aircraft — wing, center fuselage, forward fuselage, etc. — and continues to the lowest level of a work breakdown structure that identifies the major assembly. Figure 1 identifies the major assemblies and schedules for baselining. Production operations, labor standards, manufacturing support effort and cost, performance data, and indirect expenses are analyzed. Figure 2 provides the assembly baseline process. All work areas reviewed are documented and entered into a model that permits cost analysis trade-offs.

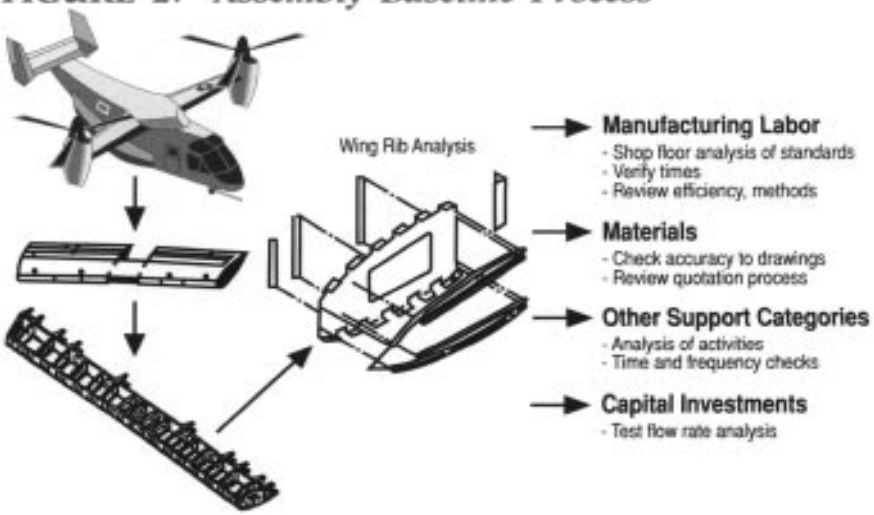
Work Areas

Direct labor, a significant cost driver, receives the most analysis. All conditions and activities associated with the manufacturing floor are reviewed. Plant layout, product flow, plant capacity and utilization, downtime, material handling systems, set-up requirements, work-in-process levels, and scrap and rework are the major areas to be analyzed. Fabrication, machining, assembly, inspection, and test labor categories are analyzed for standard hour content. Realization indices are developed for each labor standard. Other direct and indirect labor categories also are examined.

Material content is reviewed and validated. Purchasing practices are examined for commonality issues and sourcing considerations. Recommendations are made to improve the processes and supported with detailed documentation.

An estimating model is developed using estimates at the major assembly level. As the RMCB estimates become available, they replace the parametric or historically analogous estimates in the model. As the pro-

FIGURE 2. Assembly Baseline Process



gram progresses, and more information becomes known about manufacturing, revisions are made to the earlier RMCB contributions, and the process continues until all aircraft elements are baselined. The model can be used by program management doing "what-if" drills to see the immediate impact on cost of changes to programmatic issues, such as quantity changes or lot-size revisions. The model also would be able to simulate the effects of changes to tooling and manufacturing.

Results of the Program

The RMCB team directed the initial effort by concentrating on the wing assembly. This was consistent with the original plan, which identified all major subassemblies of the aircraft and proposed a phased approach to baselining each element. With a limited amount of data, but identifying every item on the indentured parts list, an estimate was developed for the wing assembly. The actual baseline estimates indicated a 28.4 percent increase over the derived estimate of the prime contracting team. This was consistent with the design-to-cost (DTC) estimate (not prepared by the RMCB team), which indicated a 23.7 percent increase over the DTC goal.

In addition to the cost-estimating capability, the RMCB task of identifying cost drivers and challenging uneconomical and inefficient practices also was successful. The RMCB team identified four specific areas involving manufacturing, assembly, dual sourcing, and fabrication that could possibly be improved. Lastly, the results satisfied the need for an independent review of the program estimates.

Shortly after the Wing study was finished, the RMCB effort was stopped, and the team disbanded.

In Retrospect

Benefits from an RMCB program could be tremendous to an acquisition program requiring production units. By independently evaluating every component, manufacturing process, and technique, the program office is assured that all alternatives are considered. Since the overall intent is efficiently built production units, the RMCB goal is aligned with the contractor's objective. After all, any increase in efficiency during production should have a positive effect on cost and, therefore, enhance the potential for greater sales in the future.

The basic premise that an independent team could be used to improve the acquisition process remains valid. However, the RMCB team experienced difficulties obtaining supportable baseline data during the FSD phase with which to make production estimates. This was largely attributable to the unknowns of manufacturing new technologies. Our experience in estimating production aircraft, using the RMCB approach, when manufacturing processes were not defined, did not yield higher confidence in estimates over other conventional estimating practices.

To use the RMCB technique successfully, the contracting authority needs to create a partnership with the prime contractor, assuring the manufacturer that the objective is to affirm efficiency and affordability in the manufacture of the aircraft. The RMCB could be viewed as negative by many contractors since it is extremely revealing in contractor practices. If the contractor sees RMCB as a tool used by the government to continually obtain cost reductions via renegotiations of the contract, then RMCB will not work. A shift in the cultural mind-set would be necessary to achieve real success with RMCB.

It is important to understand that "management by cost" is a tool to control a program. Interim results may not always be politically correct. If the cost analysis indicates an increase

FIGURE 3. Cost Performance Tool Comparison

Description	Cost Schedule Control System Criteria (CSCSC)	Recurring Manufacturing Cost Baseline (RMCB)	Should Cost (SC)
Basis for cost estimate	Contractor reporting cost information	Bottoms-up analysis, drawing based at the component level, bill of material	Cost estimating relationships
Time frame	Monthly/quarterly reports	Continuous	One-time effort
Level of detail	Negotiated on individual case basis.	Maximum	Minimum
Orientation	Uses historical information to predict final cost.	Uses work measurement to estimate.	Uses any data available over a short period of time.
Timing	Used during actual contract to estimate completion costs. Delay to set up and understand.	Used during FSD to estimate future costs of FSD and production. Updated continuously. Used during production for cost improvement. Delay to set up.	Prior to major milestone decisions and/or negotiations.
Team Skills	Accounting/audit	Industrial engineering	Multifunctional
Accommodation	Past information to indicate budget problems by exceeding cost thresholds.	Process to improve quality and efficiency in manufacturing. Can be used to establish Cost Performance Report (CPR) work unit budgets.	Snapshot analysis at an instant in time.
Noteworthy	Dependent on contractor's accounting and estimating systems.	Independent of contractor accounting system.	Dependent on openness of contractor. Similar to fact-finding.
Authority	DoD Instructions 7000.2 and 7000.10	MIL-STD 1567A	FAR 15.810[7]

in program costs, the program manager needs to consider alternatives, such as decreasing requirements or requesting an increase in budget from the decision authority. Stopping detailed cost analysis efforts or ignoring overrun reports will not correct the problem. Most likely, the problem will reappear shortly and be harder to manage. Dealing with the problem as early as possible in the acquisition cycle is best.

The concept of baselining is expensive, since it requires a team of experienced people to collect and process vast amounts of information. Additionally, RMCB is not intended to replace other tools, but rather supplement their benefit. Figure 3 compares several cost-performance tools. Using baselining when the production process cannot be defined adequately is not effective. It may be wise to wait until pilot production, when more information is known about tooling and assembly, before actively pursuing this detailed approach to cost management.

Endnotes

1. Ozanian, Michael K., "Performance Measurement - Chrysler," *Financial World*, 28 September 1993, p.53.
2. Department of Defense Instruction 5000.2, "Defense Acquisition Management Policies and Procedures," 23 February 1991, Part 11, Section A.
3. MIL-STD 1567A, "Work Measurement," 30 January 1987.
4. "DOD Should-Cost Program," Office of the Inspector General, Department of Defense, Audit Report No. 85-120, September 1985.
5. Baker, Ronald L., "Heads Up on Overhead," *Program Manager*, March-April 1985, p.24.
6. Ferguson, Major General Thomas R., Jr., "A Program Director's View of Cost," *The Air Force Comptroller*, July 1989, p.6.
7. FAR 15.810, "Should-Cost Analysis," 1990 Ed.

TAILORING AUTHORITY

In a 23 August 1994 memorandum to the Secretaries of the Military Departments and Directors of the Defense Agencies, the Honorable R. Noel Longuemare addressed the subject of "Tailoring Acquisition Procedures and Documentation for Acquisition Category (ACAT) II, III and IV Programs." Secretary Longuemare outlined several core issues that must be formally addressed at the appropriate milestone for every acquisition program. The issues bear repeating:

- Why is the program needed?
- Has the need been validated?
- What specific capabilities are necessary?
- When do the necessary capabilities need to be introduced to the field or fleet?
- How much will the program cost?
- Is the program affordable and fully funded?
- Have alternative solutions been reviewed, and why was this solution selected?
- How will the needed capability be developed and/or procured?
- Is the system/item producible?
- Can it be supported?
- How was design stability verified before entering low-rate initial production?
- How was the system determined to be operationally effective and suitable before entering full-rate production?

"It is important the Milestone Decision Authority (MDA) rigorously address these issues before making program decisions. The specific form or number of program documents should be determined by the MDA. As long as tailoring is consistent with any applicable statutory requirements, the MDA has full authority to reduce or eliminate any procedures or documents that he or she deems unnecessary."