COST AND TRAINING EFFECTIVENESS IMPACTS OF CONTRACTED C-130 AIRCREW TRAINING

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ABSTRACT

CAE-Link Corporation was awarded the contract in 1987 to develop and implement a ground-based training system for C-130 aircrew members. The Military Airlift Command and the Armstrong Laboratory recently sponsored an analysis, conducted by the Systems Research and Applications Corporation, to ascertain this new system's impacts on training costs and effectiveness. This paper analyzes the available cost and training effectiveness data generated by the old and new aircrew training systems, describes the cost-effectiveness analysis model developed for this project, and estimates the cost and effectiveness impacts of the new system. Outputs (training objectives, numbers of graduates, and proficiency levels of graduates) were found to be similar across the two systems. The ATS lowered total training costs given current student flows. However, the relative cost-effectiveness of the ATS and pre-ATS alterntives would be strongly affected by changes in the number of graduates produced.

ABOUT THE AUTHORS

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INTRODUCTION

The trend within Air Force training over the past decade has been toward viewing training programs as total integrated systems rather than as collections of courses or blocks of instruction. There has been a concurrent shift toward contracting out the design, development, delivery, and support of aircrew training. Although a number of contracted aircrew training systems have been fielded, there is little empirical information regarding their cost and training effectiveness impacts that could guide the design and specification of proposed new systems. The primary purpose of this paper is to examine the impacts of one new, contracted system-the C-130 Aircrew Training System (C-130 ATS). To support a comparison of the old and new systems, Systems Research and Applications Corporation developed a model for The Armstrong Laboratory and the Military Airlift Command (MAC) that applies cost-effectiveness analysis to training systems. The model is proving to be useful, not only to make the historical cost comparisons, but also as a management tool to help decision makers assess the likely cost impacts of future training system decisions. Moreover, this model provides a potential tool for assessing the impacts of changes at the level of training systems.

Background

C-130 aircrew training has recently undergone a number of significant changes as the formal school was converted from an in-house operation, designed and operated by MAC, into a joint Air Force and contractor operation designed by the contractor. The impetus for these changes came from the 1982 summer study conducted by the Air Force Scientific Advisory Board (SAB) Ad Hoc Committee on the Enhancement of Airlift in Force Projection. The SAB report stated that MAC aircrew training was often more inefficient and labor-intensive than it should be, in large part because modern training technologies had not been introduced. The SAB recommended (1) developing a model training program for C-130 aircrew training to use advanced training technologies effectively, and (2) assessing the impacts to guide training decisions for other weapon systems.

In response, MAC and the Armstrong Laboratory (then the Air Force Human Resources Laboratory) established a joint research program to develop and evaluate a model program for C-130 aircrews that encompassed all phases of training from initial qualification through continuation and special qualification training. The first step was to sponsor a training system design study. This effort was conducted for the Air Force by Seville Training Systems, and resulted in the Model Aircrew Training System

(MATS). Seville applied a number of concepts from modern learning theory in response to the importance of the cognitive component in aircrew training, and described how these concepts should be reflected in training system design, delivery, and evaluation (Fishburne, Spears, and Williams [1] and Fishburne, Williams, Chatt, and Spears [2]).

Concurrent with the MATS study, aircrew manpower shortages throughout the command encouraged MAC to pursue a contractor-supported training system to reduce the need for active duty, rated manpower to support training. In addition, a series of training-related C-130 aircraft accidents over a two-year period highlighted the need to restructure C-130 aircrew training as quickly as possible with a proven, positive fix.

MAC did not wait for ATS implementation to correct acknowledged shortcomings in training. Prior to C-130 ATS implementation, MAC had provided formal instructional systems development (ISD) training for in-house instructional development personnel. These people also participated in the MATS study and received the updated MATS tasks, objectives, and standards documents. In addition, MAC conducted student assessments throughout the formal school courses on both knowledge and performance. Training effectiveness was evaluated during formal school attendance and at the student's gaining unit. All results indicated that, by the late 1980s, gaining units were receiving high-quality graduates from the C-130 training program.

MAC planned for the ATS to take advantage of instructional strategies that used computer-based technology and an integrated management and support system for both continuation and formal school training. While a degradation of training would not have been acceptable, MAC did not foresee improved graduates from the new training system. Instead, MAC expected to reduce the dependence of formal school training on rated, active duty personnel, and expected to amortize the initial ATS investment through reduced manpower and flying time.

The C-130 Aircrew Training System

For this analysis, a training system is defined as the collection of resources and practices used to enable instruction of crewmembers for a weapon system, both Air Force and contractor, starting with initial qualification training and progressing through mission qualification training, continuation training, special qualifications, annual refresher training, and the instructor and flight evaluator schools. Prior to the C-130 ATS, all elements of the C-130 aircrew training system were owned and operated by MAC.

In 1987, Link Training Systems (now CAE-Link) was awarded the C-130 ATS contract. Existing training resources, including 10 C-130 Weapon System Trainers (WSTs), were provided as government-furnished equipment to be used as the contractor saw fit. Under this agreement, the contractor was responsible for designing an integrated training system that encompassed both contractor and Air Force activities across the entire spectrum of C-130 training for all crew positions, from initial entry into the C-130 weapon system through ongoing continuation training including upgrade and instructor training. The contractor was responsible for most ground-based activities such as courseware development and maintenance, training device maintenance, classroom and simulator instruction, record keeping and scheduling. The Air Force retained responsibility for accomplishing all inflight activities associated with instruction and checkrides. As part of their research support, CAE-Link collected and archived a substantial set of cost, resource consumption, student performance, and training system performance data to support a comparative study of the two systems.

The contract required CAE-Link to implement an ISD process to determine training requirements and develop objectives, criterion tests, and standards of evaluation. A detailed comparison of tasks, objectives, and standards from the old and new training systems revealed little functional difference between the goals of the two approaches to training, a result that was consistent with MAC's view that, by the late 1980's, C-130 formal school training was producing a graduate that met gaining unit needs.

On the other hand, some changes in the training process have occurred. In the old system, students went through academic, then simulator, and then inflight instruction with little or no overlap among these phases. The ATS has evolved into a two-phased sequence with the first being a more integrated flow of classroom instruction, computer-based training, and training device instruction followed (as before) by a non-overlapping flightline phase of training. In addition, the media mix has shifted toward lower-cost devices with a substantial increase in computer-based instruction accompanied by reduced flying in the aircraft.

METHODOLOGY AND PROCEDURES

Cost-Effectiveness Analysis Framework

A cost-effectiveness approach was chosen to assess the impacts of the C-130 ATS, holding constant both the quantity and quality of output from the Pre-ATS and ATS systems, where output is measured as graduates from the many C-130 training courses. By considering both the old and new training systems as two potentially different production processes for generating comparable aircrew graduates, it was possible to estimate the cost of a given rate of production over a specified time period--the economic life of the system--for each process. This analysis can be termed "forward looking." Although we used historical data to estimate key parameters of the two training systems, the purpose was not to compare the actual historical costs of the two systems, but to determine which of the two systems would produce and maintain mission-ready crews at the lower cost over the same future time horizon at the same output rates.

Note that a cost-effectiveness analysis (CEA) avoids the problems of an alternative approach, the cost-benefit study. In the latter, both benefits and costs of two alternatives must be put into the same terms-typically dollars-for direct comparison. Placing a dollar value on many benefits can be quite difficult, and often provokes considerable debate over the underlying assumptions. With a CEA framework, the authors avoided that problem by equating the output (graduates) of the two training systems, ignoring their individual or collective value. However assuming equal outputs from the two systems required the identification of valid indices of effectiveness and a search for reliable historical data with which to validate this assumption. If one system proved less effective than the other, resources such as simulator hours and number of instructors would have to be analytically adjusted to produce pre-ATS and ATS graduates that <u>should</u> perform at equal levels.

Understanding C-130 Training

To bring this CEA framework to life, a data collection team visited the C-130 formal school training operation at Little Rock AFB as well as the operational units at Little Rock, Pope, and Dyess AFBs. During these visits, they conducted interviews with instructors, training managers, resource managers for each of the four aircrew positions, line crews, CAE-Link employees, and most senior officers in the operational squadron chain of command. The objectives were to learn about the components of ATS, how it operates, how the new system differs from Pre-ATS training, and what effectiveness and cost measures might be relevant and where they existed. The team asked for assessments of graduate quality under ATS, and from those with considerable C-130 training experience, pre-ATS/ATS effectiveness comparisons.

What we learned from these interviews influenced most subsequent analytical tasks. One important finding was that the Air Force C-130 instructor force had collectively viewed pre-

ATS training as being reasonably good. This view shaped the final form of ATS courses, changing these courses from their initial designs that included substantial departures from traditional C-130 aircrew instruction to courses that look and operate more like their pre-ATS counterparts. Detailed course comparisons revealed that training time, training devices, and even the evaluation tools remain largely the same with ATS. There were no significant changes to the C-130 mission between the last years of Pre-ATS training (1986 - 1988) and the present time; therefore, no fundamental changes to formal school knowledge and skill requirements were introduced during the time frame of this study. Not surprisingly, a formal study matching the type and level of training objectives between courses from the two systems found almost no differences.

Although Link is a partner in C-130 aircrew training, it is important to remember that all flying training at the end of each course is conducted by Air Force instructors. These instructors determine whether trainees meet required proficiency standards and can graduate. Repeatedly those interviewed emphasized that proficiency standards had not changed over time, could not be varied for an individual, and that an instructor's only choice was to apply more training resources, within limits, to those who failed to meet the standards during the normal program. Thus, we concluded that the Air Force was attempting to perform an important function for this study: producing graduates from two training systems who are, in fact, equally effective on the job.

To confirm that graduates of the old and new systems were products of equally effective training, a search was conducted for valid aircrew performance measures, both for formal school students and for crewmembers completing training courses in their units. Fortunately, CAE-Link had maintained an archive of nearly 4,500 student training folders at Little Rock AFB covering both training periods. These folders contained both resource data (e.g., hours spent using training devices) and performance data (e.g., instructor ratings; checkride results) for formal school training courses. Training critique forms submitted by supervisors of new graduates, or management summaries of these critiques, were considered. Unfortunately, response rates from the field for these critiques were quite low-typically, 30-35%--and the critiques that were available were often cryptic and incomplete. As a result these forms were not useful for comparing the effectiveness of old and new systems.

There was little or no course performance data within the operational squadrons for either the Pre-ATS or ATS periods. This training is typically brief, somewhat informal, and scheduled on regular calendar cycles. Successful completion of training is often all that is recorded. More mission-oriented performance data, such as unit inspection ratings were considered, but finally rejected for our purposes because overall unit performance is affected by many factors, and the influence of Pre-ATS/ATS training could not be isolated from the effects of routine squadron training, the quality of unit leadership, budget impacts on the squadron flying hour program, and a host of other factors.

The search for relevant cost data was less problematic. While MAC does not keep detailed C-130 training cost reports for more than two years, those reports are less important than counting the actual resources associated with both systems: numbers of graduates, instructors, airplanes, flying hours, training days, overhead staff, types and numbers of training devices, etc. Management reports, student training folders, and interviews with experienced staff yielded these resource totals, and in many cases, the associated prices. In several cases, published Air Force cost factors were used to derive resource costs (e.g., cost of manpower, student temporary duty (TDY) costs, cost of a C-130 flying hour, etc.). In addition, the price paid by the government to CAE-Link to operate the ATS was obtained. This price has a large fixed component plus a component that varies by number of course graduates. Because Link's actual ATS costs are proprietary, the data incorporated into this study were limited to the contract prices.

With this information in hand, it was possible to formally identify and describe those functions, elements, and operations that comprise both training systems; that is, we circumscribed the systems to be analyzed. The systems are very large and complex. Both consist of some 43 courses taught to pilots, navigators, flight engineers, and loadmasters; and one course to teach maintenance technicians to run the engines. These courses use training devices, including 42 C-130 aircraft and 7 full-mission weapon system trainers (WSTs); Air Force instructors (plus CAE-Link instructors in ATS); and academic media, including computer-based training devices in ATS. Directly supporting these courses are logistics, maintenance, scheduling, and staff oversight functions. Indirectly supporting these courses at base level are billeting, security, and medical activities. So defined, the cost of C-130 training is approximately $167 million per year in 1992 dollars.

To understand how these courses and support systems come together as a training system, a framework for viewing the training process was developed (a simplified version is presented in Figure 1). This framework also guided the organization of cost data for comparative analysis. Formal school courses conducted at Little Rock AFB are divided into Initial Qualification and Mission Qualification phases. These titles are descriptive of course content, and most crewmembers move from the former to the latter in sequence during one temporary duty (TDY) period. The third phase-continuation training-consists of skill and knowledge refresher courses taken each year, one-time courses, and special upgrade courses such as instructor training for selected crewmembers. Most of these continuation training courses are taught in the operational squadrons, but instructor training is split between the unit and the formal school at Little Rock. Under ATS, both the Air Force and CAE-Link provide instructors for these career courses.

Parametric Modeling Approach

Modeling is the process by which the cost data were analyzed. Our cost modeling assumes that both the pre ATS and ATS programs produce graduates of equal effectiveness. The actual effectiveness adjustments required to suport this assumption are described later in the paper. The cost analysis called for mathematically linking all inputs to the training process (e.g., number of instructors) to output (trained graduates). These links are known as cost-estimating relationships (CERs), or cost functions, and their purpose is to take analyses beyond a comparison of historical data. CERs are "parametric" in the sense that they can be evaluated not only for different levels of output, but for different estimates of resource prices as well as changes to other input parameters such as instructor-to-student ratios.

CREW	TRAINING PHASE		
	Initial Qualification (# courses)	Mission Qualification (# courses)	Continuation Training (# courses)
Pilot	2	3	9
Navigator	1	1	9
Flight Engineer	1	1	8
Loadmaster	1	1	6

Figure 1. C-130 Training Courses Organized by Crew Position and Phase of Training.

This parametric approach comes at the expense of simplicity. Instead of aggregating historical costs into categories, training costs had to be mathematically modeled at the lowest level possible-major costs categories for each course, crew position, and phase of training in Figure 1. However, the parametric approach produced three significant advantages:

- **Output Adjustments**. The CEA approach demands constant output between Pre-ATS and ATS systems. If the training process were not explicitly modeled, these adjustments would likely have been *ad hoc*.

- **Sensitivity Analysis**. The effects of key assumptions, of estimates for variables and parameters, and of some methods of estimating costs can be tested relatively easily. Sensitivity analyses allowed us to focus more on assumptions that make a difference; to learn under what set of input conditions the ATS might be more or less cost-effective.

- **Course-Level Comparisons**. Total costs of the two training systems were built from the bottom up, starting at the course level. This approach made it possible to compare costs at the course level, which would have been much more difficult if an aggregated approach had been taken.

CERs can be specified only after gaining a thorough understanding of how the training system actually operates. By their nature, CERs are precise, but without access to training experts for clarification and validation, they can be precisely wrong. We were fortunate to enjoy continuous access to such experts.

Cost-Effectiveness Analysis

Effectiveness Data and Adjustments. Formal school student training folders provided one source of effectiveness data. Prior to this study, CAE-Link had conducted extensive research on the instructor ratings of task performance that were entered in these folders, attempting to discover the combination of ratings that would discriminate overall levels of student performance. Our review concluded that these ratings were not diagnostic; they could not reliably discriminate graduate performance beyond elemental task levels. Ultimately, we selected the "final exam" measures in the folders as our indices of effectiveness: checkride ratings given on a final evaluation flight and end-of-course written examinations[1].

Because checkrides are given annually to all crewmembers, they are a standard, accepted, relevant method of evaluation. Further, the content of the checkride evaluation has changed little for each crew position since the Pre-ATS period, and the rating scale used to assess checkride performance has remained nearly constant. When asked how they would assess crewmember effectiveness, those interviewed always recommended checkrides. However, these measures have real limitations. By no means are they comprehensive. Instructors have only four or five hours in flight to evaluate performance, so they focus on critical tasks. Further, C-130 instructors must train students to satisfy known performance criteria. When an instructor judges that the student can meet the criteria, the student is scheduled for a checkride. If the student is not yet capable of passing the checkride, he is given more training. Thus, the distribution of ratings is heavily skewed toward the top evaluation, a Q1 rating.

In other circumstances, these limitations might have stimulated the search for additional measures. However, various data sources were painting a consistent picture of little change in effectiveness between the old and new training systems. Given that the MAC intent for the ATS was not to produce graduates with greater skills and knowledge, that a detailed comparison of old and new system training objectives revealed only a few, limited differences, and that so many Air Force members who had taught or managed training in both Pre-ATS and ATS programs provided consistent views of the comparability of graduates, we chose to combine the findings from these data sources in a qualitative, weightof-the-evidence approach to determine whether graduates from both programs performed equally well.

To determine if the distribution of checkride ratings for each course changed from Pre-ATS to ATS, we used a Chi-square test of independence for each pair of courses. Only one course-Loadmaster Mission Qualification (LMQ)-is associated with a statistically significant difference in checkride ratings (9% more Q1 ratings under ATS). For LMQ, the new ATS is producing graduates who, as a group, are performing better at the end of training than their predecessors. For the remaining courses, the checkride data indicate that the new ATS is producing formal school graduates with capabilities equivalent to their Pre-ATS counterparts.

During interviews in the six operational squadrons, we asked Air Force members to compare the initial in-unit performance of new ATS graduates with their Pre-ATS predecessors. All agreed that the performance of new pilots, navigators, and flight engineers had not changed with ATS. Members from four of the squadrons stated that new ATS loadmasters were not as capable as Pre-ATS loadmasters, many taking excessive time to be certified for solo duty on the airplane. Notice that these ATS loadmasters are the same group whose formal school checkride ratings were better than Pre-ATS loadmasters. Subsequent interviews determined that a greater proportion of first-term airmen are entering loadmaster training today than was true during the Pre-ATS period. These airmen do very well in a structured training environment where feedback and evaluation occur daily. However, they perform less well when they must operate from technical documents as opposed to training materials, when training events occur less frequently, and when performance feedback may be less frequent and more general.

Adjustments to Equate Pre-ATS and ATS Effectiveness. Based upon the checkride and interview data, we concluded that the primary resource adjustment required to equate program effectiveness would be to add 12 days of flight training to ATS formal school loadmaster training. This figure was derived from unit interviews revealing that new ATS loadmasters require an additional 60 hours of ground and flight training beyond normal standards to be certified. Because pilot training requirements drive the flying schedule, flights are available to accommodate this extra training. Instructor and student costs are the only elements that would have to increase with this adjustment.

Another adjustment was the addition of instructor, student, and training device costs to Pre-ATS for the Engine Maintenance Run course. Although not central to this CEA study, this course is covered under the ATS contract, and those interviewed strongly believed that graduates are much better trained under ATS.

Other adjustments were made to the two systems to ensure a fair cost comparison, but these adjustments were not related to the introduction of ATS nor differences in graduate performance. For example, during the Pre-ATS time frame a C-130 squadron, along with a WST and associated career training, were located at Clark Air Base, which has since shut down. To ensure the change in travel requirements did not register a false savings for ATS, travel requirements were computed for the Pre-ATS system under the current alignment of squadrons. A second example is a flying hour cut, directed by CINCMAC during the ATS period, that was motivated solely by budget imperatives. We learned that C-130 trainers incorporated the reduction with actions unrelated to ATS, and would have taken the same actions under Pre-ATS. To make the final cost comparison fair, the Pre-ATS flying hours were reduced by the ATS reduction amount.

Structure of the CEA Model. With the adjustments identified and quantified, cost-estimating relationships were refined and a CEA model was developed using commercial spreadsheet software. Dozens of CERs, requiring an elaborate notation system and detailed documentation, were eventually specified. By way of example, the CER that specifies the hourly usage of a training device, *TD*, that can be directly attributed to each course is:

$$SoloHrs^{TD}(t) = \text{roundup}[\frac{S(t)}{Seat^{TD}}] \times Solo\beta^{TD}$$

Loosely translated, this CER indicates that device usage is a function of the number of students entering a course in year *t* moderated by theaverage per-student solo usage of this training device. Such CERs were required for all price and resource inputs that are tied to changes in the number of system graduates.

These CERs were mapped into a structured spreadsheet model, written in Lotus 1-2-3 (also available in Quattro Pro) that incorporates the training framework depicted in Figure 1. Forty-one linked spreadsheets organized into five levels of files were required to model this large, complex training system. The files are ordered from the bottom up: Level 1 files contain specific price and input information that affects all the cost analyses; Level 5 contains the final costs of training displayed by cost categories. Figure 2 presents our CEA model structure.

LEVEL	CONTENTS	PURPOSE
1	a) Resource prices and economic assumptions b) Number and type of students in each course	a) Views/changes input prices and resource quantities for personnel, training devices, travel, and Link variable contract prices; changes economic assumptions b) Computes the flow of students through sequential courses based on manpower requirements and attrition
2	Course-specific costs for Pre-ATS and ATS	Sets course parameters such as instructor-student ratio, training length, and device usage; conducts side-by-side comparisons for those costs that can be allocated to the course level
3	Phase-specific costs for Pre-ATS and ATS	Identifies supplemental (auxiliary) crew staffing; aggregates costs that cannot be allocated to one course within the same phase
4	a) Unallocated capital costs b) Unallocated base operating support (BOS) costs	a) Totals the usage and cost of shared training devices across all relevant courses and phases; computes the necessary number of devices given student flow; replaces devices whose economic life has expired b) Captures remaining unallocated costs including manpower devoted to aircraft maintenance, security, and BOS functions; contains certain operational costs such as fixed Link contract cost and ATS development costs
5	Total system costs for Pre-ATS and ATS	Totals annual expenditures in major cost categories and by courses and phases; discounts cost streams to determine present values

Figure 2. **Structure of C-130 CEA Spreadsheet Model**

RESULTS AND DISCUSSION

Is ATS cost-effective?

Our analysis indicates that the ATS is cost-effective relative to pre-ATS training in its current configuration given current contract prices and historical levels of student throughput in all the courses. The steady-state operational cost of approximately $167 million per year for combined Air Force and contractor training with the ATS is some $5.4 million less than the pre-ATS cost for the same number of graduates. Assuming a constant student flow, this $5.4 million savings (constant 1992 dollars) will hold until some of the major capital equipment must be replaced, at which time the difference will increase. From the start year of these calculations (1991) until the capital equipment is replaced (approximately 2010) the annual ATS savings will remain about 3.2% of this overall operational cost. The cost of the contract is offset largely by savings in Air Force instructor costs (approximately $16 million per year, or 41% lower than pre-ATS). In addition, ATS flying hour costs are 4% lower (more than $2 million less) and student manpower costs are reduced by 3.5% (approximately $650,000 less) per year.

The C-130 ATS did not begin operation as a mature system. Costs were incurred to award the contract, develop courseware, phase in and evaluate the new courses, purchase new academic media, take over logistics and maintenance support, build a training management system, and staff an organization to manage and support the whole operation. These costs totaled some $14 million. Incorporating these start-up costs in the Pre-ATS vs. ATS comparison, a real discount rate of 10% was imposed to determine when and how much return on investment ATS would provide the Air Force. *The CEA model indicates ATS will recoup its investment costs by the end of the 1994. After 10 years of operation the net savings, discounted back to 1991, will reach some $19.8 million.*

The choice of a discount rate is one factor that can easily be varied in the CEA model. Although the Office of Management and Budget recommends 10% real as a discount rate, some research evidence suggests this rate is too high. The starkest alternative is to examine the expected ATS profit with a discount rate set to zero, which indicates that individuals are indifferent between receiving money today and receiving the same amount in the future. As a result, any future cost savings are not dampened by discounting. Hence, a real discount rate of zero will yield the maximum possible estimate of net savings. Under this scenario ATS would be in the black by the end of 1993. After 10 years of operation, the cumulative ATS savings would reach $39 million.

An interesting follow-on question asks whether the ATS would be cost-effective with different levels of student throughput. To answer this, we calculated ATS savings under the assumptions of a 50% reduction, a 25% reduction, and a 25% increase in the required number of active duty Air Force crew members from the baseline personnel inventory. Other categories of students, such as Guard and Reserve, were assumed to remain constant; the total variations in student flow to support the changed active duty inventory were -38%, -19%, and +19%. The changes in student flow were presumed to hold over the entire 10 year period.

At sharply reduced student flow rates, the Pre-ATS system would have been more cost effective, but as student flows increase, the ATS becomes more cost effective. Our analysis indicated that, with a 50% lower active duty personnel inventory, the ATS, as implemented, would have *increased* overall training costs over 10 years relative to the pre-ATS system. With a 25% lower active duty inventory, training costs under this ATS would have been similar to pre-ATS training costs. With a 25% increase in active duty personnel inventory, cost savings from the ATS would triple relative to savings given the baseline student flow.

This relationship between student flow and the costs of the two systems is based largely on two characteristics of the ATS and pre-ATS cost structures. First, the ATS contract has higher fixed costs and lower marginal costs than the comparable parts of the Pre-ATS system. These fixed costs are incurred independent of the level of student input, overwhelming the savings on Air Force personnel at low levels of student flow. Second, the pre-ATS system was more flying-hour intensive, so training to support a 25% increase in the active duty personnel inventory would require more C-130s, driving relative costs of the pre-ATS system up sharply.

Further Uses of this Model

The efficiency of alternative training approaches. Over the past decade, MAC transformed all of its aircrew training from strictly in-house programs to a mix of Air Force and civilian contractor trainers. In each of these new ATSs, civilian contractors provide the academic and simulator training while the Air Force continues to provide in-flight training and final qualification testing.

The shift from all-Air Force systems to mixed systems provided opportunities to rethink the most efficient use of training media and other resources. For example, some training moved from aircraft to simulators. The shifts also provided opportunities to integrate computer-aided instruction and other new training technologies into aircrew training systems. Efficiency was only one reason for shifting from all-Air Force aircrew training systems to contractor-supported ATSs; the change has also helped deal with cuts in manning authorizations. In this case study, the new C-130 ATS provided more "bang-for-the-buck".

The cost advantage for the C-130 ATS could provide valuable information for decision makers in other commands and services that are facing declining budgets and personnel levels. They might consider contractor support and modernized training media as options for the future. The cost-effectiveness model was designed to enable relatively easy tailoring of parameters to allow application to other systems.

Cost-effectiveness analysis as a tool for training system evaluators and researchers. Trainers and training researchers have historically focused on micro-level issues such as assessing the efficiency of individual lessons or a new medium in a particular course. Recently, some training evaluators and researchers have begun to adopt a system-level viewpoint. These researchers might view all training associated with a particular weapon system (formal school and continuation training) as a single system. Such training systems employ a mix of courses and training media, and they produce groups of individuals with different sets and levels of competences. Evaluating improvements at each level clearly requires different metrics and methods. From a system perspective, the impacts of small changes are often simply in the noise level.

One goal of this study was to assess the applicability of cost-effectiveness analysis as a tool for evaluating system-level manipulations in training. Cost-effectiveness analysis has long provided a context for studying ex ante alternative policies or system configurations. Traditionally, analysts have used cost-effectiveness analysis to find out which alternatives would meet policy makers goals most efficiently. This study used cost-effectiveness analysis in a new way: to demonstrate that it provides a useful method for evaluating ex post system-level changes in training.

Demonstrating this new way of doing training evaluation forced the authors to overcome unexpected problems and develop new software. The lessons learned in overcoming the problems may ease the way for other evaluators and researchers, and the software should provide tools that others can use and improve.

ENDNOTE

[1]Because the content of these exams changed over time, and because the real emphasis in C-130 training is demonstrated performance in the airplane, these exam scores are only a rough indication of changes in effectiveness from Pre-ATS to ATS. In fact, we found no statistical differences in course scores between the two periods.

REFERENCES

[1] Fishburne, R., Williams, K, Chatt, J. and Spears, W. (1986). Design specification development for the C-130 Model Aircrew Training System: Phase I report (AFHRL-TR-86-44). Williams AFB, AZ: Operations Training Division, Air Force Human Resources Laboratory.

[2] Fishburne, R., Spears, W., and Williams, K. (1987). Design specification for the C-130 Model Aircrew Training System: Final report (AFHRL-TR-86-51). Williams AFB, AZ: Operations Training Division, Air Force Human Resources Laboratory.