PERFORMANCE SPECIFICATIONS FOR FLIGHT SIMULATOR PROCUREMENT CONTRACTING

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ABSTRACT

Contracting for flight simulators has some unique problems and opportunities. Because the flight simulator design must lag the design of the aircraft, scheduling flight simulator production to coincide with the initial aircraft production is very difficult. At the same time, the government's sophstication in training effectiveness and reliability measurement offers an opportunity to greatly increase the responsiveness of industry by allowing industry a greater role in program definition. This would be achieved by shifting the standard of contract compliance from hardware specifications to performance specifications.

PROBLEM

Requirements

Before a contract can be let, a good hardware procurement requires that you:

a. Define the goals of the procurement.

b. Define the hardware choices which will satisfy those goals.

c. Determine which hardware choice is most cost effective.

d. Write specifications defining the detailed requirements of the hardware choice selected.

The government is well qualified to perform the first step; i.e., define the goals of the procurement. Industry is technically best qualified to perform the remaining steps, but cannot do so because of an obvious conflict of interest. You cannot allow industry to sign its own government paycheck. As long as the contract is based upon step "d", industry cannot participate in any of these four steps.

Physical vs Performance Specifications

There is only one logical basis for contracting other than contracting to physical specifications, and that is contracting to performance specifications. In either case, compliance with specifications must be assured by the government. Assuring compliance with performance specifications is more difficult than assuring compliance with physical specifications, but performance specifications offer the following advantages as compared to physical specifications:

a. Industry is responsible for steps b, c, and d above. That is, industry is responsible for defining which hardware choices will satisfy the goals, determining which hardware choice is most cost effective and writing the physical specifications of the hardware.

b. Because of the above advantage, the most recent state-of-the-art can be incorporated relatively late in engineering development.

c. Because industry is fully responsible for the engineering development, the duration of the development program can be greatly decreased.

Critical Requirements

There are two critical requirements for successful performance contracting:

a. The performance standard(s) must be quantifiable, objective, measurable, and unequivocable.

b. The payment to the contract must be related to the satisfaction of the performance requirement in a reasonable and systematic manner.

FLIGHT SIMULATORS AS TEST BED

Performance Parameters

Flight simulators offer an ideal opportunity for performance contracting because the performance standards have already been quantified in the forms of a training effectiveness ratio and reliability. Experts disagree as to the relative importance of various tasks in defining an overall training effectiveness ratio for all of the training tasks. Nonetheless, a formula for developing an overall training effectiveness ratio can be written and can be used for performance contracting. Once written and agreed upon, the formula would become an objective standard.

TRAINING EFFECTIVENESS RATIO (TER)

$$TER = \frac{\text{TRAINING TIME TO PERFORMANCE CRITERION IN AIRCRAFT ALONE}}{\text{TRAINING TIME IN AIRCRAFT + TRAINING TIME IN SIMULATOR}}$$

FOR EXAMPLE:

$$TER = \frac{\text{100 HOURS IN AIRCRAFT ALONE}}{\text{50 HOURS IN AIRCRAFT + 100 HOURS IN SIMULATOR}} = .67$$

The Training Effectiveness Ratio (TER) is equal to the time to train in the aircraft alone divided by the sum of the aircraft and simulator training times when used together. When the simulator is a perfect substitute for the aircraft, the TER has a value of one.

The weakest element in the proposal for performance contracting of flight simulators is the actual measurement of student performance in the aircraft. This is an essential element in the TER, yet its measurement has been unrealiable in the past. The present technique, used in the operational tests of flight simulators, requires

that the instructor pilot and check pilot judge the performance of the students. The use of a subjective standard in a test which would determine a monetary payment to a contractor would invite litigation. An objective standard of performance in the aircraft would be required. This requires the placement of sophisticated test instrumentation in an aircraft. Suitable aircraft test instrumentation is available.

Performance Specifications

The specifications for performance contracting must include:

a. The formula by which the overall training effectiveness ratio will be computed.

b. The Reliability, Availability and Maintainability (RAM) requirements.

c. The test plan which would be followed in developing the RAM data and in deriving the training data from which the training effectiveness ratio would be computed.

d. A weighted formula for assigning a nominal fee for achieving contractual TER and RAM minimums plus a scale of awards and penalties for exceeding or failing to meet the standards.

Training Effectiveness Ratio Example

An example as to how an overall training effectiveness ratio could be computed is depicted below:

EXAMPLE OF OVERALL TER FORMULA

COMPONENT COMPUTATION			COMPARATIVE IMPORTANCE WEIGHTING (W)
COMPONENT A:	VOR APPROACHES	$TER_A \geq .75$	$W_A = .30$
COMPONENT B:	NDB APPROACHES	$TER_B \geq .80$	$W_B = .20$
COMPONENT C:	HEADING, ALTITUDE AND AIRSPEED MAINTENANCE	$TER_C \geq .85$	$W_C = .50$
		SUM =	1.00

OVERALL TER COMPUTATION

$TER = W_A \cdot TER_A + W_B \cdot TER_B + W_C \cdot TER_C$

OVERALL TER $\geq (.30)(.75) + (.20)(.80) + (.50)(.85) \geq$ **.81**

The essentials are very simple:

a. Identify the skills which you want the simulator to train.

b. Using a delphi or similar process, agree upon the comparative importance weighting for each skill.

c. Determine training effectiveness ratios for each skill you want the simulator to train.

d. Multiply each training effectiveness ratio by its comparative importance weight and add.

Hardware Performance Example

In addition to the training effectiveness, three hardware performance specifications should also be considered which deal with RAM; i.e., with reliability, availability and maintainability. These two elements answer the questions:

a. Is the equipment reliability such that the equipment is adequately available for training.

b. Is the cost of maintenance within an acceptable range.

c. Is the cost of operation within an acceptable range.

EXAMPLE RAM/OPERATING CRITERIA

$$\text{OPERATIONAL AVAILABILITY } (A_O) = \frac{\text{TOTAL TIME - DOWN TIME}}{\text{TOTAL TIME}} \geq .95$$

MEAN MAINTENANCE COST PER MONTH (MMC/M) $\leq$ $3000.00 PER UNIT

MEAN OPERATING COST PER MONTH (MOC/M) $\leq$ $10,000.00 PER UNIT

The three parameters which address these three questions are operational availability, mean maintenance cost per month and mean operating cost per month.

Combining Into Incentive Contract

Finally, there must be a systematic way of combining all of these factors into an incentive awards contract.

EXAMPLE OF CONTRACT INCENTIVE AWARDS FORMULA

P = BASE PRICE PER UNIT FOR EXACTLY MEETING THE CONTRACT
T = TRAINING INCENTIVE (PLUS OR MINUS)
R = RELIABILITY INCENTIVE (PLUS OR MINUS)
C = MAINTENANCE COST INCENTIVE (PLUS OR MINUS)
O = OPERATING COST INCENTIVE
F = FINAL PRICE

$F = P + T + R + C + O$

T = .02P (NUMBER OF HUNDREDTHS OF EXCESS (+) OR SHORTFALL (-)) ON TER
R = .03P (NUMBER OF HUNDREDTHS OF EXCESS (+) OR SHORTFALL (-)) ON A_O
C = .01P (NUMBER OF HUNDREDS OF DOLLARS BELOW (+) OR ABOVE (-)) ON MMC/M PER UNIT
O = .02P (NUMBER OF HUNDREDS OF DOLLARS BELOW (+) OR ABOVE (-) ON MOC/M PER UNIT

The numbers used above are examples only. The training, reliability, maintenance cost and operating cost incentives must be weighted both according to their relative importance and according to the units chosen to measure them. If one of the four factors is weighted very heavily as compared to the others, the contractor will naturally concentrate his efforts on that one factor to the detriment of the other three.

Other Regulatory and Engineering Requirements

There are a number of hardware requirements which are handled best in an absolute fashion rather than as an incentive sliding scale. These include safety, human factors and regulatory engineering design requirements.

Pitfalls

There are five pitfalls which must be avoided in performance contracting. First, care must be taken that the weightings applied to the standards for the training effectiveness ratio, the operational availability, the mean maintenance cost per month and the mean operating cost per month are balanced, thereby encouraging the pursuit of all four standards. Second, the potential range of the awards and penalties should be sufficient to encourage the serious contractor while eliminating all possibility of profit for any contractor who would abuse the system. For example, the penalty for falling substantially below the standard for the training effectiveness ratio in extreme cases should be sufficient to completely eliminate the government's financial obligation to the contractor. This might require the use of additional penalties if the training effectiveness ratio falls more than a specified amount below the standard. Third, the test aircraft must be instrumented sufficiently to provide objective measures of student performance. Fourth, contract modifications must be treated as add-on contracts with their own performance criteria. Performance contracts are not very amenable to change. Fifth, since the possibility of a contractual penalty exists, partial payments to the contractor during the development and initial production phase should be minimized and should never exceed the financial ability of the contractor to repay.

Government Expertise

In contracting to engineering specifications, the government is required to maintain a sophisticated in-house engineering capability for the purpose of designing and verifying hardware specifications. In performance specifications, the area of required government expertise shifts to testing. The basic testing design which establishes the performance levels for incentive awards must be included in the contract. The general test parameters which must be included in a performance contract are:

TEST ELEMENTS WHICH MUST BE INCLUDED
IN SPECIFICATIONS FOR
PERFORMANCE CONTRACTING

1. ORGANIZATION WHICH WILL BE RESPONSIBLE FOR TEST.
2. PLACE WHERE TESTING WILL BE CONDUCTED.
3. NUMBER OF SUBJECTS TO BE USED AND THEIR GENERAL SOURCE, E.G., STUDENT PILOTS.
4. NUMBER OF HOURS AND/OR REPETITIONS TO BE USED IN ESTABLISHING RAM AND MAINTENANCE COST PERFORMANCE.
5. THE TRAINING TASKS TO BE USED AND THE CRITERIA BY WHICH TRAINING EFFECTIVENESS RATIOS WILL BE CONDUCTED.
6. THE NUMBER OF TRAINING HOURS OR REPETITIONS TO BE USED IN COMPUTING TRAINING EFFECTIVENESS RATIOS.
7. THE INSTRUMENTATION AND METHOD OF CRITERION MEASUREMENT TO BE USED IN BOTH THE AIRCRAFT AND THE SIMULATOR.

SUMMARY

In summary, performance contracting of flight simulators requires that the government define the performance requirements logically, mathematically and reliably. The government must then formulate all of this into a contract package in which there is a reasonable expectation that the contractor can meet or exceed the performance specifications and in which exceeding or failing to meet the performance specifications is awarded appropriately.

These awards and penalties should be sufficient to encourage the serious contractor and to remove all profit potential from a contractor who might be tempted to abuse the freedom which such a system provides him. Properly applied, this approach should increase the pace of technological development, while decreasing both development time and cost.

STEPS IN PERFORMANCE CONTRACTING

- DEFINE TRAINING EFFECTIVENESS STANDARDS
- DEFINE RAM STANDARDS
- DEFINE MAINTENANCE COST STANDARD
- DELINEATE ABSOLUTE STANDARDS
- DEVELOP INCENTIVE AWARDS FORMULA
- DEFINE TESTING PROGRAM WHICH WILL ESTABLISH VALUES FOR AWARDS
- INCORPORATE ALL OF THE ABOVE IN A REQUEST FOR PROPOSAL (RFP)
- ACCEPT BIDS ON THE BASE PRICE

ABOUT THE AUTHOR

Dr. James W. Dees is the Technical Advisor of the New Systems Training and Simulator Acquisition Division at the U.S. Army Aviation Center. Prior to this, he was a methodology officer for the U.S. Army Aviation Board; a Senior Scientist for the Human Resources Research Organization (HumRRO); a *Senior Engineering Psychologist for the McDonnell* Aircraft Corporation (now McDonnell-Douglas). While at McDonnell, he was responsible for a significant portion of the human factors for the

Gemini Spacecraft, including basic research on human vision in space and the engineering simulation responsible for the design of the Gemini attitude and translational control systems. While at HumRRO, he was responsible for the "Marksman" studies which resulted in the redesign of Army rifle marksmanship training. At the Army Aviation Board, he was responsible for the methodology on a number of operational tests. As Technical Advisor for the New Systems Training and Simulator Acquisition Division, he is concerned primarily with the testing and management associated with simulator acquisition. He is the inventor of the motion picture mirror stereoscope which he used for laboratory investigations of distance estimation in space. He is the author of 40 publications and presentations.