AVAILABILITY GUARANTEES

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ABSTRACT

A new appraoch to logistics support has been introduced to the development of training devices, in general, and to flight simulators specifically. The availability guarantee is now appearing in Requests for Proposals for flight simulators. Although the Government may have a primary objective to obtain a high degreee of service from training devices, it has also imposed the full spectrum of logistics considerations upon the contractor. Logistics considerations must become an integral part of the design, if a contractor is going to meet the availability requirements. This must be a consideration of design to insure a supportable trainer. This paper reviews the status of current attempts to impose availability guarantees upon flight simulator contracts, and discusses the pros and cons of this approach from the Government and contractor positions. The paper also discusses penalties applied to non-performance, and types of contracts under which these are most applicable. It addresses the current requirements for the basic "ilities" of the classical support approach, and the advisability of continued use of them. These requirements include, but are not limited to: Reliability Programs and Demonstrations, Maintainability Programs and Demonstrations, Supply Support, Support Equipment, Technical Documentation Standards, and Training. The paper evaluates each of the classical elements of support under various support concepts where an availability guarantee is imposed by contract, and offers recommendations on the level of surveillance required for each.

INTRODUCTION

The availability guarantee is a relatively new approach by the Government to achieve a supportable training device with the risk being assumed by the contractor. This approach is being applied to both the acquisition and support phases of the life cycle. The acquisition phase imposes a requirement on the developing contractor to demonstrate that the trainer can achieve a given level of availability. In the support phase, a contractor must maintain a trainer at the guaranteed level of availability. In both phases of the life cycle, penalties are imposed for failure to meet the availability objective. The authors believe that these are reasonable goals, and that they can be achieved. However, the Government has the responsibility to tailor the application of availability guarantees in both the acquisition and support phases, e.g., to the desired maintenance concept.

AVAILABILITY MEASUREMENTS

As we have noted in the introductory paragraph, availability guarantees are being applied to both the acquisition and support of trainers. The three most commonly used measures of availability are: inherent, achieved, and operational. An availability guarantee, applied to the acquisition process, must use either an inherent or an achieved availability as a benchmark. An operational availability should only be applied to a maintenance support contract, and then only if the trainer being supported has demonstrated an achieved availability equal to or greater than the specified operational availability. The developing contractor has no influence upon the support system or the operational environment after he has delivered the trainer. The exception, of course, is when the developing contractor also has a follow-on support role. In this case, however, he is in the role of a support contractor and must perform to support the availability goal.

The definition of inherent availability is the ratio operating time to operating time plus mean corrective maintenance time. This is expressed by the equation:

$$A(i) = \frac{MTBF}{MTBF+MTTR}$$

Where:
$A(i)$ is the inherent availability;
MTBF is the mean time between failures;
MTTR is the mean time to repair.

This expression defines the availability as designed into the trainer. Achieved availability adds the preventative maintenanace factor to the equation. Operational availability, however, considers all maintenance actions and all down time under operational conditions. It is expressed as:

$$A(o) = \frac{MTBMA}{MTBMA+MDT}$$

Where:
$A(o)$ is operational availability;
MTBMA is the mean time between maintenance actions;
MDT is the mean down time.

Thus, it is imperative that the Government define precisely what is meant by availability, and how it is to be applied. Many of the measurements that we have seen, are in reality a mission reliability, that is the probability that a trainer will successfully complete a given percentage of the missions without failure. The only aspect of availability is the maintenance turn-around time between missions or corrective maintenance time for a failure. Otherwise, the Government is asking for a reliability guarantee that, depending upon mission length, may be beyond the state of the art. A guarantee, so stated, ignores the other logistics aspects of supportability.

ELEMENTS OF AVAILABILITY

Maintenance is the driver in all the elements of supportability. The level of supportability is truly the key to reaching an acceptable availability. The foremost element of availability is reliability, as measured by the failure rate or mean time between failures (MTBF). The fewer failures in a system, the less the other elements come into play. The other factor of availability is maintainability, which is the down time, or mean time to repair (MTTR). The repair action brings into play the other aspects of supportability - fault isolation, documentation, training, support equipment, and spare parts.

The MTBF of a trainer is primarily a function of design, but the quality of maintenance does tend to degrade the inherent quality designed into the device. In addition to preventative maintenance, poor repairs will cause repeat failures, thus creating a higher failure rate. From an availability standpoint, the down time is greatly impacted by those logistics elements that are not part of the inherent availability calculation. As one can well imagine, an incompetent repairman may never find the cause of a failure and thus, cannot fix it. On the other hand, even the very best technician can't fix a failed item if he does not have the spare piece part or spare assembly required to accomplish the repair action. Todays training devices are so complex that they must be well documented. Even the most skilled technician cannot be expected to know all that there is to know about any one of them. Thus, complete and concise technical documentation is important to the repair process. This complexity is a driver in the requirement for an adequate complement of test equipment. This requirement may be for both manual and automatic test equipment (A T E). At this point, it should be clear that mean down time is comprised, not only of corrective and preventative maintenance actions, but also includes supply lag time - the time required to transport a part from supply to the trainer. If all logistics considerations are not adequately addressed, the actual repair action becomes a small portion of the total down time of a system.

AVAILABILITY GUARANTEE APPLICATIONS

The maintenance concept must be considered in the application of availability guarantees in both the acquisition and support of trainers. Here, we are not addressing the various maintenance levels, but the level of customer involvement in the support of the trainer. Many questions concerning the maintenance concept must be answered. Some of which are:

Will the device be maintained by uniformed personnel, by civilian Government employees or by contractor personnel?

Will the Government provide supply support in any form and if so, specifically what?

Will the Government provide off-equipment maintenance support?

Will the Government provide support for test equipment?

Will the Government provide an initial support package, consisting of spares and test equipment?

How much time is planned for daily maintenance (scheduled down time)?

The answers to these questions will have a definite impact upon the ability of a contractor to support a trainer at a given level of availability. Several support factors may change with the maintenance concept. These include the following:

Repair - Discard decisions;
Test Equipment requirements;
Documentation Standards;
Spares requirements;
Training requirements;
Overhaul requirements.

Any change to any of these factors will be reflected in the maintenance documentation. Training considerations will also be changed or eliminated. Thus, a tailored availability guarantee clause must account for the maintenance concept.

Availability guarantees applied to the acquisition of a trainer must achieve the goal of delivery of a device which meets or exceeds a stated availability. The concept for support of the device must be stated, and the demonstration period must be of sufficient length to measure the total support system under the stated maintenance concept. The demonstration must, however, only measure those items purchased under the contract. If the acquisition contract calls for the delivery of a complete support package, it then becomes reasonable to assume that a demonstration of the operational availability can be performed. If, however, items of support are to be purchased subsequent to the contract for a training device, only inherent or achieved availabilities can be measured. The difference in these options is the environment in which they are measured.

A demonstration in the contractor's facility can only establish inherent availability. One that is performed at the operational location using a Government purchased and contractor recommended support package will demonstrate operational availability. In both types of demonstrations the clock should be stopped to accommodate any logistical support activity beyond the actual repair. For example, if parts are not available when needed, if test equipment is required to fault isolate and it is not readily at hand, the clock should be stopped. At any time the repair is delayed for other support activities, adjustments to availability measurements must be made. The contractor should not be held responsible for the performance of Government personnel. The Government also has a responsibility to provide the spares and test equipment recommended by the contractor, unless the contractor is tasked to provide them under terms of the acquisition contract. No manufacturer can afford to provide guarantees that his equipment will continue to operate if it is not maintained by the book. For example, most warranties are voided if there is evidence that the equipment has not been operated or maintained as specified by the warranty. In cases where support packages are purchased, this support should be subjected to a demonstration.

The contractor decisions on the make-up of this package should be followed closely. If recommended support items are not provided in the recommended quantities, allowances must be made in the availability measurement for those shortages. The contractor has the responsibility to recommend an adequate, but not excessive, quantity of spares and support equipment. He also must prepare and deliver clear and concise technical documentation to support the maintenance concept stated in the contract. The measure of what is adequate and what is excessive can, in some instances, be very subjective. Logistic Support Analysis (LSA) output should provide a measure of reasonableness. A full LSA is usually not required for the acquisition of a training device due to cost and the small numbers procured. A tailored version is normally appropriate. In the event that the Government is not satisfied with the LSA output, the contractor is obligated to provide justification for any level of spares or support equipment deemed excessive by the acquisition agency. The demonstration of the availability of the device should not allow for the introduction of spare parts or test equipment that has not been recommended as part of a support package.

When an availability guarantee is applied to contractor support, it must also undergo a certain degree of tailoring. If the suport contract is only for maintenance personnel, then the Government assumes responsibility for the logistic support - spares, test equipment, maintenance manuals, and any other area not associated with maintenance personnel. The Government has, in effect, only rented bodies from the contractor. In this case, adjustments to any availability computation must be made for down time that is caused by shortfalls in Government provided support. If a trainer is not ready for training for an extended period of time due to non-availability of a part, the down time cannot be counted against the contractor. A dispute may result when an item is required for fault isolation but is not the cause of the failure. This could be a ruse by a contractor to alter the measurement of availability to one that is more favorable to his performance. Thus, a great deal of care should be taken to define the terms and conditions of a contract for maintenance only.

Total contractor maintenance is defined for purposes of discussion in this paper, as contractor responsibility for all aspects of maintenance. This includes: maintenance of the trainer, maintenance and management of all spares (including piece parts) and test equipment (including calibration requirements) and the maintenance of all documentation. The application of availability guarantees to this type of contractor maintenance is not subject to as many gray areas of responsibility as it is with the rental of maintenance bodies. In this scenario, the contractor has full responsibility for trainer maintenance and for all associated support elements. Assuming the maintenance concept as previously discussed has been clearly defined, the total contractor maintenance provides the best environment in which to administer and enforce contractor performance in maintaining a trainer at a specified level of availability.

In either the total maintenance or the body shop contract, the contractor should insist that the trainer have a proven record at the specified availability or a demonstrated achieved availability which is equal to or greater than the one to which he must perform. Without this, the contractor may be attempting the impossible.

PENALTY CLAUSES

The incentive for the contractor to perform to the specified availability is the penalty clause. The penalty clause is, in most cases, a reduced price or incentive fee, with the amount of reduction calculated on the difference between the performance and the specified availability. Contracts and proposals seen by the authors, have invoked a reduction in price, based on the percent or fraction of a percent below specification. This reduction escalates as the performance decreases. We have not seen any positive incentives for exceeding the specified availability. This type of incentive (disincentive) has been employed on maintenance contracts. On development contracts, the "stick" has been the requirement, as necessary, for no cost ECP's to achieve the specified availability. Both of these approaches have been employed in several contracts and proposals with little or no variation between the type of development or the type of maintenance support. The indiscriminate application of availability guarantees to a wide variety of programs invites excess cost in development and/or default in maintenance contracts.

The Government has in recent years attempted to use some form of fixed price contract for most developmental contracts. There are, however, cases where new development pushes the state-of-the-art and some form of cost plus contract must be let. It is questionable whether or not a contractor can be expected to meet an availability guarantee while engaged in the development of new technology. If an availability guarantee is levied upon a new technology development, we suspect that the cost will be considerably higher than for a production effort, or for the same new development without the availability guarantee. Any guarantee or warranty carries an implied risk, and this risk is the probability of financial loss multiplied by the potential amount of that loss. This calculation must be part of the contractor's bid. When a contractor bids to produce a trainer which is within the state-of-the-art, his risk is small and the probabilities approach a deterministic value. Thus, his bid on a firm fixed price (FFP), or fixed price incentive fee (FPIF) contract will contain a minimum risk factor. When the bid is for a training device with major new technology involved and the Request for Proposal (RFP) is FFP or FPIF, the contractor must include a large risk in his bid. If a new development RFP is put on the street as a cost plus (CP) or cost plus incentive fee (CPIF) contract, there is an incentive to over design, at Government expense, to avoid any cost penalties associated with an availability guarantee.

In the area of contractor maintenance, the primary contract type is a FFP. This type of contract produces the least cost risk to the Government. That is the least risk, if the terms of the contract are fulfilled by the maintenance contractor. If, however, the contractor cannot meet the availability guarantee, and defaults because of potential losses due to penalties, the loss of training time will extract a cost that is not measured in contract dollars. The authors do not foresee this situation arising with any of the major flight simulator manufacturers. There are some "body shop" contractors that bid to do contract maintenance and recruit anyone off the street who can fill a position. It is in this situation, where the low overhead "body shop" has a competitive cost advantage over the simulator manufacturer. It is questionable whether or not some of these low overhead operations can withstand the penalties which are imposed for failing to maintain trainers at a specified level of availability. Hence, there is the possibility that one or more of the smaller maintenance contractors might default.

CONTRACTOR CONSIDERATIONS

When faced with an availability guarantee requirement, a contractor must have a thorough understanding of, and be willing to invest in both Integrated Logisitcs Support (ILS) and Reliability, Maintainability, and Availability (RMA) early in the design phase and continue with the commitment through trainer delivery. Both ILS and RMA are essential to producing trainers with design characteristics which will yield the specified availability. This design approach must be understood by both the contractor and the Government. In the purest sense, it is not essential for the Government to call out ILS and RMA deliverables in the contract if an availability guarantee is invoked. These "ilities" are a prerequisite to achieving a trainer which meets the availability specification. The Government must, however, realize that these tasks are still necessary, and will be accomplished as part of the system engineering process. Thus the bids for engineering will include the ILS and RMA functions and other associated costs. Consequently, initial development costs may be somewhat higher than previous trainer acquisitions, but a device which meets the availability guarantee will yield substantial savings over the life of the system.

The advent of the availability guarantee has forced "up-front" logistics upon the contractor. In the past, logistics has been the tail that was wagged by the engineering dog. Since logistics performance is now a criterion which will have an impact upon profit, it has truly evolved into the system engineering arena. The ILS functional elements that require special emphasis include supply support (provisioning), support and test equipment (S&TE), technical documentation, and training. In order to achieve a guaranteed availability rate, it is essential that properly trained maintenance personnel have the required repair part(s), technical manuals, tools, and test equipment readily available to accomplish the repair action in the shortest possible time. Special emphasis must also be placed upon the engineering functions of reliability and maintainability early in the design phase. These considerations must remain uppermost in the mind of the engineer throughout the program. Component parts must be selected to meet the highest standards of reliability. The assemblies selected for use must have the highest possible Mean Time Between Failure (MTBF).

Designs must not compromise the inherent characteristics of these components. Where necessary, redundancy may be incorporated into the design to overcome reliability shortcomings. Component packaging must not compromise the inherent reliability of the design and, every effort should be made to reduce component stress. An analysis of the design must be accomplished to discern critical components and assemblies, and if possible, the MTBF of the critical areas should be improved through better components or redundancy. When Government Furnished Equipment (GFE) proves to be a weakness in the design, the designer may consider on-line redundant equipment. The same approach applies to incorporating contractually specified equipment into the system design. In this way the contractor can influence the MTBF of equipments over which he has no design control.

The second factor in the availability equation is maintainability, as expressed in terms of Mean Time to Repair (MTTR). There are several techniques by which MTTR can be improved. One of these is to improve the physical interface between the training device and the maintenance technician. This involves ergonomic considerations such as accessability, visual identifiers, height and location of heavy assemblies, and other human factors considerations. Up to this point, we have listed only the most elementary aspects of design contributions toward a more available system. As any maintenance technician knows, the major act in returning any system to an operational state is not the repair action, but the determination of what has failed. The designer can enhance the troubleshooting process by incorporating Built-in-Test (BIT) and Built-in Test Equipment (BITE) into his design. However, when BIT or BITE is considered in the system design, the reliability of these must exceed that of the equipment that it is designed to test. Otherwise, it will create false alarms which will increase the level of maintenance activity and decrease the technician's confidence in these diagnostic tools.

Another aspect of maintainability over which the designer has control is assembly packaging and the assembly/subsystem interfaces. For complex assemblies, where rapid diagnosis or repair is not possible, modular packaging may be a consideration. Modular packaging should not, however, be used indiscriminately, because it is expensive from a supply support standpoint. The logistician must not only provision the module, but he must also provision the individual assemblies. Here is an area of ILS which plays an important role in the systems engineering process. Another area of importance, in which ILS is a key player, is the impact BIT and BITE have on technical manuals. BIT and BITE are also vital elements to the training requirements. Thus, ILS is a major player in the system design and the support package development that become key elements in meeting an availability guarantee.

When there are major subcontractors or vendors involved, they must also be part of the development team with regards to meeting an availability guarantee. Perhaps the most difficult problem to solve is the allocation of availability requirements. It is clear that no prime contractor can pass an availability demonstration if subcontractor or vendor provided equipment is deficient. There are several approaches to allocating this responsibility. As we pointed out in the discussion on availability measurements, availability is a function of MTBF and MTTR. Subcontractors and vendors can be required to demonstrate these characteristics to a level which meets the system goal. It is the prime contractor's responsibility to provide the interfaces and systems engineering necessary to meet the availability specification. Another approach is to have the sub and vendor participate in the availability demonstration. This approach can be costly, since their participation implies a risk commensurate with that of the prime contractor. Further, commercial manufacturers supplying "off shelf" hardware may be totally disinterested in supporting or even backing such demonstrations of their hardware. In many cases, vendors have provided equipment months or even years before such a demonstration takes place. In the area of shared responsibilities, we offer no suggested approaches, only "food for thought." Each contract has peculiarities which may suggest an approach to the issue.

RISK - BENEFIT CONSIDERATIONS

Availability guarantees, complete with penalty clauses, give the Government a high probability of obtaining reliable, easy to repair flight simulators. The Government also has assurance that key ILS considerations, such as supply support, support and test equipment, and documentation have been thoroughly analyzed. Hence, realistic support costs are identified up front, and not after the trainer has been delivered. If the trainers are to be maintained by Contractor Logistics Support (CLS) there is a less stringent technical manual requirement. (This assumes commercial maintenance practices.) The provisioning and S&TE, identified as essential to support the trainer, is purchased with the trainer. Hence, the trainer's availability, when required, is virtually assured. A problem here is that the contractor may, for obvious reasons, tend to overestimate the provisioning and S&TE requirements.

Availability guarantees are not without risk to the Government. The biggest risk is the possibility that the contractor will fail to meet the availability goals. Meeting the availability guarantee is very important, as failure to achieve them can have an adverse impact on critical training programs. Training courses are scheduled, based upon the guaranteed availability rate, and disruptions causing training delays which are expensive may result in a shortfall of qualified pilots.

Another Government risk is that the availability guarantee cannot be met by any contractor due to trainer complexity or to the restrictions placed upon the contractor (e.g., GFE, Govt specified CFE). In short, the Government may have been too ambitious and/or did not properly tailor the trainer requirements. Failure to properly document requirements may also result in difficulty in competing both follow-on production and CLS contracts.

The contractor's risks include the inability to design and produce trainers that will meet or exceed the availability rate. This risk is caused in part by GFE and Government specified CFE with MTBF and MTTR that degrades the overall availability. (Overall trainer MTBF will be lower than the component - subsystem with the lowest MTBF). Therefore, the Government must take into consideration the impact of their decisions on the contractor's ability to comply. The contractor should only be penalized for those aspects of the trainer over which he has direct control. Therefore, the Government should consider not including GFE failures as part of the contract availability guarantee. As previously discussed, a precise definition of availability is required and the manner in which availability will be measured needs to be fully explained and understood by both parties. Recognition of the trainer logistics support concept (CLS, Govt. only or Govt. augmented by contract maintenance personnel) should be considered in determining the measurement of system availability.

SUMMARY

Availability guarantees can be an acquisition tool which will result in the production of training devices yielding a greater training potential at a lower life cycle cost. They are not, however, a tool which can be applied indiscriminantly without some degree of tailoring to meet a specific trainer requirement. The Government agency responsible for the acquisition must review several aspects of their proposed support concept prior to establishing the availability guarantee specifications and penalty clauses. As we have discussed, the maintenance concept dictates what can and cannot be guaranteed during the operational support phase of the trainer's life cycle. Finally, the Government and the contractor must understand the benefits and the shortcomings of the availability guarantee. The Government will have to tailor it to the acquisition and to the maintenance concept. The contractor will have to address supportability as part of the systems engineering effort, not as a follow-on effort to the trainer design.

A complete understanding of these requirements by both parties and an appreciation of the goals and limitations of each will provide the basis for establishing good working relationships. Further, this assists in meeting the common goal of producing the best possible trainer at a cost effective price with added assurances of equaling or exceeding the specified availability guarantee.

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