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SYSTEMS ANALYSIS DIRECTORATE
ACTIVITIES SUMMARY
DECEMBER 1976

JANUARY 1977

US ARMY ARMAMENT COMMAND

SYSTEMS ANALYSIS DIRECTORATE

ROCK ISLAND, ILLINOIS 61201

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This monthly publication contains Memoranda for Record and other technical information that summarize the activities of the Systems Analysis Directorate, US Army Armament Command, Rock Island, IL.

The subjects dealt with are: Integrated Logistics Support (ILS), Elements and Application; and Copperhead Fifth Quarterly Review

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Section I. GENERAL

1. This monthly publication summarizes the activities of the Systems Analysis Directorate. The purpose of this note is to give wider and more timely distribution on subjects of concern to the command.

2. The most significant Memoranda for Record (MFR's) and other technical information will be published as notes or reports at a later date.

3. In order to assure accurate distribution of this publication, addition or deletion of addresses to/from the DISTRIBUTION LIST are invited and should be forwarded to the address below.

4. Inquiries applicable to specific items of interest may be forwarded to Commander, US Army Armament Command, ATTN: DRSAR-SA, Rock Island, IL 61201 (AUTOVON 793-4483/4628).

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Section II. MEMORANDA AND OTHER TECHNICAL INFORMATION

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REVIEW OF THE SHORT COURSE:

INTEGRATED LOGISTICS SUPPORT (ILS),

ELEMENTS AND APPLICATION

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DRSAR-SAM 26 NOV 1976

MEMORANDUM FOR RECORD

SUBJECT: Review of the Short Course: Integrated Logistics Support (ILS), Elements and Application

1. Background.

I attended the subject course during the week of 15 - 19 Nov 76 at UCLA. Although offered by the UCLA Extension for Continuing Education in Engineering, the course was organized by Clinton Van Pelt, a project engineer at McDonnel - Douglas, and was taught by fifteen faculty members drawn from aerospace firms and from the Air Force and Navy. The backgrounds of the faculty were diverse, ranging from RAM-D, through support functions such as maintenance engineering, spare parts provisioning, technical publications, test and support equipment, personnel and training, facilities, and management information. A consistent effort to integrate the presentations was made by the coordinator and by the speakers representing the various logistics specialties. I believe this effort was quite successful. However, the examples chosen to represent the materiel of hardware logistics were selected almost exclusively from military and commercial aerospace.

2. Course Content.

The course was designed to provide an overview and appreciation for the scope of a logistic system which is internally harmonious or integrated and, additionally, well integrated with the development process which produces the equipment to be supported. Broadly, the presentations fell into two categories -- those dealing with the resources of logistics -- spare parts, publications, test and support equipment, personnel and training, training equipment, and facilities -- and those dealing with the tools, data, and methods of analysis -- data reporting systems, repair level analysis, life cycle costing, contract warranties, and cost-benefit analyses.

3. Certain key questions must be addressed relative to the support of a new system entering the inventory. These questions involve the use of the logistic resources to provide an adequate level of system availability at minimum cost. Ideally the concepts of life cycle costing and assured (constrained) availability should be applied as early as feasible in and throughout the development process. The instructors repeatedly emphasized that analyses employing these concepts should be applied throughout development in making design trades which may strongly affect system availability and/or cost of support.

4. Logistic Engineering.

From the point of view of logistic engineering some of the important decisions involve:

(1) The basic maintenance concept -- replace versus repair and identification of discardable items.

(2) The choice of level of repair for repairables.

(3) The choice of means of identification of failure or improper performance such as inherent or built-in test (BIT) versus built in test

equipment (BITE) versus external test equipment.

(4) The choice of type of test equipment -- general purpose, special purpose -- and level of skill required to operate and to maintain the test equipment itself.

(5) The choice of maintenance and operator training equipment and the support requirements for this equipment.

These decisions individually and collectively impact the number and type of spares required, the number and skill level of maintenance personnel required, the need for training resources, and the mobility and flexibility of the support system as a whole. Obviously, these elements have a significant life-cycle cost impact. The instructors in ILS made the point that the support costs often exceed the system acquisition cost over the period of ownership. Therefore, to make minimum life-cycle costing more than just a buzz word it is essential to give a significant amount of attention (analysis) to the logistic impact in making the above decisions.

5. Systems Analysis.

In listening to the various logistic specialists, I was impressed with the difficulty in obtaining the desired integration of the disciplines in a coherent manner to support a variety of systems. Many of the problems associated with system support span a number of specialties and suggested to me various study areas which might benefit from systems analysis. The following studies and activities are candidates for ARRCOM Systems Analysis with the assistance of other directorates:

(1) Cost-benefit trade studies relative to suggested product improvements designed to improve availability and/or reduce the remaining life cycle cost at, perhaps, the expense of performance and the certain cost of retrofit.

(2) Studies to assess the implications for maintenance effectiveness of alternative new-item maintenance policies such as BIT, BITE, or test set.

(3) Critical review of optimum level of repair analyses (ORLA) using maintenance system-level simulations.

(4) Studies to suggest and evaluate means for reducing maintenance personnel and/or skill levels required for new or product-improved equipment and to quantify the life-cycle cost reductions accruing from various alternatives.

(5) Assist cost analysis personnel in quantifying the support costs associated with or implied by certain product features. To be useful for making new-(or product improved-) system tradeoffs, the cost estimating relations (CERs) for various support costs such as (a) training, (b) publications, (c) provisioning of spares, (d) maintenance actions (clean, lubricate, replace, repair, etc.), and (e) facilities and equipment should be simple functions of product features identifiable at that stage of the life cycle of the system.

(6) Studies to improve the methodology for initial provisioning of spares.

(7) Studies to improve the methodology for location of replacements in the float.

(8) Provide Red-team service to ARRCOM commodity managers in assessing the effectiveness of maintenance training including training aids and simulators and the perceived quality of technical publications.

(9) Review long-term implications for readiness and logistic responsiveness of make-or-buy decisions and policies.

(10) Assist TRADOC in COEAs by developing and providing logistic inputs such as (a) availability estimates, (b) numbers and types of maintenance personnel required, and (c) support costs including new or improved facilities.

(11) Examine the stockpile and production capacity implications for existing and developmental munitions due to the introduction of a novel system such as Copperhead.

(12) Assist JCAP and PM for production base modernization in examining the effectiveness and responsiveness of production and rework facilities.

(13) Assist PMs and commodity managers in quantifying the survivability implications of (a) proposed product improvements and value-engineering changes and (b) requested deviations from specifications in product under manufacture.

(14) Participate in Test Integration Working Group (TIWG) meetings prior to OT 2 to assure the collection of pertinent logistic data.

6. Recommendations.

I would recommend that managers and analysts in ARRCOM at the GS12 level and above who are actively involved in ILS* attend this course. Additionally, I recommend that managers in the Logistics Engineering Directorate and in the Systems Analysis Directorate examine the list of studies suggested by this course.

George J. Schlenker

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*Including in particular personnel within the LED, MA, MM, CP, and SA.

HIGHLIGHTS FROM THE COPPERHEAD

FIFTH QUARTERLY REVIEW

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DRSAR-SAM 23 DEC 1976

MEMORANDUM FOR RECORD

SUBJECT: Highlights from the Copperhead Fifth Quarterly Review

1. The fifth quarterly review of the Copperhead program took place at the Martin Marietta Corporation (MMC) plant, Orlando, Fl on 8 and 9 Dec 76. By invitation I attended as a representative of DRSAR-SA. This was the fourth Copperhead review at which DRSAR-SA had a representative.

2. As has been the practice at previous Quarterly Reviews (QR), the SA representative was assigned to the Systems subgroup. For the benefit of CAWS personnel who were unable to attend the Systems subgroup sessions, I am presenting an account of highlights from these sessions. These sessions were chaired by Dave Amberntson (MMC) during the absence of Phil Morrison.

3. The topics planned for discussion were:

a. autopilot status

b. sequencer status

c. flight simulation status

d. charge constraints

e. OT 2 firing table requirements

All of these topics were covered while I was present except e. Perhaps this was discussed in my absence since I multiplexed myself between the Systems subgroup and the Guidance subgroup. The above topics are discussed below in sequence.

4. Autopilot Status.

It was pointed out that there have been no changes to the functional block diagram of the autopilot nor to autopilot params since the last quarterly review. However, insofar as the hardware is concerned, significant changes have been made. At the last QR the problem of signal inversion in the output of the roll rate sensor (RRS) at large (absolute) roll rates seemed to have been solved through the expedient of placing an initial condition (IC) voltage on the integrator in the roll autopilot such as to drive the roll controls (torques) in the counterclockwise direction (opposing the 6 to 8 hz induced clockwise spin) at the start of roll control. The effect of the IC was to quickly drive the roll rate into a region in which there was no sign inversion in the output with roll rate. This "fix" had, in fact, been demonstrated on a lab simulation of the rolling "projectile" with autopilot. However, subsequent, careful studies at MMC revealed that, due to component tolerences, it was possible under certain conditions to create overshoots in the roll rate which would send the RRS into an inverted portion of its transfer function. Further, whenever the RRS is operated in the saturated portion of its transfer function poor roll loop damping results. To correct these problems, MMC decided to (a) increase the linear region of the transfer function of the RRS and (b) to clamp the output voltage at saturated value (of proper sign) whenever the roll rate exceeded a prescribed absolute value. To effect (a), it was necessary to reduce the output gain of the RRS, worsening the signal-to-noise (S/N) ratio. To minimize the S/N problem due to a low signal over a relatively long high-impedence lead, one stage of preamplification is to be incorporated within the RRS electronics. This change has been incorporated in the vendor spec.

5. Sequencer Status.

Although no changes in actual sequence of actions have occured since the last QR, an additional 200 millisec has been allowed for the ± 30 volt battery to reach threshold voltage. This change will have no operational impact. Although unrelated to the sequencer as such, it came to my attention that MMC has incorporated a different strategy for torquing the gyro after the seeker has decorrelated when a string of pulses is missing. In June of this year the requirement to align the gyro with the body upon decorrelation was dropped. The present strategy is simply to null torquing signals which would arise from line-of-sight rates. In my opinion the present strategy is superior. This opinion is based upon a small study in which we examined guidance accuracy as a function of the mean time between dropped-pulse sequences with the two decorrelation strategies treated separately. A strategy in which the gyro is simply freed and the g-bias held proved to be least sensitive to the accuracy degrading effects of pulse dropout. In fact, with this strategy no significant degradation occured until the mean time between dropped pulse sequences is less than about 4 sec.

6. Flight Simulation Status.

Several interesting points have emerged relative to the ongoing guidance accuracy and performance analysis. It was noted that the hit probability and PE figures calculated by MMC for G-T ranges of 12 and 18 km agree exactly with the DRSAR-SA calculations for a comparable scenario. The DRSAR-SA results were contained in information sent to CACDA to support Legal Mix 5, Phase 2. I find this agreement encouraging in view of significant differences in analytic methods. As indicated at the last QR, the guidance CEP calculated by MMC cannot be compared directly with the SA result. The reason for this is due to a difference in definition. MMC refers coordinates of the impact to the average position of the laser spot centroid obtained for the last second of flight. This calculation is meaningful in a test environment in which the spot position can be monitored at the target on a pulse-by-pulse basis. In the DRSAR-SA definition of CEP the position from which all misses are calculated is the intended center of aim, fixed with respect to the target. Normally, the projectile is closer to the actual spot at impact than to the center of aim. Consequently, the CEP calculated by MMC is smaller than the figure calculated by DRSAR-SA.

7. At the last QR MMC was concerned about poor PE at 20 km and, using high-angle fire, at 5km. To better understand the reasons for the poor performance under these conditions additional parametric analyses were conducted. For the max range case, it was discovered that a significant proportion of the loss of performance was attributable to failure to acquire and reach the target. Further analysis showed that certain, sensitive errors were being assigned excessively large values. For example, the round-to-round variation in coefficient of drag (CD) and static margin (SM) were bigger than is reasonable. Accordingly, the deviations in C_D were reduced from 5% to 1% and the deviations in SM from 0.2 caliber to 0.1 caliber. Additionally, the magnitude of the gyro drift rate is now modeled as a uniformly distributed random variable over the region from 0 to 0.1 deg/sec in both pitch and yaw. This is similar to the treatment given this error source by DRSAR-SA. The net result of these changes is to significantly improve hit probability and PE at 20 km. If even better performance at max range is required, it will be necessary to exercise close quality control on factors, such as fin and wing alignment, which influence round-to-round variations in aero params. Further, it will be necessary to reduce the allowable gyro drift rate.

8. The performance at 5 km G-T range using the upper register has been shown to improve if the glide (FUFO) option is employed instead of the ballistic option. The reason for this improvement is that impact position bias can be reduced with glide since this mode makes a better computation of g-bias, particularly for high QE trajectories. This discovery implies that range tables should reflect a preference for the glide option over an expanded domain of launch conditions. Additionally, it appears to me that more effort should be expended to calculate via computer simulation and test via AUR field tests the trajectories that will (probably) be employed during OT 2.

9. <u>Charge Constraints.</u>

Joe Lung (MMC) presented a paper in which he discussed MMC's concern that future 155mm propelling charges satisfy contraints set by the present Copperhead design. As MMC sees it, future charges such as the XM211 or modifications to the XM201 must conform to the acceleration and velocity limits imposed by the operational envelope of CLGP. These are, in part,

(a) a design acceleration limit of 7200 gees and a proof test limit of 9000 gees, maximum.

(b) a minimum parmissible axial acceleration history of 800 gees for 10 millisecs in order to activate the warhead fuse.

(c) a minimum muzzle velocity of 700 f/s in order to activate the second environment sensor.

(d) a charge zone velocity of 1050 $\pm$ 50 f/s so as to achieve min range of 5000 m at max QE.

(e) a charge zone velocity of 900 $\pm$ 50 f/s so as to achieve min range of 3000 m at 200 mils min QE.

At present it is not clear whether any of these constraints are seriously violated over the range of operating conditions. As an example, one can imagine that a "hot" lot of XM201 propelling charges, temperature conditioned to 145 deg F, and fired in a new XM185 cannon might create an maximum acceleration of Copperhead in excess of 7200 gees. It is unlikely that the acceleration would exceed 9000 gees but would occasionally exceed 7200 gees. In view of this situation and unanticipated future -- but similar -- situation, I suggested that MMC or, perhaps, a government agency undertake a reliability study of Copperhead with projectile acceleration as one important variable. This suggestion was received quite unenthusiastically by both MMC representatives, who felt that such a study was premature.

10. After some discussion concerning the compatibility of Copperhead with the XM211 propelling charge as well as foreign prop charges, I suggested that MMC and the government consider a modest study concerned with interior ballistic compatibility. With some reluctance by Dave Amberntson, this suggestion was made an action item. However, the suggestion was rejected at a meeting of the whole. It appears that the above study suggestions should be undertaken to avoid possible future problems. If these efforts do not fall within the present scope of work of the contract, then, perhaps they should be performed by a government agency. In any case, intelligent decision making concerning the projectile-cannon-charge interface demands that someone eventually followup on these suggestions.

11. One final highlight of the discussion at the Systems subgroup needs to

be mentioned. MMC repeated their position that the temperature spec for Copperhead ought to be modified to conform with limits for safe operation imposed by the propelling charge. MMC claims that a reduced specification is feasible if temperature sensors are present in the tube since the round could be extracted if adequate warning of an unacceptable thermal environment were given.

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