PROCUREMENT CYCLE MODELING AND SIMULATION

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ABSTRACT

The objective of this simulation was to ascertain the mean time required to process a procurement action and the variability of this time. A cumulative probability distribution was generated for each step as well as a rejection probability. A Monte Carlo computer program was used to determine the time required to process through the organization and these "make time" distributions were tested against known distribution for goodness of fit.

I. DATA ACQUISITION AND MODEL

This simulation was conducted to determine the "make time" for purchase orders and contracts in the Guidance and Control (G&C) Directorate, US Army Missile Command. This Directorate is comprised of six operational branches and an administrative section. It is basically a research organization within which requirements for new materials and contracts are generated by engineering and scientific personnel on a random basis.

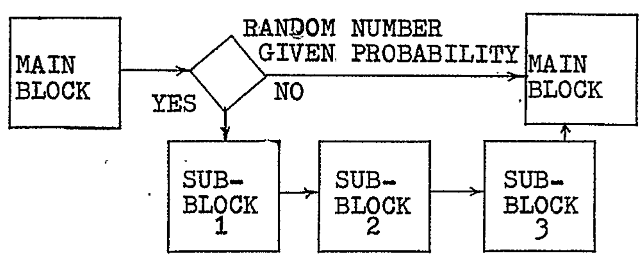
Personal interviews were conducted with various individuals throughout the G&C Directorate. Those interviews included engineers, researchers, secretaries, administrative officers, and the Director. The purpose of the interviews was to gather as much data as possible regarding the flow of procurement packages. A general model for preparation and review of procurement packages within G&C Directorate was prepared from information gathered during the interviews. Questionnaires and typist logs were prepared and distributed to all Branch Chiefs, secretaries, and engineers within the Directorate. Completed questionnaires togather with the information from the timing test were sufficient to identify the cumulative time distribution for each operation.

A general model of the entire procurement process within G&C Directorate was constructed. The six branches are represented by parallel lines of main blocks and then they are connected in series with ten more main blocks which represents common steps within the chain. Each block represents a definable piece of work required to complete a procurement package. At each main block there was a rejection probability. This rejection could be due to insufficient funds, incomplete requirements, typing errors or changing of organizational goals.

A computer program was developed for performing the Monte Carlo simulation operation by first constructing a simple building block model of an alternate within an operation of the system and this building block is shown in Fig. 1. Associated with each main block or building block of the overall general model is a set of three sub-blocks. These sub-blocks represent work that must be redone because of errors, redirection, etc; e.g., if the main block represents typing, sub-block 1 could represent review, sub-block 2 retyping, and sub-block 3 approval. Associated with each main block is a probability of going from one main block directly to the next. This represents the probability of a rejection, and subsequent corrections and review of procurement actions.

FIGURE 1

Building Block Model



The program works as follows; a random number between 0 and 1 is generated by a sub-routine and compared with a probability obtained from that block of questionnaires. If the random number is less than the probability distribution, each of the sub-blocks associated with that main block is entered and the times selected. If the random number is greater than the probility, the program goes directly to the next main block distribution for a time value, and sub-blocks are not included.

II. RESULTS

The outputs from the Monte Carlo program included: Mean, Standard Deviation, and Variance for the service times and are shown in Tables 1 and 2.

TABLE 1

Purchase Requests

Branch	Mean Time (Hours)	Standard Deviation
1	16.82	4.46
2	16.26	3.49
3	22.25	6.66
4	28.36	5.16
5	17.76	3.54
6	19.71	4.99

TABLE 2

Contracts

Branch	Mean Time (Hours)	Standard Deviation
1	46.11	10.23
2	78.27	5.66
3	27.01	5.29
4	35.47	8.34
5	-	-
6	42.19	8.89

The service times were expected to be normally distributed due to the Central Limit Theorem; therefore, a test was needed to prove this hypothesis. The KILOMOGOROV-SMIRONOV Test was found appropriate in this situation. The normal F(X) and sample SN(X) probability distributions are easily obtained where N is the number of observations or points to be compared. The KS-1 Test then tests the absolute difference between theoretical and empirical distributions at N points. The maximum of these absolute deviations is compared against a table of critical values (K). If the calculated value is above the critical value the hypothesis of normality is rejected. In mathematical terms:

$$\text{MAX} \left| F(X) - SN(X) \right| < K_n$$

where K_n is a function of number of observations.

The KS-1 Test was conducted on all the distributions and confirmed the normality at the 0.005 level of criticality except for one. Additional research was performed at this point to find a model to which the non-normal case could be fitted. The Weibull distribution was found to be a good model for time functions, such as this case, because of its non-negative characteristics and flexibility in curve shape. The Weibull distribution which yielded the best model is

$$F(t) = 0.00018^{2.35} e^{-0.00018t^{2.65}}$$

This model was then tested using the KS-1 Maximum Deviation Test by converting to F(t), which yielded:

$$\text{MAX} \left| F\ (\text{Weibull}) - S\ (\text{test data}) \right| = 0.197$$

At an α of 0.05, the critical value of the KS-1 Test is 2.64; therefore, the Weibull model is accepted as a valid one.

The fact that a Weibull model is accepted, the character of the co-efficients imply that as time passes the actions that have not been completed become more critical and have more priority than those generated later. In other words, the status of the procurement actions are monitored within this branch and those actions that are lagging receive the greatest action.

III. CONCLUSIONS

A normal model was assumed based on the Central Limit Theorem but the one Branch that does not exhibit normality indicates a positive feedback through the system. As the time between origination and completion becomes long, more emphasis is placed on these lagging actions. Other Branches that flow normally indicate that the flow is not being checked on and followed up by the originator of the action. As expected the Branch which prepares the most technically sophisticated contracts requires the most preparation and review time.

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