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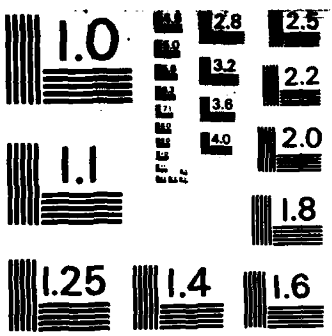

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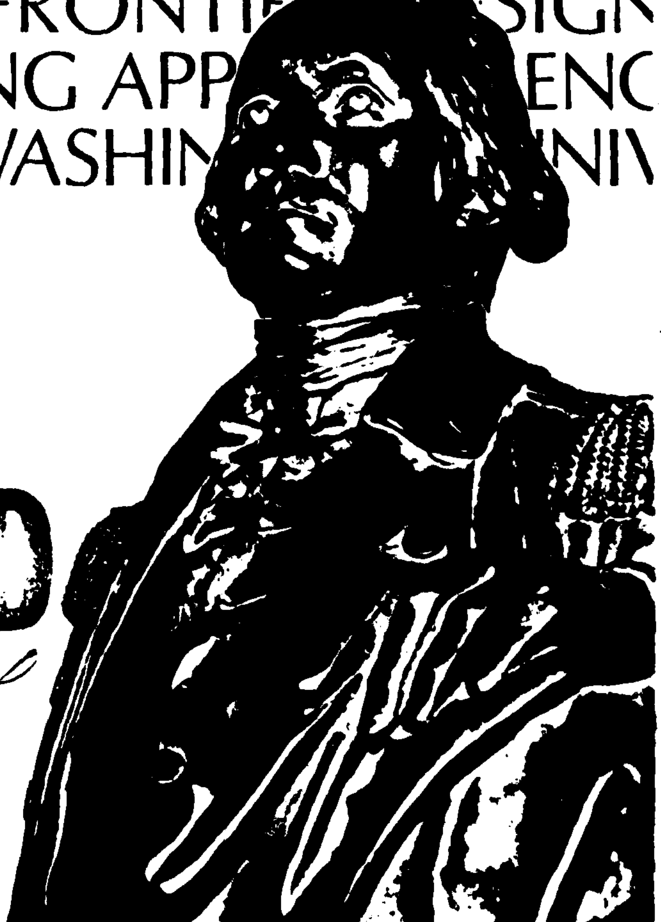

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Program in Logistics
GWU/IMSE/Serial T-477/83
30 August 1983

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School of Engineering and Applied Science
Washington, DC 20052

Institute for Management Science and Engineering

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report illustrates the use of a particular set of criteria for analyzing logistics models. This set is an expansion of the entries in the data banks at the Defense Logistics Studies Information Exchange, Fort Lee, VA, which are used to prepare "model abstract" computer printouts and the regularly published "Catalog of Logistics Models." The present report in fact illustrates the type of analyses that might be included in a "Handbook

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20. Abstract (Cont'd)

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This report illustrates the use of a particular set of criteria for analyzing logistics models. This set is an expansion of the entries in the data banks at the Defense Logistics Studies Information Exchange, Fort Lee, VA, which are used to prepare "model abstract" computer printouts and the regularly published "Catalog of Logistics Models." The present report in fact illustrates the type of analyses that might be included in a "Handbook of Models and Source Data" for a few models of major importance. The sortie-generation model of the Logistics Management Institute is the example used to illustrate this approach to model analysis.

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0. Introduction

This report illustrates the use of a particular set of criteria for analyzing logistics models, namely, the following.

1. Problem background
2. Objectives (primary, secondary,...)
3. Pertinent variables
4. Measurements and indexes
5. Modeling (deterministic, stochastic, relationships,...)
6. Analytical techniques
7. Validation or measures of effectiveness
8. Inventory of data files
9. Inventory of computer programs
10. Numerical examples
11. Applicability and intended users
12. Critical comments
13. References

This set is an expansion of the entries in the data banks at the Defense Logistics Studies Information Exchange (DLSIE), Fort Lee, VA, which are used to prepare "model abstract" computer printouts and the regularly published "Catalog of Logistics Models."

The present report in fact illustrates the type of analyses that might be included in a "Handbook of Models and Source Data" for a few models of major importance to a command such as the Air Force Logistics Management Center. The sortie-generation Model (SGM) of the Logistics Management Institute, as presented in References [1] - [6], is the example used to illustrate this approach to model analysis.

Our general recommendation is that such a handbook should not be implemented for any sizable number of logistics models; it would be too expensive to prepare and maintain except on highly selective bases. Indeed, use of such a handbook would probably serve to provide only bare improvements over the practice of using the DLSIE data bases, and others, to identify sources which are then pursued as appropriate to obtain detailed information.

1. Problem background

The problem is to estimate the maximal number of sorties per time period (day) that can be flown by a specified type of aircraft in a wartime scenario. This estimate should be based on the characteristics of the aircraft and of the support systems (maintenance crews, recoverable spares stock levels, base and depot repair facilities, etc.).

2. Objectives

There are three primary objectives.

1) To develop stochastic models of attrition, breakdown, repair, and logistic support that can be related to the process of sortie-generation of attack-fighter aircraft squadrons, under wartime scenarios.

2) To develop simulation algorithms that can generate estimates of the expected (maximal) number of sorties per wave, and of the expected number of sorties of one aircraft per day, over a prolonged period of time.

3) To arrive at estimates of sustainability in wartime scenarios.

There are four secondary objectives.

1) To provide the technique for allocating budget resources to recoverable spares procurement and repair, which take account of the military essentiality of the weapon systems.

2) To construct data files required by the SGM, containing

manpower authorization, maintenance performance, spares distribution by weapon system by base, and so forth.

3) To construct models of "notional" (typical) air bases containing aircraft maintenance crews, and logistic support.

4) To preprocess data from a variety of Air Force data systems for use by the SGM.

3. Pertinent variables

The pertinent variables can be grouped into seven sets.

0) Scenario Variables

0.1 Number of aircraft in base (UE)

0.2 Number of aircraft in reserve

0.3 Number of aircraft in maintenance (NMCM) at the beginning of the first day

0.4 Flying days

0.5 Number of waves per day

0.6 First takeoff time

0.7 Last takeoff time

0.8 Minimum recovery time

0.9 Sortie length

1) Aircraft Status (state)(cycle)

MC - Mission capable

NMCM - Non-mission capable maintenance

NMCS - Non-mission capable supply

CL - Combat loss

RE - Reserve

2) Launch status

   Successful

   Abort for repair

3) Sortie status

   Successful return

   Combat loss

4) Repair status:

   No repair needed

   Type of repair needed (WCS, SENSOR, AFCS, INSTR, ECM,...)

5) Status of Repair Centers

   5.1 Number of repair crews available (authorization)

   5.2 Service rate of crews

   5.3 Number of NMCM aircraft in center

   5.4 Number of NMCS aircraft in center

   5.5 Stock levels of recoverable parts in center

   5.6 Length of repair

   5.7 Cost of repair

6) Recoverable spares variables

   6.1 Removal rate

   6.2 Quantity of part i per aircraft

   6.3 Predicted future application rate

   6.4 Initial stock level

   6.5 Initial number in resupply

   6.6 Rate of Base NRTS (requires depot repair)

   6.7 Resupply times (days) for base and for depot

7) SGM output variables

7.1 Average number of sorties/period

7.2 Average number of sorties/day

7.3 Average number of NMCM/period

7.4 Average number of NMCS/period

7.5 Cumulative losses (average)

7.6 Average number of aircraft in reserve

This completes the listing of the pertinent variables.

4. Measurements and indexes

The variables listed in the previous sections are mostly counting variables (discrete), with some exceptions where the actual repair time is considered. There is no explicit measure of efficiency. The SGM estimates the expected number of sorties of each aircraft per day, over a 30-day period. This provides implicitly a measure of efficiency and sustainability. The expected number of sorties per day depends on the maintenance procedures, inventory system, repair crews, and so forth. The efficiency of the system is directly related to this expected number.

5. Modeling

The model is stochastic in terms of the transitions of aircraft from various states, and in terms of the length of time the aircraft stays at a given state of 1) above (MC, NMCM, NMCS, CL, RE). Each aircraft is subjected to random sortie abortion during the launch period TL, with a specified probability. If sortie is aborted, the aircraft becomes NMCM or NMCS. If it is not aborted, the aircraft takes off. During the sortie or flight time the aircraft is subjected to random attrition. That is, with a specified probability of attrition, it is lost in combat. (Transition from MC to CL). An aircraft which returns from a sortie may require repair in one or several repair stations, due to damage sustained by enemy's fire or parts failure in flight. These events happen at random with specified probabilities. It is also uncertain which type of repair will be needed, and how many parts will have to be replaced. The model provides specific assumptions about these random events, and about the repair time distribution. These assumptions are formulated in Reference [3].

6. Analytical techniques

Following the stochastic model outlined above, the expected number of sorties of an aircraft per period (wave) is estimated by simulation. The simulation algorithms generate uniform random numbers, and by comparing these numbers to the probabilities of specified events decisions are made whether those events happened or not. Length of repair times are generated by the well-known techniques of simulating exponential or Erlang random variables. Thus, by proper bookkeeping, the status of each one of the aircrafts is followed at all times. In this manner, the number of sorties in each wave can be determined. Each simulation run continues for a specified number of days, namely, 30. These simulation runs are replicated independently for a specified number of times, and averages of number of sorties are computed.

7. Validation

The validation efforts of the SGM are described in Reference [3]. These efforts include extensive testing of the software and sensitivity analyses to verify the validity of the model algorithms and approximations. The above tests were followed by an examination of the adequacy of the SGM to predict actual sortie generations in a sortie surge exercise "Salty Rooster," which was conducted in 1978 at an Air Force Base in Germany. The SGM predictions were compared to the actual number of sorties during the first four days of the exercise. It is claimed that the SGM results (or predictions) were "remarkably close" to the actual results. These comparisons did not test the model in situations of constrained resources or for sustainability. Another step in the validation was to run SGM against the Air Force Logistics Composite Model (LCOM), which is itself a complicated simulation system. The LCOM estimates of the expected number of sorties per day, for a period of 30 days, were lower than those of the SGM. There is an attempt to explain this discrepancy by pointing to the higher post sortie break rates used by LCOM.

8. Inventory of data files

The SGM requires several data files for input. For this purpose, a Spare Subsystem was developed. It provides the means of translating Budget-Program 15 (BP15) resources and depot-purchased equipment maintenance (DPEM) resources into a spare posture (a set of stock levels by NSN and their location).

Another system developed is the Aircraft Availability Model. This model provides availability versus cost curves for each model design (MD) aircraft in the Air Force inventory. Each point on such a curve represents the minimal cost mix of spares and depot level repair. The input data for the Availability Model are obtained from AF Logistics Command D041, D041A and K004 data systems. Other programs developed are the following.

Interactive Budget Allocation

Shopping List

Distribution Model

Setup Programs

Maintenance Subsystems

9. Inventory of computer programs

A complete listing of all the computer programs, in FORTRAN, needed for the SGM is given in Reference [2]. A list of SGM files and Programmer's Manual is given in [4].

10. Numerical examples

A numerical example is given in Reference [2].

11. Applicability and intended users

The SGM was developed for the Department of Defense for the purpose of assessing the readiness of the Air Force, in terms of the maintenance and logistics support systems. It appears to be an applicable model. All computer programs and subsystems are reported to have been tested.

12. Critical comments

The development of the SGM is a substantial achievement. It seems to be the first model that can provide estimates of the expected number of sorties that can be generated over a long period of time as a function of the number of maintenance and repair crews and other logistic parameters. There are some shortcomings of the model that could easily be rectified. One of these deficiencies is the lack of precision estimates in the printout of the simulation results. A numerical example (see [2]) provides the averages of 40 simulation replicates, but does not provide the standard errors of these averages. Hence, one cannot evaluate the precision of the results.

One can also criticize some of the simulation stochastic models as being too simplified and maybe somewhat unrealistic. For example, the simulation of the types of repair that an aircraft may need in post-sortie breaks assumes that the events of breakage or failure of different parts of the aircraft are independent. This assumption is questionable. However, further complication of the model does not necessarily guarantee more accuracy, due to the high complexity of the model.

13. References

The SGM is documented in the following six volumes.

[1] ABELL, JOHN B. (1981). Sortie-generation model system; Vol. I--Executive summary. Logistics Management Institute, Washington, DC. (LD 46241MA).

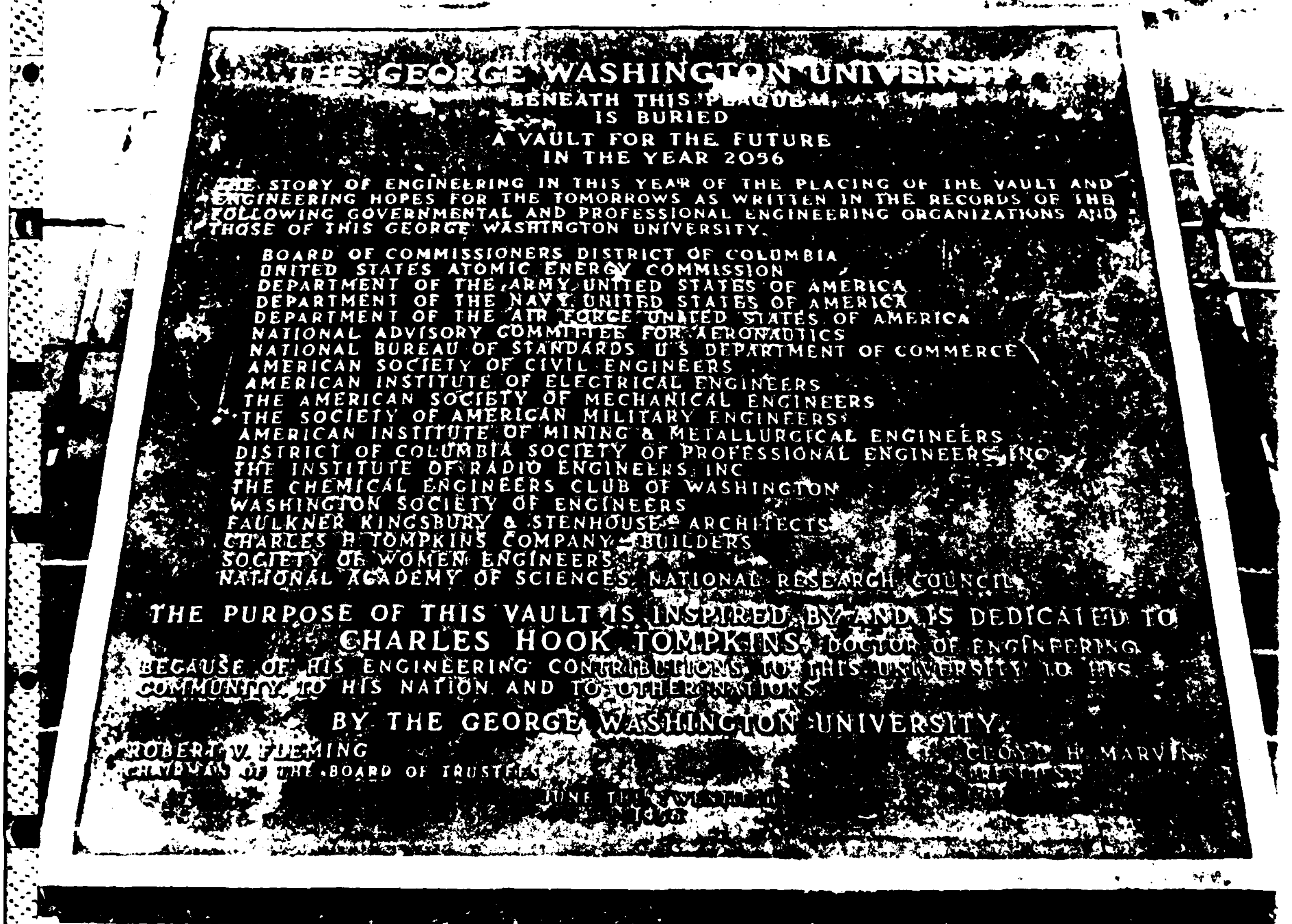
[2] ABELL, JOHN B. , ROBERT S. GREENBERG and MICHAEL J. KONVALINKA (1981). Sortie-generation model system; Vol. II--Sortie-generation model user's guide. Logistics Management Institute, Washington, DC. (LD 46241MB).

[3] ABELL, JOHN B. and MICHAEL J. KONVALINKA (1981a). Sortie-generation model system; Vol. III--Sortie-generation model analyst's manual. Logistics Management Institute, Washington, DC. (LD 46241MC).

[4] ABELL, JOHN B. and MICHAEL J. KONVALINKA (1981b). Sortie-generation model system; Vol. IV--Sortie-generation model programmer's manual. Logistics Management Institute, Washington, DC. (LD 46241MD).

[5] ABELL, JOHN B. and F. MICHAEL SLAY (1981). Sortie-generation model system; Vol. VI--Spares subsystem. Logistics Management Institute, Washington, DC. (LD 46241MF).

[6] GREENBERG, ROBERT S. (1981). Sortie-generation model system; Vol. V--Sortie-generation model maintenance subsystem. Logistics Management Institute, Washington, DC. (LD 46241ME).



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