

## CAPABILITIES AND EXPERIENCE

THE WASHINGTON

### General Background

The personnel were formerly the senior members of the Mathematics Group of the Weapons Systems Evaluation Group (WSEG). WSEG performs operational evaluations for the Director of Defense Research and Engineering and for the Joint Chiefs of Staff. (The role of WSEG at the Department of Defense level is somewhat analogous to the roles of RAND, RAC, and OEG at the individual service level.)

The mathematics group (one of six major divisions of WSEG) has existed since 1957, and has had the mission of providing mathematical, analytical, modeling and computational support directly to WSEG projects, and indirectly through a program of research in development, maintenance, and refinement of analytical and computational techniques and models in areas of interest to WSEG. In addition, it has the responsibility for operation of the WSEG computing facility.

The personnel at present are Dr. Hugh Everett, III, head of the WSEG mathematics group since 1957 and project leader of several WSEG projects; Dr. Robert J. Galiano, project leader of several projects and member of the Mathematics Group; Paul M. Fitzpatrick, chief of programming; and Betty Jo Ellis, chief of computer operations.

## Problem Formulation, Analysis, and Project Management Experience

The experience of the present personnel in support of WSEG projects has ranged from, on the one hand, efforts by individuals on model building, mathematical analysis, computational assistance, and operations research in support of general project commitments to, on the other hand, leadership of projects involving complete responsibility for all phases (formulation, modelling, analysis, computation, report preparation, briefings to outside agencies). Thus the group has considerable experience in overall project management through its participation in numerous military operations, research studies from conception and formulation, through development and application of analytical techniques, to determination of conclusions and presentation of recommendations.

In addition to direct project support activities, the personnel have been involved in an extensive research effort over the years (with consequent experience) in the fields of: Weapons effects and weapons effects models; Target vulnerability (hardening); Fallout models; General optimization techniques (particularly optimal allocation of resources); National vulnerability and damage assessment modeling (both aggregated and highly detailed); Measures of effectiveness and cost-effectiveness methodology; Strategic War gaming models; Large scale air-defense simulation models; Optimum defense deployment models and techniques (including active-passive interactions); Mobile vs. Fixed Systems; Applications of theory of games to defense doctrines and tactics; Optimal targeting techniques; Statistical methods (weapons system reliability analyses, evaluation of Monte-carlo calculations, development of confidence procedures, etc.); Ballistic missile trajectory and accuracy analyses; Limited and general war gaming for the national military command level; Ballistic missile payload optimization and effectiveness analysis; and others. In general, the efforts listed above have been selected because the results have provided new and

definive methodology (often widely used outside WSEG) or useful extensions to existing techniques of the evaluation community.

Involvement as consultants in the work of outside agencies (or "ad hoc" groups) has been a recurring source of diverse experience. Similarly, the inclusion on many WSEG projects of industry teams has often added valuable new insights to the experience of the group, as has, the day to day contact with the personnel that compose WSEG—from experienced senior military officers, physical scientists and engineers, to historians, economists, and even philosophers.

#### Programming Experience

In addition to participation in normal "problem-solving" programming, all "system" programming (compiler modification and development, utility and debugging aids, automatic moniter system development, etc.) and unusual or difficult applications were performed by the present personnel.

"System" Programming experience includes: Assemblers; Compiler (FORTRAN) modifications; Moniter system development; Debugging aids (symbolic trace and memory dumps); Automatic recovery procedures; Subroutine library development.

"Applied" Programming experience includes: Medium and large scale simulations (both time-step and event-store type); Strategic war games; National damage assessment programs; Fallout models; Active and passive defense deployment models; Optimum allocation of effort models (non-linear); Numerous cost-effectiveness analyses, accounting (payroll and social security); Automatic document editing; Very numerous assorted small and medium scale programs for computation of results, exploration and sensitivity analyses of mathematical models developed by the analyst-programmer himself.

Advanced programming techniques which have been employed include: event-store executive system for large scale simulations; Dynamic allocation of

storage; List-processing techniques; Symbol string manipulation and translation; Randomization for data storage and retrieval; Random sampling techniques for damage assessment and other applications; Monte-carlo calculating techniques; Efficient automatic error detection and correction techniques for magnetic tape (programmed); Recursive subroutines and algorithms; Associative memory and pattern recognition programs; Adaptive subroutines (e.g. integration with automatically varying steps); Programming language extensions via pre-processor before compiling; and finally, A vast number of lesser "tricks of the trade" developed over the years to solve specific problems.

An especially noteworthy point concerning the experience of the personnel arises from the past policy of the Math Group of WSEG that the analyst generally performs his own programming. As a consequence, the very considerable programming experience of the present personnel has been heavily influenced by practical considerations of solving the overall problem in the most expeditious manner, in contrast to pure programming experience "for its own sake" divorced from the ultimate objectives. All of the operating system improvements, library subroutines, and general programming techniques and policies have thus been developed in response to real needs, and have had considerable value. Since our personnel have participated heavily in all phases from formulation, modelling and analysis through programming and debugging to final results, they are uniquely qualified in the general areas of programming, operating systems design, and computer facility management.

Computer Operations and Management Experience

The group has had complete responsibility for selection; installation planning; programming and operating system development; subroutine library, utility and debugging routine programming; operations and scheduling, etc. for three successive computer facilities:

	<u>Installed</u>	<u>Status</u>	<u>Years</u>
a. Royal McBee LGP - 30	1957	leased	1.5
b. IBM TAPE 650 System	1959	leased	2.5
c. CDC 1604 System	1961	owned	2.5

The group consequently has very broad and deep experience in all phases of computer facility operation and management, from small to large scale computer systems. (The 1604 is essentially a 24-hour operation).

Numerous techniques and procedures have been developed to facilitate program efficiency for large production programs, and simultaneously to maintain very short turn-around times and powerful debugging aids and methods for small programs.

### Potential Customers

Potential initial customers, who presently have knowledge of and high respect for the capabilities of the group, and for whom the services of the group could be useful include: Office of Civil Defense, Arms Control and Disarmament Agency, Institute for Defense Analyses, Comptroller, Sandia Corporation, Advanced Research Projects Agency, President's Scientific Advisory Committee, Control Data Corp., Kirtland Computer facility, Minneapolis-Honeywell, National Security Agency, Bellcom, Aerospace Corporation.