SAINT, A DIGITAL SIMULATION LANGUAGE FOR THE STUDY OF MANNED SYSTEMS

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INTRODUCTION

Development of SAINT evolved over a period of five years and was based upon experience gained in having used the Siegel-Wolf, two-man, operator simulation model (Siegel and Wolf, 1967). That particular model viewed system performance in terms of operator activities over time. It was written in FORTRAN but was not modularly constructed. Modifications of the program sometimes led to unforeseen difficulties which complicated debugging new routines.

If human factors were to be considered during design, there was a need to better describe man's impact on system performance, and conversely there was a need to improve the description of how the system impacted the operator. This needed to be accomplished in a form readily accepted by the engineering community.

Two languages were particularly popular at the time: GPSS (General Purpose Simulation System) (Scriber, 1974) and SIMSCRIPT (Markowitz, et al., 1963). Both required special compilers, so neither could be easily modified. GASP II (Pritsker and Kiviat, 1969) was SIMSCRIPT-like in its modeling constructs or descriptive concepts, but executed under the FORTRAN compiler. The Siegel-Wolf model could be represented in GPSS. It was believed it could also be represented in GASP. However, it was subsequently discovered that P-GERT (Whitehouse, 1973), developed using the GASP subroutines, was a more suitable vehicle for capturing the basic character of the Siegel-Wolf model.
SAINT Evolution

Pritsker observed that the Siegel-Wolf model was basically an activity-on-node representation of discrete event sequences (Elmaghraby, 1977). P-GERT had been developed to analyze this class of models. However, because of the dynamics of time stress formulated by Siegel and Wolf, their networks were non-linear with time varying parameters. Task times could vary as a function of defined levels of workload "time-stress". P-GERT was only capable of portraying and analyzing linear, time-invariant networks. Therefore, the first stage of SAINT development was devoted to generalizing the formal representation of the Siegel-Wolf model (Pritsker et al., 1974) and extending P-GERT to capture this model of man.

The second stage of SAINT development was a major advance and exploited recent developments in GASP IV (Pritsker, 1974). This allowed combined modeling. Continuous processes could be represented as differential or difference equations and solved by the Runge-Kutta-England fourth-order integration algorithm. This permits one to model the equations of motion for an aircraft that describe its position and attitude over time. To illustrate a simple combined model, a very elementary representation of aerial refueling was developed (Wortman et al., 1974). No attempt was made to portray vehicle dynamics to any high degree of fidelity, and the operator's control actions were simplistically described by a strategy that mechanismically provided discrete regulation of vehicle acceleration. However, the model did provide some interesting insights. The preliminary formulation led to excessive numbers of disconnects and breakaways. Systematic variations in scan rates and regulatory actions demonstrated that with more frequent scanning and less dramatic regulatory changes, better system performance was achieved. While there was no attempt at exactness of representation, certain general conclusions were apparent from even this simplistic portrayal of man-machine interaction.

During the third stage of SAINT development, revisions were made that completely divorced SAINT from the original Siegel-Wolf model without precluding its implementation, should one choose to do so. It was recognized that other formulations of behavioral dynamics might be preferred, and a modeler should not be forced to use a prescribed formulation such as workload "time-stress" if that did not appear relevant in the system context being addressed. SAINT III documentation was not separately prepared, but the technology was applied to modeling a remotely piloted vehicle drone control facility (Wortman et al., 1976). SAINT permits a modeler to describe task times (or any event duration) as either a sample from a prescribed distribution, a derived value (as a function of prescribed parameters), or as some combination (as in the Siegel-Wolf model, where the average and standard deviation of a normal deviate vary with stress level).