DR. HAROLD JOSEPH HIGHLAND is Professor of Data Processing and the chairman of the department at the New York State University Agricultural and Technical College at Farmingdale. He was Fulbright Professor of Computer Science and Operations Research at Helsinki University of Technology in Otaniemi, Finland and Dean of the Roth Graduate School of Business of Long Island University. He has taught and/or lectured at the University of Belgrade (Yugoslavia), University of Lisbon and University of Coimbra (Portugal), City University of London and Polytech of Central London (England), College of Medicine of the University of Helsinki (finland), McMaster University (Canada), Hofstra University among others.

He is Editor of **Simuletter** and also **Performance Evaluation Review**. He is Associate Editor for Digital Simulation - Discrete Systems for **Simulation** and Associate Editor for Data Processing for **The Journal of Irreproducible Results**. Also he is Associate Editor and a member of the Editorial Board of **The Accounting Journal**. Furthermore, he has been Editor of the 1974, 1976 and 1977 **Proceedings of the Winter Simulation Conference.**

Dr. Highland is a member of IMACS WP1 on simulation languages, the Task Group of IFIP WG 7.1 on a dictionary of modeling and simulation, and the supplementary task force of AFIPS CS&E Taxonomy Project. He is active in a number of professional organizations among which are the Association for Computing Machinery, the Institute of Electrical and Electronic Engineers, the Operations Research Society of America, the American Statistical Association, the Society for Computer Simulation, The Institute for Management Sciences, the American Institute for Industrial Engineers, the Association for the Advancement of Science and the American Federation of Scientists.

A TAXONOMY APPROACH TO SIMULATION MODEL DOCUMENTATION

Dr. Harold Joseph Highland
New York State University
Agricultural and Technical
College at Farmingdale

In preparing this presentation I find myself in the ineluctable position of an applications-oriented practioners espousing a pedogical approach to simulation model documentation. Although theoretically cloistered in an academic environment, my teaching is applications-oriented and not theoretical, a reflection not only of my industrial background but also my lack of a formal theoretical education in computer science.

Therefore, I must note that this is a non-traditional paper in the field of simulation model documentation in that:

- first, no definitive system of documentation is herein presented,
- secondly, personal suggestions and reactions are included instead of following the pristine scientific approach, and
- thirdly, my prime purpose is to nudge those engaged in modeling and simulation into action in the development of some system of model documentation.

Need for Documentation Ontology

It is apparent even to the noviate in simulation modeling that a comprehensive system of model documentation does not exist; in fact, even a simple universal documentation system is absent. This is no animadversion of the simulation specialists since they are more concerned with the development and validation of models and have little if any time to devote to this difficulty task of a generalized documentation system.

Yet, some difficulties should reasonably be expected to accompany change, for change is nearly always difficult. Without a formal or universal system of simulation model documentation, planning is oft a palliative euphemism for guessing. The planning phase in this area does not really imply the existence of a potential for fulfilment,

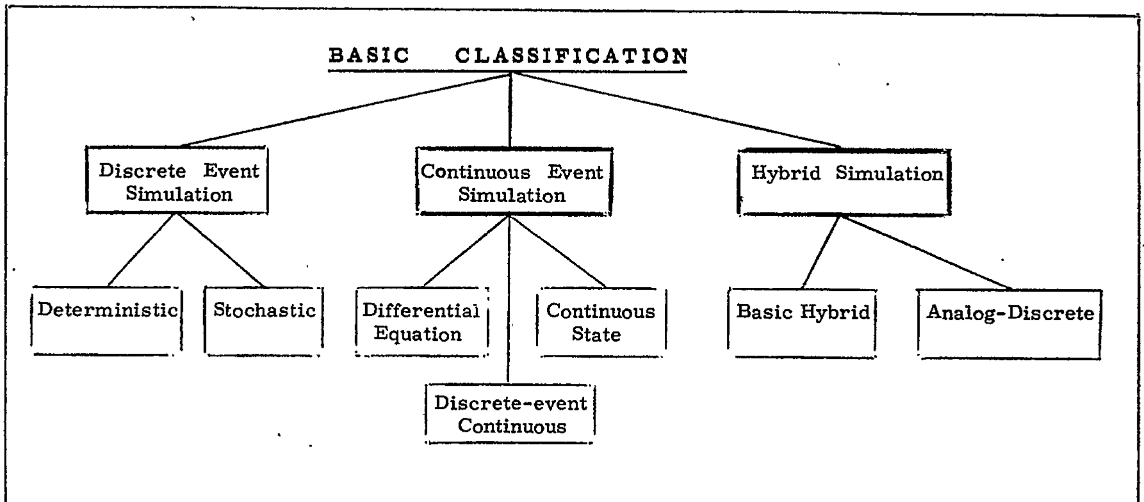

FIGURE 1 – Elemental Classification

BASIC MODEL CLASSIFICATION

A. PURPOSE

1. Activity scanning
2. Process interaction
3. System evaluation
4. Predictive variability
5. System optimization
6. Personnel training

B. MODEL CHARACTERISTICS

1. Time frame
   a. Static
   b. Dynamic finite
   c. Discrete states
   d. Continuous states
2. System composition
   a. Stable
   b. Unstable
   c. Degenerative
3. System size
   a. Macro or aggregate
   b. Micro or detailed
4. System state
   a. Static
   b. Transient
5. Elemental operation
   a. Transformation
   b. Sorting
   c. Morphism or feedback
6. Environmental interaction
   a. Autonomous
   b. Non-autonomous
7. Degree of Mapping
   a. Replicative real-world
   b. Quasi-replicative
   c. Hypothetical
8. Elemental components
   a. Entities
   b. Attributes
   c. Variables

C. RELATIONSHIPS AMONG ENTITIES

1. Symbiotic
2. Synergistic
3. Replicative
4. Antithetic
5. Interdictive

D. ATTRIBUTE CHARACTERISTICS

1. Environmental
   a. Autonomous
   b. Non-autonomous
   c. Adaptive
   d. Non-adaptive
   e. Exogenous
   f. Endogenous
2. Time/space relationships
   a. Static
   b. Dynamic
      i. Deterministic
      ii. Stochastic
   c. Kinematic
3. Volatility
   a. Stable
   b. Unstable
   c. Controllable
   d. Non-controllable

E. VARIABLE CHARACTERISTICS

1. Statistical nature
   a. Non-random
   b. Random
      i. Empirical
      ii. Generated
      iii. Deterministic
      iv. Stochastic
2. Interrelationship
   a. Independent
   b. Dependent
3. Environmental
   a. Endogenous
   b. Exogenous
4. Impact State
   a. Decision variable
   b. State variable
   c. Antithetic or limit variable

FIGURE 2 – SYSTEMS'S MODEL CLASSIFICATION

even with sincere and conscientious effort. A universal system of simulation model documentation may not be possible. But it should be possible to develop such a system to encompass virtually all models and replace the inextensible system which exists today.

There are two parts to a documentation system as I see it. The first is a written record of all aspects of simulation model development and operation. It serves as a communication vehicle among those working on and with the model, provides historical perspective and serves in a measure as a quality control instrument. It also provides easily read information about the simulation model to outsiders interested in either learning more about the model or in possibly using the model.

The second part of simulation model documentation, the one which is addressed in this paper, is a classification system. It is in many respects similar to the old Dewey decimal system or the current Library of Congress system for classification of books. Just as 0-395-21411-4 indicates a volume combining computing and physics, so would 01-802-371-913 indicate a stochastic discrete event simulation of a predictive, stable macro model of urban housing policies utilizing supplementary income allowances and written in SIMSCRIPT II.5 .

Such a system can be developed in a bifurcated manner:

- on the one hand, we can examine the myriad of existing simulation models engulfing us and attempt to create order out of chaos; or
- on the other hand, we can create such a classification system as a hierarchial, structured system based on modeling and simulation theory using a taxonomy approach.

A Taxonomy Model of Classification

We can start using the convential triad found in simulation textbooks as shown in the Basic Classification (see Figure 1 - Elemental Classification - on the first page of this paper). I have used this starting point since it is one with which we are all familiar. The second part of the classification system can be based on the classification of the basic model (see Figure 2 - Systems's Model Classification - on the facing page).

It should be noted now that the development of this taxonomy classification system is by no means complete. It is presented since I feel that this is one approach that should be considered. It is presented in order to obtain critical reviews from simulation practioners and theoreticians. The approach is not sacrosanct; it can be modified to accommodate the peccadilos of the more knowledgeable. Its structure, I believe, is generally known, and with familiarity there is less shock in the process of change. The basic structure is the classical presentation of a general course in simulation.

LANGUAGE TAXONOMY

A. DISCRETE SIMULATION LANGUAGES

1. General Purpose Languages / Activity Oriented /
   a. General purpose language programs
   b. General purpose language supplementary packages
2. Basic Discrete-Event Simulation Languages
   a. Statement oriented simulation languages
      i. Event oriented languages / SIMSCRIPT class /
      ii. Process oriented languages / SIMULA class /
   b. Block oriented simulation languages
      i. Transaction flow languages
   c. Special purpose simulation languages / systems class /
   d. Special simulation language packages

B. CONTINUOUS SIMULATION LANGUAGES

1. Differential Equation Based Languages
2. Modified Block Oriented Languages
3. Continuous State Languages

C. HYBRID SIMULATION LANGUAGES

1. Continuous change
2. Discrete change

FIGURE 3 - SIMULATION LANGUAGE CLASSIFICATION

TAXONOMY OF APPLICATIONS

A. COMPUTER SYSTEMS

1. Component hardware
2. Software systems
3. Software packages
4. Network analysis
5. Systems prediction and reliability
6. Data base: structure and management
7. Information processing

B. BUSINESS, INDUSTRY AND AGRIBUSINESS

1. Financial analysis
2. Scheduling and resource allocation
3. Manpower utilization
4. Pricing policy evaluation
5. Marketing and economic growth
6. Food supply and/or distribution
7. Power generation and distribution
8. Process control analysis
9. Manpower training
10. Mineral exploration and extraction
11. Communications
12. Transportation analysis
13. Decision analysis
14. Stock and commodity analysis

C. GOVERNMENTAL AND SOCIAL SYSTEMS

1. Military: warfare/weapons
2. Learning processes
3. Educational policies
4. Population dynamics
5. Urban analysis
6. Housing policies
7. Land utilization
8. Aerospace and space systems
9. Nuclear policies
10. Human factors engineering
11. Fire and police services
12. Gaming and game theory
13. Psychological processes
14. Behavorial analysis
15. Social systems analysis
16. Political science analysis

D. ECOLOGICAL AND ENVIRONMENTAL

1. Energy systems
2. Water polution and purification
3. Air and metoerological analysis
4. Waste control
5. Noise control
6. Earthquake analysis
7. Food supply and population
8. Food chemical analysis

E. WORLD MODELING

1. World social systems
2. Food/population analysis
3. Weather analysis
4. Economic projections
5. Resource allocation
6. Political analysis
7. Geopolitics

F. BIOSCIENCES

1. Health delivery systems
2. Health care planning
3. Clinical medicine analysis
4. Basic biological analysis
5. Basic chemical analysis
6. Pharmacology
7. Biomedical analysis
8. Hospital operations
9. Biophysics applications
10. Endemic disease analysis
11. Epidemic analysis
12. Psychotherapy analysis

FIGURE 4 – APPLICATIONS CLASSIFICATION

The foundation for the classification by simulation language is contained in the language taxonomy (see Figure 3 - Simulation Language Classification - on the previous page). Another basic ingredient in any classification system should contain information about the model's application. One approach is shown in the taxonomy of applications (see Figure 4 - Applications Classification).

A Documentation Abstract System

It is possible that a numerical system such as that used by the Library of Congress would be too cumbersome for practical use. I do not propose that we use a 500-page manual to decipher the model's classification code. It is something that would be useful and something toward which we should strive.

However, in the meantime we might consider the development of an abstract system for classification and have that system rooted in the taxonomy. Just as we have abstracts of journal articles, we should consider a standardized form for a simulation model abstract. It might be primarily a basic checklist with supplementary material included to provide some additional detail.

A Final Note

Needless to say the taxonomy presented herein is not complete. Possibly the most critical section is that dealing with model validation. It was not my intention to present a definitive taxonomy as the basis of a classification system, but instead to start a dialogue among specialists in modeling and simulation interested in this aspect of simulation model documentation, a phase too easily overlooked in light of all the other problems present.

This call for documentation and classification is not new. It has been made in the past by both Ira Kay of the Southern Simulation Conference and John McLeod, now editor emeritus of Simulation. Both have sparked some development but the task is far from complete. Possibly we can take another small step forward now.