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Computer program documentation is important to proper model use. Common causes of poor documentation include: organizational negligence and lack of capability, difficulty in clearly communicating a description of the model, motivation on the part of the modeler to prepare good documentation, absence of examples of good documentation, inadequate time funds, staff.

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DOCUMENTATION NEEDS FOR WATER RESOURCES MODELS[1]

by William K. Johnson[2]

Introduction

This document discusses various problems associated with preparing good computer model documentation and identifies and describes ways by which such documentation may be improved. Following this introductory section the following topics are discussed:

- the nature of computer models and their documentation
- the relative importance of good documentation to increased model use
- common causes of poor documentation
- requirements for producing good documentation
- constraints to producing good documentation

Together these topics address the problem of how to produce better documentation to make more efficient and effective use of computer models.

The views expressed here have developed over the past ten years from experience with the development and application of medium to large computer models in the field of water resources engineering. The models with which the author has been associated are widely used nationally and internationally, by public and private organizations, and by practitioners and academics. In their field they are probably the most widely used models in the world today.

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[1]Prepared for the U. S. Congress, Office of Technology Assessment Study on Use of Models for Water Resources Management, Planning, and Policy, August 1982.

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It is this author's view that success in the use of these models is due principally to the assistance available to the user. It is assumed the models are needed by professionals in the water resources field, and that they are theoretically and technically sound. But their wide-spread and successful use comes from the fact that an organization exists which uses the models regularly, and professionals within that organization are available to assist in model application. In addition, these professionals conduct training courses on the models; update, revise and correct models and their documentation; write and present technical papers on model applications. In other words the model, after development, is fully supported. By contrast most universities and private organizations do not support their models after development. It can be argued that this is not their function. This is probably true. Even so, there must exist somewhere an organizational unit to provide support, otherwise the model will not be used.

Good model documentation is needed and necessary. It should be prepared for every model and it should be done well. However, it is not a substitute for the assistance of a professional who understands the model and who is using it regularly. Documentation is not a substitute for training, for technical papers and reports on application, for updating, revising, or correcting computer code. Continuing support is central, with it documentation has its proper place.

Nature of Computer Models and Their Documentation

When discussing the success and failure of computer models and the need for and relative importance of good documentation it is of paramount importance to understand the nature of a computer model. It is an explicit set of instructions, written in a special, machine executable language, and organized in a methodical manner. The person who develops a computer model is usually a technical specialist with expertise in a particular discipline, e.g., engineering, and one who knows how to read and write this special language. His "computer model" is his set of instructions to do something, for example, to simulate the operation of a reservoir. These instructions are his, the logic is his, they are unique to this person. Given the task to develop a computer model to simulate the operation of a reservoir no two persons will write the same set of instructions. As a consequence the models will not compute exactly the same, nor will they handle different conditions the same. Still, both may give answers which are technically correct. The point is that the myriad of instructions which go into a computer model (around 4,000 for a medium size computer program) are unique to the person writing those instructions. And this poses problems when it comes to documentation.

Generally, there are two types of documentation: programmer manuals and user manuals. Programmer manuals are designed to assist others in understanding the logic and organization of the instructions by which the model operates. This is useful when it is desired to change the instructions in some way. User manuals are designed to assist those who wish to use the model to do whatever it was developed to do. The user is not so much concerned with the instructions and how they are organized, but with how to prepare input to get a desired output. Most of the discussion in the sections which follow refer to user manuals as they are the more common and necessary.

User documentation requires the technical specialist who wrote the model's instructions to translate those machine executable instructions into English and to organize this translation in a way which, on the one hand, communicates the logic and organization of the instructions and on the other, communicates how to use the model. This task of translation is not an easy one. To write instructions to a machine, whose response is known and predictable requires one skill. To translate those instructions for a variety of persons, whose interpretation is unpredictable is quite a different task. This is the heart of the task of good preparing documentation.

Importance of Good Documentation to Increased Model Use

Two principal reasons computer models are not used are that either they are not trusted or they are not needed. Since this conflicts with the generally accepted myth that a model is inherently good and should be used, a word of explanation is necessary and will serve to place documentation in proper perspective. In spite of what has been written and said about the need for and desirability of computer models and the seeming ease with which they are applied they are nonetheless viewed with a great deal of skepticism by professionals with experience in the application of models to engineering and other problems. This skepticism is rooted in years of experience with models and their application. Usually a new model doesn't do what it is expected to do. There can be many reasons for this, however, the professional working on a project is not about to entrust the calculations for some aspect of his project to a computer model which is not understood or which produces questionable results. The criterion for trustworthiness is an acceptable record of use (preferably by those other than the model developer) and the availability of persons to answer questions concerning its use. While good documentation assists the user in understanding the model and its capability and helps him to decide whether it is needed, it does not produce trustworthiness. If a model is needed and is trustworthy, i.e., will do what it is suppose to do, it will be used even if the documentation is lacking. If a model is needed and has good quality documentation, but is not to be trusted, it will not be used. Thus, good documentation helps in understanding a model, but it is not a principal factor in its acceptability and use.

Many models are not used because they are not needed. Development of a model, testing of a model, and preparation of proper documentation does not create need - it creates a model. There is evidence enough that some models find wide acceptability and use with poor documentation, while other models with seemingly all the necessary documentation never are used. One reason is simply that many models are not needed.

Two conclusions may be drawn from the preceding. First, good documentation will never be a substitute for model applications and user assistance in the eyes of the potential user. Trustworthiness is built upon successful application and available support. Second, good documentation does not create need. The user, functioning in the free market, will welcome models which are trustworthy and help in solving problems. Lack of acceptance does not mean this welcome has been withdrawn.

Common Causes of Poor Documentation

Five common causes of poor computer model documentation are identified below.

- When models are developed by government contract frequently the organization funding the development does not have the organizational unit to take responsibility for its operation and maintenance or is unwilling to allocate time and staff for such support. Such negligence and lack of capability for quality control encourages and tolerates poor documentation.
- It is a difficult, time consuming task to translate instructions and logic from a machine executable language to English in a way which clearly communicates how a model operates and how it should be used.
- The person who writes the machine instructions may not have the patience, ability, or interest to translate and interpret these instructions into English.
- Good documentation is not as common as poor documentation. Consequently the person who writes documentation may not be aware of what constitutes good documentation.
- Inadequate time, funds and staff are commonly allocated to the documentation task.

Completing development of a computer model may be viewed as the beginning or the end. An organization which has a unit to support and maintain a newly developed model will view its development as the beginning - the beginning of its use, its application, its growth in capability. As a consequence there will be greater incentive for preparing good documentation to support the long term commitment to the model. An organization which does not have a unit for support and maintenance, or which may have such a unit but does not assume the responsibility, will view its development as the end. While it may be hoped that the model is picked up and used by others, no commitment of resources (time, staff, funds) is made. In this situation, there is less incentive to prepare good documentation since development of the model and associated documentation complete the work.

The difficulty of preparing good documentation should not be underestimated. A medium size computer model will consist of several thousand explicit instructions. To properly use the model the user must be provided with documentation which provides: (1) clear instruction on how to prepare input data such that each machine instruction is executed properly, (2) a clear understanding of the physical, engineering, mathematical, biological etc. processes or methods which are used in the model, (3) a clear understanding of the model output and how that output relates to the phenomena being modeled, and (4) a clear knowledge of how the model will respond to different combinations of input instructions and study conditions. In the world of computer models, close is not good enough. The computer demands (and gets) exactness. The user's input data cannot be almost correct. The machine executable instructions cannot be nearly complete. The task of preparing good documentation is one of bringing to the user a clarity of thought, understanding, and knowledge such that precise instructions can be given and the model's response will be as desired and expected.

With regard to the third problem, the person (or persons) who have written the machine instructions for a model really have no need for documentation other than as a reminder of what they may forget. Documentation is principally for others. The person writing the machine instructions knows what they are, what they are intended to do and how they are organized.

Questions or problems can be readily answered. It is difficult then to develop the patience to place oneself in the user's role and communicate all that is needed to be known and understood about the model. In addition, such communication requires writing abilities different from those required for the computer. To prepare instructions in a machine executable language for a digital computer is quite a different task than writing in English for people. While each requires logic and organization, their nature is quite different. Some people can do both, many can do only one or the other. Also, it is a special skill to be able to write in English without using excessive computer jargon which may obscure the real meaning. Lastly, is the question of interest. Clearly, the rewards in both public and private practice are for computer model development, not for post facto documentation. Such rewards are generally professional (papers published) and economic (projects completed).

There is a need for more examples of good documentation. The basic requirements for good documentation will be discussed in the next section. Like a quality crafted chair, it is more than four legs, a seat, and back, which makes it a quality product - it is the workmanship and materials which go into it. Likewise for model documentation.

It is fair to say that most computer model development takes longer, takes more funds, and is more complex than estimated at the beginning. The additional time, funds, and staff are often taken from that allocated to documentation. This creates an atmosphere of pressure and shortage of of time where patience is needed. Under such conditions documentation can be prepared, even documentation meeting specified standards. However, it is usually not good, well thought-out, clearly communicated documentation.

Producing Good Documentation

Organizational Support. There is no substitute for having an organizational unit which is responsible for a model's development and documentation, and is responsible for its continuing use and maintenance. The technical quality of documentation (in contrast to visual quality) can only be assessed through model use. For models developed by contract such a unit can work with the contractor during the contract to guide and evaluate the documentation. Final payment can and should be withheld pending completion of acceptable documentation. This will require testing and using the model.

Knowing that a model and its documentation will be thoroughly used and evaluated by competent technical specialists under the contract will be a strong incentive for the person who wrote the machine instructions to carefully communicate the necessary information to the user. It will be an incentive to develop the necessary patience and interest in the documentation task. During the review process concepts, instructions and examples which are not clear can be clarified in the documentation. As discussed under the causes of poor documentation the principal task of the person who wrote the machine instructions is to translate these instructions into English for the user. When a competent user is available under the contract to test and evaluate these instructions, their adequacy can be evaluated and improvements made.

For models not developed by contract but developed within an organization the problem is more difficult. Here peer and organization review are necessary. However, as model development nears completion competition for time and staff become acute. In this case it is important that the model be applied by others. As the model is used the developer will receive peer feedback on the adequacy of the work, and this hopefully will lead to improvement. This is probably the best way to encourage good documentation.

Documentation Content. When there is a need for information on model use and it is not covered, or is inadequately covered, in the documentation the potential user has three principal options: (1) contact the person who wrote the machine instructions for the model, (2) attempt to decipher the machine instructions, or (3) not use the model. The first may not be possible, the second is time consuming, and the third is to be avoided. Consequently, it is important that the documentation be complete, clear, and accurate. The following is a list of essential information which should be included in user documentation:

. Introduction

. Theory and Computational Methods

. Model Capabilities

. Data Requirements

. Input Specifications

. Output Description

. Example Applications

The "Introduction" should present information on the origin and author of the model, when it was developed, an overview of its capabilities and limitations, computer equipment requirements, the person and organization responsible for support, and other general information of importance to the user.

"Theory and Computational Methods" should describe the engineering, economic, biological, etc. theory or theories used in the model or if they are commonplace in the profession appropriate references may be cited. This should include a complete description of the equations, notation, and principles used. Frequently various mathematical or statistical methods are used in the computations. These should be identified and described or references cited. The general computational procedure, i.e., the order of computation, should also be described.

"Model Capabilities" should describe what the model is designed to do and what it will not do, if this is not obvious. This will include both basic capabilities and, as is common in more complex models, optional capabilities.

A section describing "Data Requirements," written in the context of the engineering, economic, biological phenomenon being modeled can be most useful to the user. With both the theory and model capabilities set forth, the user is directed to the data required by the theory to produce the desired results. This data description is different from the input specifications.

"Input Specifications" describe how the user should prepare data to properly meet the machine executable instructions. The data requirements mentioned above were in the context of the theory and capability, i.e., in the context of the professional discipline. When preparing input specifications these data are put into a form which is acceptable to the machine instructions. Here precision is critical for proper execution of the program.

"Output Description" should provide a description and explanation of all output from the model. This should include an explanation of all terms, abbreviations and notations. Units and time periods should be described and all output devices-printer, tape, CRT, etc. should be discussed.

"Example Applications" are most important. In the examples the theory, capability, data requirements, input and output are all illustrated. Examples over a wide range of applications should be selected. Each example should be clearly organized with textual discussion from theory to output. Examples should also be selected to allow validation of the model when it is used on a computer different from the one on which it was developed.

The foregoing is a brief description of the basic content of user documentation. These items are an essential and necessary part of good documentation. Even so, their inclusion does not insure quality. One could discuss each of these topics and still produce poor documentation. A knowledge of what should be included in good documentation must be coupled with motivation, ability and time to prepare it.

Constraints to Producing Good Documentation

As discussed previously the principal need to produce good documentation is continuing organizational support and maintenance of the developed model. The principal constraint is the lack of such organizational support and the associated fixing of on-going responsibility for the model. Models are frequently developed by universities and private contractors for government organizations, however, there is no organizational unit to use and maintain the model, thus, it doesn't take long for the model (and taxpayers investment) to get "shelved." Yet this same model may appear in the literature and give the "appearance" of being operational. Yet the only source of assistance is the documentation developed with the model.

Overcoming this constraint is both easy and difficult. It is easy in that all that is needed prior to development of the model is that the responsibility for its on-going application and maintenance be assigned to a person and organizational unit. And, that this information be made available with the model. It is difficult to overcome in that there can be a "paper" designation of responsibility and a token allocation of resources for use and support. Probably the best approach is not to allow model development unless it is fully supported and maintained by the sponsor of the model.

There are no major constraints to documentation content whether by standards or some other means. The major elements of good documentation are well known, some examples exist, and they can be required in any government contract or within the government by any agency. Those for whom models are to be developed simply must desire that it be done properly.

Summary and Conclusions

The following points have been discussed to provide an understanding of some of the important causes of poor documentation and to suggest ways by which documentation can be improved.

- A computer model is an explicit set of instructions written in a special, machine executable language. Documentation is a translation of these instructions into English such that a user is provided with a clear understanding of the model and its use. Such a translation requires skill, patience and interest.

- The principal reasons computer models are not used are that either they are not trusted or they are not needed. Good documentation is of secondary importance until trust and need are established.
- Several causes of poor documentation include: the absence of an organizational unit to provide on-going support and maintenance; the difficulty of the task of preparing good documentation; the lack of writing ability on the part of the model developer; a definition of what constitutes good documentation; inadequate time, funds and staff.
- The principal needs for producing good documentation are: an organizational unit which is responsible for model development, documentation, and continuing use and maintenance; identification of the essential information which should be included in user documentation; a model developer who has the desire, ability and time to prepare good documentation.
- The principal constraint to producing good documentation is the establishment of responsible organizational units within each agency to support and use developed models.

The development of a computer model should be viewed as the beginning of a new tool, a new technology, a new capability. Documentation is intended to assist future users in the application of the model. However, documentation can never be successful by itself. On-going technical and organizational support are needed. Someone must be responsible for its future.

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