IS STANDARDIZATION OF COMPUTERS FOR TRAINING SIMULATORS A MYTH?

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SUMMARY

The increased use of digital computers in training devices and operational equipment since 1960 has presented many new problems to NTDC. A study of the application of digital computers to training devices and of the experience with these devices in the field has revealed problems in hardware, software and personnel that must be resolved if training devices using digital computers are to satisfy the complex requirements imposed on them. A discussion of some of these problems and a recommendation for a short and long range approach to their solution is presented in this paper.

HISTORY

Often, in the initial development and application of digital computers and digital techniques to operational equipment and training devices, special purpose equipment and techniques were designed and developed to perform a special function. It was felt that it was more economical to design the computer for a specific purpose rather than to design or to purchase all of the additional capacity of a general purpose machine. Very often, the special purpose equipment was all that could meet the environmental demands imposed on the operational equipment. As the requirements of the problem changed and modifications were required, it was necessary to design additional equipment or make extensive modifications in the existing equipment. Because of the initial investment in time and money in the original special purpose concept or the stringent nature of the environmental requirements, this was the only way to proceed with modifications. It soon became apparent that with continually changing requirements in the computer system due to changes in tactics, design, equipment, and capabilities in the operational world, that the flexibility of general purpose digital computers in the long run overcame the short range economic advantage of special purpose equipment.

As the state-of-the-art of digital computers progressed, with increasing speeds, smaller size, and more reliable operation, general purpose digital computers have tended to replace special purpose computers in many systems. As an historic example, the Navy's operational ATDS system had progressed from a DDA (Digital Differential Analyzer) magnetic drum type machine through a magnetic drum, general purpose type, digital computer to a random access magnetic core, general purpose type, computer. This same progression from special purpose digital computers has been evident in training device development.

In the past, in the training device field, we have had a very broad range of requirements for digital computation. These requirements have been filled in each specific case by examining the problem and providing a digital computer, either special purpose or general purpose, that will meet the minimum requirements specified. This had led to the proliferation of a variety of special and general purpose machines. Each of these machines may have been the most suitable one for the particular device at the time of its conception. However, the variety of machines has led to a variety of spare parts, programs and programming methods, maintenance training requirements, and modification problems.

We are presently performing a survey of the digital computers used in NTDC training devices since we first began using general purpose digital computers. Some very interesting statistics have been accumulated as a result of this survey. The preliminary data reveals the growth and use of digital computers, the range and breadth of computers and computer characteristics, and the variety of computer types and manufacturers used in training devices.

Figure 30 shows the number of computers versus the year of acceptance of the devices. The proposed figures are projections for devices under contract or proposed which definitely

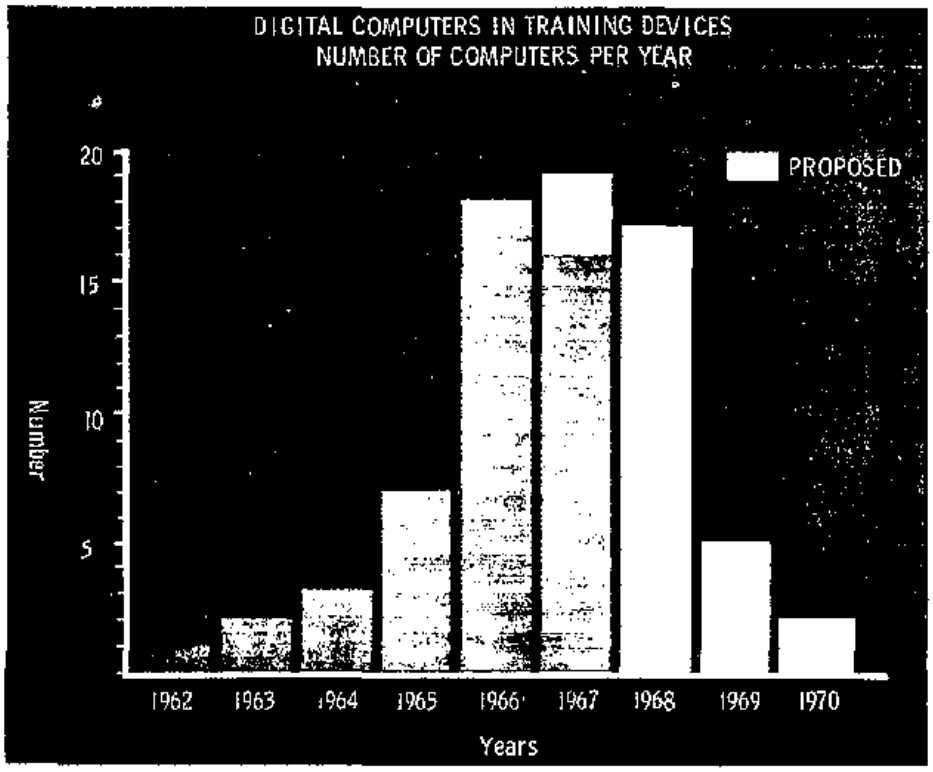

Figure 30. Digital Computers in Training Devices
Number of Computers per Year

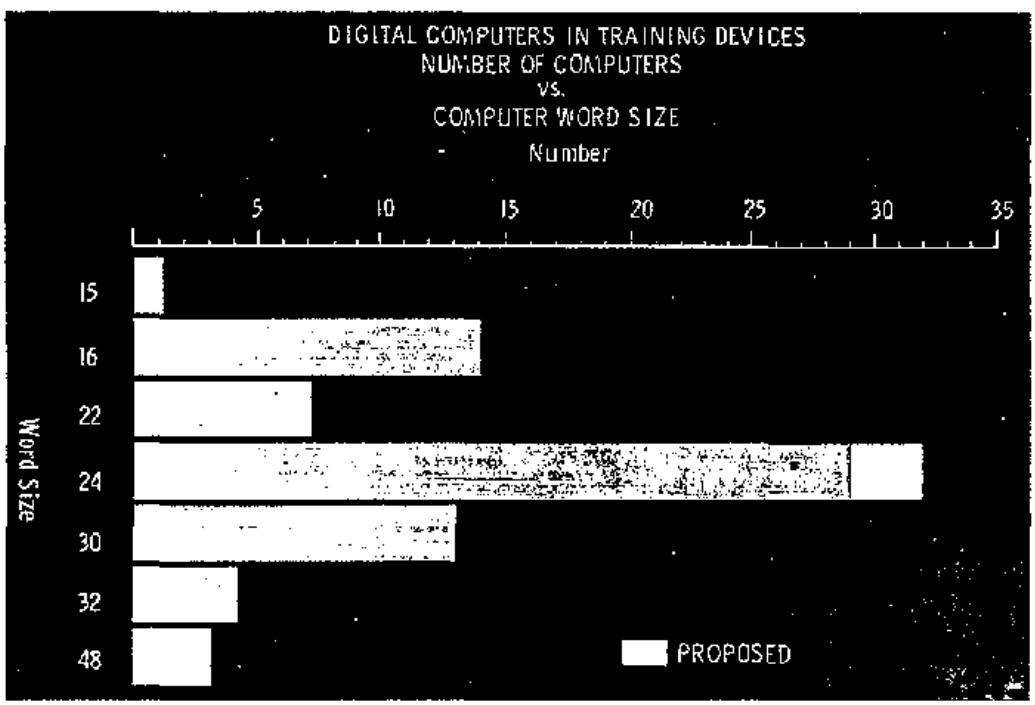

Figure 31. Digital Computers in Training Devices
Number of Computers vs. Computer Word Size

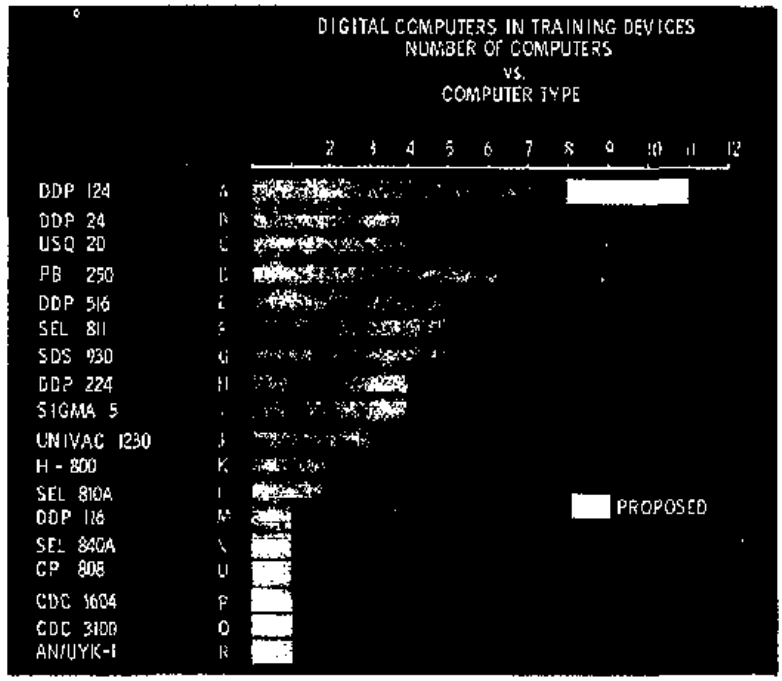

Figure 32. Digital Computers in Training Devices Number of Computers vs. Computer Type

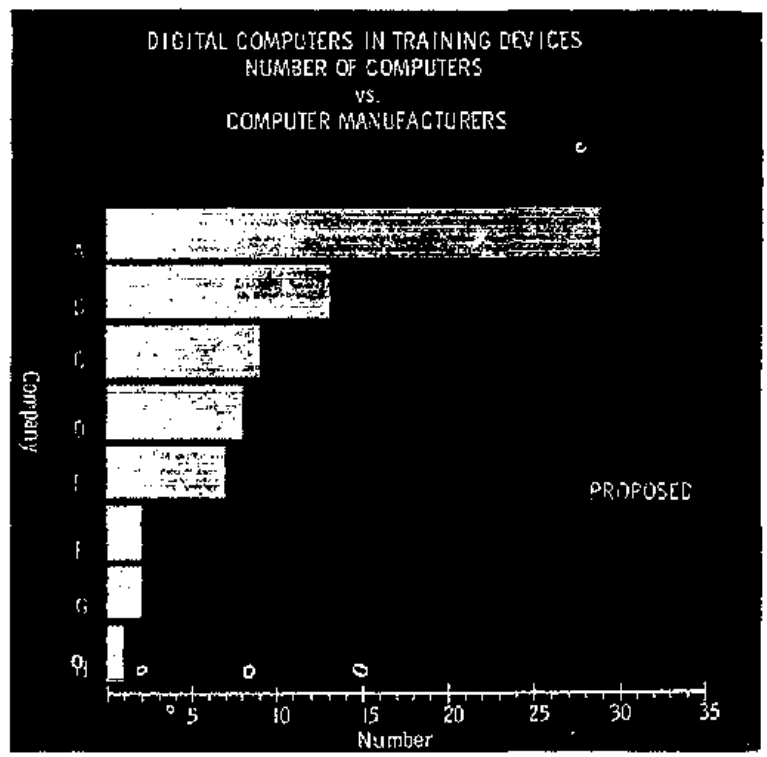

Figure 33. Digital Computers in Training Devices Number of Computers vs. Computer Manufacturers

have digital computers. There has been no attempt to project estimates for devices required in the future but not under contract or proposed and for which there is no specific digital computer requirement. The decrease in the number of computers after 1967 is therefore misleading because of the way the figures were obtained and plotted. The graph does indicate the growth in the use of digital computers in our trainers, i. e. from one computer in 1962 to 18 computers in 1966. However, the total number of computers per year is still less than the number that might interest the larger computer manufacturers.

Figure 31 indicates a range of word sizes used in our digital computers. The greatest number of computers, i. e., 29, used 24 bits, which has been the more popular size for medium size machines. It will be noted that 16 bits is the next most numerous and 30 bits, which is used in the Naval Tactical Data System computers, is the next most numerous. The use of the NTDS computer has been an attempt at standardization with all the attendant advantages. However, even in this system, computers become obsolete and since 1960 there have been three versions of the USQ-20, the NTDS computer.

Figure 32 indicates the number of computer types utilized in training devices. There have been 18 separate types of computers used in training devices in the past 5 years and this does not include the variations in the USQ-20. It is most interesting that 9 of these, and possibly 10, are no longer manufactured and may be considered obsolete. It will be noted that the total of any particular type is a maximum of 10, or possibly 11, if the proposed trainers are purchased.

Finally, Figure 33 indicates that over this 5-year period, one manufacturer has provided 29 machines with three more proposed for the future. While not shown in the figures, these 29 include five different types with no more than 11 of any one type. This is certainly not a number that any computer manufacturer will get very excited about or that any one will get rich on. It will also be noted that eight different computer manufacturers have provided computers for training devices. This then presents a brief picture of the history of the last five years of the use of digital computers in training devices, many computers, many manufacturers, many types and much obsolescence, certainly not a fruitful field for the investment required to design and produce a universal standard computer or family of computers. Of course, the picture is not as dark as I have painted it, because the AF, NASA, the simulation industry and the airlines are also customers of the same type of machine.

At this time it would give me great pleasure to announce the introduction of a standard Navy computer for training devices which will be furnished to our device manufacturers as GFE. This computer will be a state-of-the-art, third generation machine with a word size variable from 16 through 48 bits in one bit increments. It will be modular in memory with a memory capacity variable from 2000 words to 132,000 words. It will be modular in speed so that it can take care of our slow, as well as our fast problems. It has been designed so that all computer manufacturers may equitably and competitively manufacture it. Programs will be compatible from the smallest machine to the largest machine and vice versa. And of course, spare parts and maintenance procedures will be identical for all machines. Finally, the machine with slight modification can be up-dated to a fourth generation machine so that it will not become obsolete and the investment in programs, spares, and operator and maintenance training is effectively recoverable.

This brings me to the title of my paper, "Is Standardization of Computers for Training Devices a Myth?" As I have said before, it would give me great pleasure to announce this standardized and universal training device computer but unfortunately this standardization is a myth at the present time. The rest of this paper will deal with a more realistic approach to the standardization of computer techniques in training devices.

PROBLEMS

What are some of the major problems we face? As the age of digital computer activated

training devices in the field increases, the problem of up-dating and modification increases. Changes in the training requirements, changes in the operational equipment being simulated, changes in the application of tactics, all require changes in the computer and/or the program. These changes may be major or minor but they all require an analysis reprogramming possibly additional computer capacity and/or speed, and personnel to perform these functions.

One of the advantages of digital computers, especially general purpose computers, is their inherent flexibility whereby changes in programing can change characteristics of the training device. Special purpose computers are generally less flexible and less amenable to change. The Center has attempted to make provision in its hardware specifications for this flexibility for modification by specifying general purpose digital computers having certain minimal expansion capabilities in spare time and spare memory. These computers specifications have been a part of all our major training device procurements. Most of these specifications have been incorporated in toto into MIL-STD-876, Military Standard, Digital Computation Systems for Real Time Training Simulation.

Often in special purpose computers, and less frequently in general purpose computers, this expansion capability is provided but in a way which is not easily utilized and defeats the very flexibility which we seek.

The ultimate solution would be to have universal computers, with universal programs, modifiable simply, and on the site, by untrained personnel. I have already discussed this standardized universal computer solution.

A variety of alternatives to the solution of these major problems is possible. Essentially these would involve standardization of hardware design, software, and military and civilian personnel training. Let us look at each of these alternatives individually.

HARDWARE

The utlimate solution as far as hardware is concerned is the development of that universal digital computer to be used for all training devices or the adaptation of existing or proposed commercial computers to this end. Let's standardize!! As I have indicated,the extensive range of training devices requiring digital computers would require a variety of word sizes, computer speeds, memory capacities and peripheral equipment that would make the use of a computer that could meet all these requirements uneconomical in the less complex devices because it would be essentially too large for the job. While it is true that the Center does require a great many digital computers, it is questionable that the development costs for such a universal computer would be justifiable in the numbers we require. The use of an available commercial machine as a standard is possible but not probable and would further complicate the situation with problems of competition, proprietary rights, conformance with BuBud, DOD, and SECNAV ADP Instructions, etc. In addition, the state-of-the-art of computers has progressed so rapidly and the effective obsolescence rate is so high that the effective life time of a computer system is about four to five years and restricting ourselves to one universal computer would limit us in taking advantage of changes in the state-of-the-art.

A second alternative would be the development of a family of compatible digital computers which could be modular in capacity and easily combined to provide for the requirements from the smallest to the largest training device. This solution provides even more obstacles in equipment design than the first alternative although it would in a sense tailor the size, speed, capacity, etc., to the requirements of the training problems.

The most practical alternative at the present time is to specify the use of general purpose digital computers, preferably commercially available ones. In this fashion, the Center obtains the advantages of progress in the state-of-the-art, the availability of large software libraries developed by the computer manufacturers and other users, and the extent of stand-

ardization prevalent in the industry. Maintenance, operating and programing personnel are available from industry-trained channels.

The last and least desirable alternative is the design of special purpose computers for a range of problems or for a specific problem. This alternative adds logistic problems of special spare parts, special training and generally dependence on the original prime contractor for assistance in any modification program.

The only effective standardization we can realize in hardware at this time is in the standardization of certain computer characteristics by the computer industry under pressure from the National Bureau of Standards, Center for Computer Science and Technology, the Department of Defense, the Navy or for training device computers by the Naval Training Device Center. Standardization is possible in word or byte format, in logical levels, in input-output format, controls and levels, in analog to digital and digital to analog conversion methods, and the like. This type of standardization would permit interfacing equipment of different manufacturers, and would eliminate some of the unpleasant aspects of dependency upon any one manufacturer for additional equipment or spares. Additionally this type of standardization would be more likely to permit updating with fourth generation equipment without major modification. We hope our survey of digital computer activated or actuated training devices will result in a compilation or a design guide of effective standards of this type for training devices. The problem is compounded by our dependence on industry for computers that meet our standards.

SOFTWARE

In the software area it would be most desirable to have a universal simulation language or a simulation compiler which would permit programs to be written that could be used on any type of general purpose digital computer. This suggestion might be feasible but is extremely impractical. The computer industry itself has spent millions of dollars trying to develop universal languages such as COBOL, ALGOL, and PL 1 which are still not applicable to all computers. The cost of such an effort would be staggering.

A simpler and more realistic approach would be to specify universal data formats, data files, types of executive control and other programing standards which would provide the most efficient programing of simulation problems especially in the analysis and flow charting stage and would lend itself to assembly by assembler or compiler languages commercially available in the general purpose digital computer field. Unfortunately the programing (including problem analysis, mathematics, etc.) of digital computers cannot be a completely automated or technician type task and professional talents would still have to be utilized. However, the standardization of data files and formats, executive controls, standard routines and I/O methods would make possible the training of these professionals and their efficient utilization on more than one machine.

A lesser alternative would be the establishment of standards of programing and documentation in some sort of reasonable general purpose format compatible with the state-of-the-art and training of commercial scientific programers, so that programs could be modified with some study by reasonably capable programing personnel.

The least desirable alternative is the development of special purpose programing methods and standards which would be unintelligible to all personnel except those trained in these specific programing methods. The training of these personnel would be applicable only to a particular system. The Center could not avail itself of programers trained elsewhere in the state-of-the-art and would require extensive training programs to train or retrain such personnel for these special applications.

PERSONNEL

In the last category of standardization for modification is the area of programing personnel. The most desirable alternative would be to have military personnel trained in universal computer and universal programing methods available at digital computer installation sites for program maintenance and modification. It is doubtful that the professional talents required for such positions would be readily available in sufficient quantities within the military structure. It would be likely that personnel of limited training could be made available to provide for routine maintenance and minor modification of programs after training on the specific computer in the device.

Another alternative, for devices which are large and complex and are located at major training bases where GTS (Government Technical Service) personnel are available, would be the training of GTS personnel as programers. These personnel could provide for extensive modifications where extensive modifications, where extensive analysis in aerodynamics, mathematics and programing are required.

An alternative which would be very satisfactory provided sufficient priorities and personnel were available is the development of an in-house programing capability at NTDC which could serve as the development center or clearing house for all training device programs, program libraries and program modifications for the fleet. In the case of devices using NTDS computers we have utilized the Fleet Programing Centers for this purpose. Unfortunately these organizations have tremendous workloads of their own and cannot impose training requirements upon their existing operational workloads.

As it is not possible to develop this in-house capability immediately, competitive procurements among a reasonable number of software contractors would provide a means of modifying programs and also build up a capability in the computer software field for the type of programing required by NTDC. In order to employ this alternative it would of course be necessary that reasonable standards of programing and program documentation be implemented so that sufficient material would be available for these contractors to independently update training devices.

The last and least desirable of all alternatives is to return to the original prime contractor each time a modification or update is required because he alone has the capability and understands the program, its documentation and the computer that he has provided.

This then is our short-range approach to standardization—a standardization of hardware and software techniques rather than any attempt to standardize on hardware or software itself.

What is the long range approach? The long range approach is a Navy-wide approach. In August 1967 the Chief of Naval Operations issued a letter to all commands having data processing responsibilities, emphasizing his concern "over the proliferation of computer types programing languages, peripheral equipment and varying documentation in Navy Combat Data Systems" and "to initiate planning for future standardization." Working groups are being established for in-house software support, equipment standardization, and standardization of software production techniques.

Many of the objections enumerated earlier to standardization become invalid if applied to an all Navy or all DOD effort. The standardization of computers and their provision as GFE to trainer manufacturers may then be a possibility.

So, ladies and gentlemen, in answer to the question, "Is Standardization a Myth?", the answer is, no. A myth, to quote Webster, is "a person or thing existing only in imagination." Rather, standardization is a goal. And our deadline? Late 60's. Would you believe 70's?