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# Development Of Program For Computer-Aided Structural Detailing Of Ships

B-171635

Department of the Navy

**BY THE COMPTROLLER GENERAL  
OF THE UNITED STATES**

JULY 19, 1971

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COMPTROLLER GENERAL OF THE UNITED STATES  
WASHINGTON, D.C. 20548

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Dear Mr. Ruppe:

In response to your letter dated December 21, 1970, we have examined into the Navy's development of the Computer Aided Structural Detailing of Ships (CASDOS) program. The attachment to your letter, which was from an anonymous source, raised the following questions.

- Was the development of CASDOS necessary and were the Government's interests protected in the development effort?
- Did the Navy develop a computer program that was already available on the commercial market?
- Will the Navy's CASDOS program be a competitor to commercially available computer programs?
- Is the Navy providing free of charge a commodity or service having salable value?

In addition to a discussion of these matters and our conclusions, we have included some background information on the CASDOS program to provide a better understanding of the Navy's actions regarding the program.

The Navy had, in our opinion, a valid requirement for initiating the development of CASDOS. The decision to continue this program appears to have been reasonable and in the Government's interest. Commercial programs were not available when the CASDOS development was begun. Currently available commercial programs would require extensive and costly modifications prior to their use by the Navy.

To the extent that some portions of the CASDOS program will be separable and have commercial ship applications, they could be competitive with commercial programs if they are made available through a computer service network or Government-sponsored library. This appears, however, to be limited in nature because CASDOS is being developed specifically for the design and construction of Navy ships.

The details of our examination follow.

OBJECTIVE OF CASDOS

The Navy has been actively involved in the application of computers in ship design and construction processes since 1948. The Navy now has more than 165 ship computer programs in operation and about 40 more under active development. The programs range from conceptual design modeling of ships to the development of detail design and working plans for construction. It is in this latter phase, the preparation of detail design and working plans, that the Navy's main thrust to achieve automation of the ship design process has occurred.

The Navy's CASDOS program is expected to enable a computer to (1) accept as input basic contract plans and specifications, (2) verify the design to Navy specifications, and (3) produce the detailed working plans and fabrication drawings needed for actual shipyard construction. As by-products, the CASDOS program is planned to enable the computer to provide bills of material, weight reports, and control tapes for automated steel-plate-cutting equipment.

The CASDOS program is the largest and most ambitious computer program for ship design sponsored by the Navy. When completed, it will consist of more than 200,000 program statements, as contrasted to other Navy or commercial ship computer programs which range in size from 5,000 to 40,000 statements.

The CASDOS program is one part of an overall Navy plan to achieve total automation of the ship design and construction processes. The objective of the overall plan, called Computer Aided Ship Design and Construction (CASDAC), is to develop general-purpose computer programs like CASDOS for use in all phases of ship design and construction.

According to Navy officials, CASDAC, through its automated function, will permit a ship designer to design better and faster, to examine more alternatives, and to produce more complete and error-free designs. This is a long-range program

expected by the Navy to extend over a 15- to 20-year time span and to require total funding of about \$160 million.

#### DEVELOPMENT OF CASDOS

At the time the Navy initiated development of CASDOS, most of the Navy's ships were being constructed in Government-owned shipyards. Recognizing a need to improve its shipbuilding operations, the Navy turned to the computer as a possible tool for reducing design time and cost. Following the successful production of engineering drawings by computer in 1962, the Navy awarded a contract in November 1962 to determine the feasibility of using a computer to design detailed ship structures.

On the basis of successful results of the feasibility contract, the Navy solicited proposals for the development of a computerized ship design and detailing program. Eleven firms responded with proposals. On the basis of technical competence, Arthur D. Little, Inc., Cambridge, Massachusetts, was selected as the development contractor. In June 1965 a contract at an estimated price of \$1.8 million was awarded to Arthur D. Little, Inc., to develop the CASDOS program. Although a completion date was not specified in the contract, the contract provided for delivery of specified work within 35 months of the effective date of the contract, or by May 1968.

Significant progress was shown in the development of CASDOS under this contract. For example, in December 1966 a ship's bulkhead was detailed by computer in a completely computerized operation. In 1967 ship bulkhead plates were cut using numerical control tapes produced by CASDOS.

In 1968 a revision in Navy ship construction policy led to a reevaluation of the CASDOS program. The revised policy called for contracting for detail design work of Navy ships and for the construction of Navy ships in private shipyards. Consequently, the CASDOS program was no longer needed by the Navy for its in-house use to the extent originally intended. The Navy, however, elected to continue this program.

According to Navy officials, several factors entered into the decision to continue the CASDOS development. First, early test results were excellent and showed the use of the CASDOS program to be superior to manual methods. Cost savings of up to \$2.6 million for a large ship were predicted in addition to a reduction of about 10 months in the lead time necessary for ship construction. Further, the Navy had a sizable investment in CASDOS and one of the most important portions of the program--the mathematical description of the ship form--was nearing completion.

An even more important consideration was that there was no similar ongoing development effort in the United States, and it was foreseen that private shipyards could use CASDOS for the construction of ships built to Navy design criteria and specifications. The Navy anticipated that it would achieve the cost savings and design time reductions whether CASDOS was used by the Navy or by a contractor.

As a result of the Navy's decision to continue CASDOS, a follow-on contract was awarded to Arthur D. Little, Inc., in August 1968. This contract, estimated at \$1.2 million, provided for funding the development program through June 1971. The contract called for the continuation of the original development effort and expansion into additional ship design areas to attain the capability to completely detail the design of an entire ship.

Progress has also been demonstrated under the follow-on contract. Since 1968 most major portions of the CASDOS program have been completed. According to the project engineer, the completed portions of the program were to be tested and ready for operational use by June 1971. Several portions of the program already have been used to perform some of the actual detailing work for two new Navy ships. Reports received by the Navy from private shipyards engaged in naval construction indicate that the program, to the extent it was available, performed satisfactorily.

According to the CASDOS project engineer, the development program will be completed by June 1972. A Navy official stated that about \$100,000 of additional funds would be required to complete the development and that, upon completion of this work, no further effort in the form of follow-on contractor support would be required from the development contractor.

### Conclusions

In our opinion, the Navy had a valid requirement for entering into the CASDOS development. In addition, the selection of the development contractor was made in accordance with approved procedures.

On the basis of the anticipated cost savings and reduction in lead time from the potential use of CASDOS by private shipyards for Navy ships and on other stated rationale, the Navy's 1968 decision to continue the CASDOS development appears reasonable and in the Government's interest.

### AVAILABILITY OF COMMERCIAL COMPUTER PROGRAMS TO FULFILL THE NAVY'S NEEDS

#### Commercial developments

According to Navy records and information furnished by Navy officials, there was no similar development effort in the United States when the CASDOS development was begun. There were, however, three programs under development in foreign countries. These were the AUTOKON program which was being developed in Norway and the VIKING and STEERBEAR programs which were being developed in Sweden. Of these, only AUTOKON is now available for sale commercially in the United States.

The AUTOKON program has been available since 1966. The program, as developed, was designed to produce paper tapes used to control automated steel-plate-cutting equipment with input data being derived from previously prepared detailed structural drawings. The program was later modified to

provide additional capabilities. According to a report on the Scandanavian Maritime Community dated February 1971 and prepared by the Maritime Administration, U.S. Department of Commerce, AUTOKON currently is capable of performing several ship detailing functions. The report states also that "the production system AUTOKON" may be linked to a Norwegian-developed ship design program called PRELIKON. PRELIKON, at the present time, consists of basic ship design packages for three types of commercial ships--tankers, bulk carriers, and alternative use ore/bulk/oil carriers.

In addition to the foreign developments, several computer-aided ship design and construction programs have recently been developed by shipyards in the United States. The Avondale Shipyards, Inc., New Orleans, Louisiana, developed a program called CALIKON which is comparable to the AUTOKON program in its use and capabilities. The Sun Shipbuilding and Drydock Company, Chester, Pennsylvania, has a license to convert the Swedish STEERBEAR program for the company's future use. The Newport News Shipbuilding & Dry Dock Company, Newport News, Virginia, is experimenting with a ship computer program called TRIDENT. According to a company official, TRIDENT will be comparable to AUTOKON or CALIKON.

Other shipyards have developed smaller programs, but we could find no other developments of the magnitude of those mentioned above.

#### Differences between CASDOS and commercial programs

The CASDOS program and the commercial programs were developed for different purposes. When the CASDOS development began, the Navy was interested in using a computer to reduce time and cost in the structural detailing portion of an overall ship design and production program. Input to CASDOS was to be design information and primary output was to be detailed structural drawings prepared in accordance with Navy ship specifications. Although the Navy contract for CASDOS did provide for developing tapes to control automatic

equipment, this feature was considered to be a by-product of the development effort rather than one of its primary objectives. When the CASDOS program was begun, it was intended to be used in-house by the Navy, which did not have any automated steel-plate-cutting equipment. Therefore CASDOS was originated primarily as a design detailing tool, as contrasted to a production tool.

According to Navy records and other sources of information, commercial programs available when the CASDOS development was started were oriented toward production and were developed to automate the production of tapes used to control production operations. Although subsequent improvements have moved at least one commercial program (AUTOKON-PRELIKON combined) toward the design phase, this capability did not exist in 1966. At that time commercial programs were more in the nature of production tools.

The CASDOS program and commercial programs were designed for significantly different types of ships. CASDOS was developed specifically for the structural design of Navy ships, with Navy ship design specifications being an integral part of the program. Generally Navy specifications are more stringent than commercial specifications and consequently construction to Navy specifications is more costly.

Further, CASDOS was developed to be capable of producing structural design drawings for combat ships ranging from small destroyers through aircraft carriers. Structurally these ships differ from commercial vessels, the major difference being that Navy vessels are longitudinally framed and have main supports running the length of the ship; whereas commercial vessels are transversely framed and have supports running across the ship.

According to the Maritime Administration report, the two foreign programs (AUTOKON and PRELIKON), when linked together, would perform detail design and production functions and, so far as we could ascertain, would constitute the only currently available commercial program that approximates CASDOS. The

report indicates, however, that some aspects of the AUTOKON program are still under development. Moreover, the report indicates that the combined AUTOKON-PRELIKON program could be used only for detailed structural design of three specific types of commercial ships. Consequently, according to a Navy official, the AUTOKON-PRELIKON program would not be capable of the structural design of ships to Navy specifications without extensive modifications.

### Conclusions

In view of the differing requirements that CASDOS and commercial computer programs were developed to meet, we believe that none of the commercial programs that then existed, or were under development when CASDOS was begun, could have fulfilled the Navy's needs.

Although a commercial program is now being modified to provide some of the same capabilities as those of CASDOS, these capabilities did not exist when CASDOS development was begun. Further, our review indicated that this modified commercial program would not be usable for the design of Navy ships without extensive modifications to provide for differences in specifications and methods of framing and construction. It is possible that extensive modifications to computer programs such as these would cost as much as the development of completely new programs.

### CASDOS AS A COMPETITOR OF COMMERCIAL PROGRAMS

As discussed above, the CASDOS program was specifically developed for the design and construction of Navy ships. Consequently, without extensive modification, CASDOS would not be suitable for the design and construction of commercial ships. Moreover, the CASDOS program was developed primarily as a ship design aid whereas commercially available programs were developed primarily as ship production aids.

Although the CASDOS program in its entirety could not be used for the production of commercial ships, some parts of the program, such as the subroutines involved in the preparation of control tapes for automatic plate cutting machines, presumably could be used. In one instance, a commercial shipbuilder (Seatrain Shipbuilding Corporation, New York, N.Y.) did attempt to use the CASDOS control tape preparation subroutine. According to Navy officials, this trial was inconclusive because the subroutine was not sufficiently developed at that time to be adaptable to commercial shipbuilding operations.

Earlier, this CASDOS subroutine had been successfully used in the construction of a Navy vessel at the Puget Sound Naval Shipyard, Bremerton, Washington.

#### Conclusions

In our opinion, CASDOS is not now competitive with computer programs available on the commercial market. Some portions of CASDOS, however, can apparently be separated from the rest of the program and may have commercial ship application. To the extent that these conditions exist, some of the subroutines could be competitive with commercial programs.

#### NAVY DISTRIBUTION OF CASDOS AT NO CHARGE

Computer programs developed for Department of Defense components or activities represent a valuable resource. Prior to 1969, Department of Defense policy regarding the release of these programs to non-Government entities was based on serving the public interest. In response to an Air Force inquiry, however, the Assistant Secretary of Defense (Comptroller), in a memorandum dated April 1969, cited an Attorney General's ruling that computer programs were to be considered as property and were to be subject to user charges. But he also stated that this should not discourage or prevent the release of computer programs to non-Government entities when in the public interest. In October 1969, in order to develop specific

policy, the Assistant Secretary of Defense requested the accumulation of information regarding non-Government requests. Since 1969, however, no further action has been taken by the Office of the Secretary of Defense to publish specific policy guidance.

The Navy, to a considerable extent, has established its own policy concerning the distribution of Navy computer programs. A Navy instruction concerning such distribution states that:

\*\*\*\* Their value to a potential user is primarily economic; if he is given one of these programs to use, he thereby foregoes paying the development cost himself. \*\*\*\*

Thus the Navy has recognized that its computer programs have value. However, the Navy's instructions for distributing the programs do not contain provisions for selling or renting them. Instead, all distribution is apparently authorized to be made on a no-charge basis. We were informed by the Deputy Comptroller of the Navy that Navy computer programs may be made available to private users on a no-charge basis in the following circumstances.

1. When a Government contract provides for the use of a program in fulfillment of the contract.
2. When the Government would, under contract, incur the cost to develop a similar program.
3. When a requested program can be made available through the Computer Software Management Information Center (see p. 12), in which situation the Navy may, alternatively, furnish the program directly to the requester.
4. When the requester is a member of a user group--an organized group of program users with common interests--in which the Navy organization participates.

When requests are made to Navy organizations or commands for Navy computer programs that do not meet one of these criteria, they are to be submitted to higher Navy authority for approval.

The Navy has encouraged the use of CASDOS in shipyards holding Navy contracts. In October 1968 the Navy advised 15 ship contractors of the CASDOS project and stated that maximum benefits to both the Navy and its shipbuilders appeared possible through its use. The announcement went on to state that the CASDOS system was incomplete, had not been validated in a shipyard environment, and would entail verification by the user.

To date, three private shipyards have used completed portions of the CASDOS program. Two of these shipyards--Newport News Shipbuilding & Dry Dock Company, and Litton Industries Ingalls Shipyard, Pascagoula, Mississippi--were participating in major Navy ship construction programs. The third shipyard--Seatrain Shipbuilding Corporation--specializes in the construction of commercial vessels, primarily oil tankers, and did not have any Navy ship construction contracts.

The complete CASDOS package has not been used by any shipyard because portions are still under development. In each case where the Navy made the incomplete program available, it has been, from the Navy's viewpoint, a means of obtaining test and evaluation results of the operational use of CASDOS. Further, in each case CASDOS was made available through the development contractor only after its use was requested by the shipyards.

The Navy has not incurred any cost in providing the incomplete CASDOS program to shipyards, and it has received the results of practical application of CASDOS in a shipyard environment. In addition, the Navy received the benefit of an important program modification, the cost of which--about \$10,000--was borne by the using shipyard. This modification was necessary for the future use of the complete CASDOS program by private shipyards having Navy contracts.

The Department of Defense has not developed a policy for making computer programs available through a Government-sponsored library called Computer Software Management Information Center; however, the Navy plans to put parts of the CASDOS program in that library. The Center, which is operated by the University of Georgia under contract with the National Aeronautics and Space Administration, was established as a means to make available to the public, at nominal cost, the vast library of unclassified Government-developed computer programs. It currently has more than 900 computer programs in its library, including about 30 Navy programs.

The Center charges a nominal fee (usually about \$300) for each computer program that it distributes. The fee proceeds are used to defray administrative and processing costs. According to a National Aeronautics and Space Administration official, no part of the fee proceeds is turned over to program-contributing Government agencies for application toward the development costs of the programs.

A Navy memorandum issued in December 1970 provided for the no-charge release of computer programs to private entities that are members of user groups in which a Navy organization participates. In view of the Navy's participation in the Ship Industry Advisory Council, the Navy considers that organization to be a user group for Navy ship computer programs. Thus under Navy policy, members of the Ship Industry Advisory Council are entitled to receive Navy ship computer programs free of charge.

The Ship Industry Advisory Council was established by the Navy about 3 years ago to promote the free exchange of information, technical ideas, and problem solutions between the Navy's private shipbuilders and the Navy. In addition, the Navy wished to encourage the sharing of privately and publicly developed computer programs for the design and construction of naval ships.

Through the Ship Industry Advisory Council, the CASDOS program and at least 12 other Navy-developed computer programs

for ship design and construction are planned to be made available to U.S. shipyards on a nationwide computer service network. The network tentatively selected for this purpose, called Cybernet, is owned by the Control Data Corporation, St. Paul, Minnesota. According to Navy officials, Cybernet was chosen because it is the network that offered the best technical features to meet Navy needs. A contract to make Navy computer programs, including CASDOS, available to Ship Industry Advisory Council members through the Cybernet network is currently being negotiated between the Navy and the Control Data Corporation.

According to the Deputy Comptroller of the Navy, the Navy's plans for future additional distribution of CASDOS are not firm, pending resolution of certain policy questions.

### Conclusions

We believe that some of the computer programs developed by the Navy have economic value. Navy instructions recognize that some of their programs have economic value although they do not provide for its specific quantification. The Office of the Secretary of Defense has provided some directions which are to be followed by the military services in making programs available to non-Government organizations; however, at the time of our inquiry, the Office had not published specific formal policy on this matter.

To the extent that the CASDOS program is made available through a computer service network or Government-approved library, it may become competitive with commercially available programs. This will be limited, however, because the program is being developed specifically for Navy ships.

Inasmuch as the Navy obtained test and evaluation benefits through the use of parts of CASDOS by three private shipyards, this use appears to have been in the Government's interest. Since the Navy's plans for the future distribution of CASDOS are not firm, they cannot be conclusively evaluated at this time.

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We trust that the above information is responsive to your needs. We plan to make no further distribution of this report unless copies are specifically requested, and then we shall make distribution only after your agreement has been obtained or public announcement has been made by you concerning the contents of this report.

Sincerely yours,

  
Thomas B. Acosta  
Comptroller General  
of the United States

*u* <sup>+R</sup>  
The Honorable Philip E. Ruppe  
House of Representatives