UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

MISSION ANALYSIS AND
SYSTEMS ACQUISITION DIVISION

B-199008 **RELEASED** MAY 24, 1982

118750

The Honorable Jack Brooks
Chairman, Committee on Government
  Operations
House of Representatives

Dear Mr. Chairman:

Subject: Evaluation of DOD Comments Re: "DOD Instruc-
          tion 5000.5X, Standard Instruction Set Archi-
          tectures for Embedded Computers"

As requested by your office, we have evaluated the Department
of Defense (DOD) comments on our letter report "DOD Instruction
5000.5X, Standard Instruction Set Architectures for Embedded
Computers" (MASAD-82-16, Jan. 27, 1982).

We recommended that the Secretary of Defense not implement
Instruction 5000.5X. We also recommended that the Secretary of
Defense direct the services to reevaluate their ongoing efforts
and demonstrate why they are more cost effective than standardiz-
ing on a high-order language such as Ada and relying on the com-
puter industry to provide the stimulus for computer architectural
innovations.

DOD disagrees with our conclusions and recommendations. DOD
continues to take serious issue with our assessment of the via-
bility of Instruction 5000.5X. DOD maintains that its rationale
for curtailing high hardware and software costs is sound. That
is, by legislating the architectures for embedded computers, DOD
contends that hardware and software costs will be minimized.

However, we contend that DOD's approach of mandating its own
architectures should be challenged because it duplicates commer-
cially funded hardware and software research and development in-
vestment. More importantly, it constrains the creative potential
of the electronics industry in applying modern technology to solve
military problems. We are also concerned that the duplication will
result in DOD spending considerable amounts of research and devel-
opment money for technologically obsolescent computer systems. We
address each of DOD's concerns in our enclosed evaluation. In ad-
dition, we plan to provide a comprehensive evaluation of their key
issues in our forthcoming report on this subject.

(954047)

As arranged with your office, unless you publicly announce
its contents earlier, we plan no further distribution of this
report until 30 days from the date of the report. At that time
we will send copies to interested parties and make copies
available to others upon request.

Sincerely yours,

W. H. Sheley, Jr.
Director

Enclosure

EVALUATION OF AGENCY COMMENTS

DOD INSTRUCTION 5000.5X, STANDARDIZATION

SET ARCHITECTURES FOR EMBEDDED COMPUTERS

DOD LETTER

I must respectfully disagree with your conclusions that:

    o "...this (proposed) policy would lock DoD into the use
       of inferior technology."

    o "...DoD would not be able to take advantage of private
       industry's technical innovations."

    o "...it would severely restrict competition to those
       companies willing to help DoD implement obsolete
       technology."

Our experience to date has demonstrated the opposite effect.
Hence, we believe the proposed policy is an established success,
even before formal issuance.

OUR EVALUATION

The majority of programs within DOD that use embedded com-
puters do not use computers defined by this proposed standard.
The experience in the Navy where standard computers are used
cannot, by any stretch of the imagination, be considered "an
established success."

DOD LETTER

The GAO was invited to observe meetings of the recent Defense
Science Board review of this subject. However, the two groups
reached quite different conclusions. Further, the conclusions
and recommendations of the GAO report do not track with their
earlier reviews of this same issue ("The Department of Defense's
Standardization Program for Military Computers--A More Unified
Effort is Needed," June 18, 1980, LCD-80-69).

OUR EVALUATION

The report (LCD-80-69) mentioned is almost 2 years old.
Some of the conclusions reached at this earlier date could indeed
be different and would again demonstrate the rapid technology
advance within the computer industry.

DOD LETTER

One recommendation from that earlier report, and echoed in the current letter report, is that Ada should be implemented as DoD's standard programming language. We agree. We followed GAO's recommendation to establish a tri-Service program office for that purpose.

OUR EVALUATION

We are pleased that DOD is moving forward with Ada. It appears, however, that the computer industry may be moving faster than DOD, because DOD is not uniformly and readily accepting its own success with Ada.

DOD LETTER

Experience with the principles of 5000.5X, although it has not been formally issued, are:

- There were 12 significant bidders for the Army Military Computer Family (MCF) Program based upon the Government MIL-STD-1862 Instruction Set Architecture (ISA). Earlier, when the program was based upon a commercial ISA, there were only two.

OUR EVALUATION

The previous program which resulted in only two bidders had more problems besides the data rights to a commercial architecture. Many bidders did not bid because the requirement was for standard interchangeable boards with competition at the board level. The Army has since revised the MCF program and deleted this ill-conceived requirement. It is also important to note that the present MCF program which was bid on a cost plus basis is experiencing cost overruns. The only participant, which currently markets commercial computers, has been terminated by the Army.

DOD LETTER

- There are over 20 suppliers of computers built to MIL-STD-1750 including four from England (Enclosure 1).

OUR EVALUATION

There appears to be some inaccuracies in this statement and enclosure I. We have determined that at least two of the suppliers named by DOD do not market 1750A computers.

DOD LETTER

- Significant cost avoidances have been demonstrated on the F-111 upgrade and the F-5GII aircraft as a direct result of this available competition.

OUR EVALUATION

The cost comparison to claim savings was between the 1750A computer and older computer models which were replaced and which had much higher costs. No comparison was made between 1750A and currently available proprietary products with greater functionality and lower total life-cycle costs.

DOD LETTER

- The Army is using MIL-STD-1750 equipment in at least two systems.

OUR EVALUATION

Two systems are a very small number in view of the total population of the Army's systems.

DOD LETTER

- There is a formal agreement for the Air Force to use the Army's MIL-STD-1862 ISA when available.

OUR EVALUATION

The Air Force can choose to use the Army architecture, however, they are not required to do so.

DOD LETTER

As we read the current report, there are two salient differences
in viewpoint between our position, which has evolved over the past
six years, and that of the GAO and a small segment of the computer
industry:

OUR EVALUATION

DOD suggests that only a small segment of the industry agrees
with us. However, the American Electronics Association with ap-
proximately 1,900 members, many of which are major computer sup-
pliers, and Computer and Business Equipment Manufacturers Asso-
ciation, which represents members whose total industry related
revenues are in excess of $50 billion and employ about 750,000
people, have both publicly expressed concern regarding approval
and implementation of DOD Instruction 5000.5X.

DOD LETTER

o   Defense must be concerned with the acquisition of adequate
    equipment (minimum-essential with provision for realistic
    growth) and the life-cycle support of that equipment.
    Post-acquisition costs normally run from three to ten times
    original acquisition costs for hardware. Software costs
    for a system over its life also range to several times
    the hardware costs and the proportion dedicated to soft-
    ware is growing.

OUR EVALUATION

DOD continues to focus on hardware acquisition and post ac-
quisition costs. Their estimate of software costs are grossly low.
A recent Electronics Industry Association report concluded that
software costs represent about 65 percent of the cost of an em-
bedded computer system and will grow to about 85 percent of the
system cost by 1990 which is about the time some of the proposed
architectures will be implemented.

DOD LETTER

o   We do not agree with the GAO assessment of "commercial"
    versus "military" technology in this field.

OUR EVALUATION

DOD appears to be in disagreement with itself. A recent quotation by Dr. DeLauer, Under Secretary of Defense for Research and Engineering, states

"* * * the military community <u>must</u> take advantage of
the <u>incredible strides</u> that have been made in the
<u>commercial sector</u> in <u>data</u> and signal <u>processing</u>. We
<u>must tap</u> this source to secure equipment that is <u>more</u>
<u>timely</u> and <u>effective</u> and <u>less costly</u>." (Emphasis added)

The Secretary of Defense also stressed this approach in his fiscal year 1983 annual report to the Congress. He stated

"* * * greater effort will be placed on avoiding de-
velopment costs by increased utilization of commercial
market place supplies and equipments through accelerated
use of industry standards and development of simplified
specifications and commercial item descriptions for de-
fense procurement of competitive off-the-shelf items."

DOD LETTER

The Defense Science Board Task Force on Embedded Computer Resources
Acquisition and Management has reported out to the full Defense
Science Board. Their findings and recommendations with respect
to proposed Instruction 5000.5X are summarized in Enclosure 4.
The Board, in accepting the Task Force results, recommends that
we proceed with 5000.5X and further recommends that we work with
industry to seek a means to add "commercial" Instruction Set
Architectures to its list. We will aggressively pursue that
added recommendation.

The Task Force's final report is in preparation and should be
available by mid-April. I will have a copy provided to you as
soon as possible.

OUR EVALUATION

We have not seen the Defense Science Board Task Force report
at this time. When the final report is available, it will be eval-
uated as a part of our current review of DOD's efforts to standard-
ize military computers.

DOD LETTER

GAO's second recommendation to limit our standardization efforts
to programming language alone is not practical at this time. We
do not agree that significant architectural innovations are nearby.
We do not believe that a technological filibuster while awaiting
breakthrough and production availability is sound. We will follow
closely the results of industry-sponsored research as well as that
sponsored by DoD and make every honest effort to select the most
appropriate equipment for our needs.

OUR EVALUATION

We do not purport that standardization be limited to pro-
gramming languages; however, we believe that standardization
should be occurring at high level interconnect and software in-
terfaces. We have determined that significant architectural in-
novations have been developed in the commercial computer environ-
ment and believe that these innovations will continue.

DISCUSSION OF OUR LETTER REPORT
"DOD INSTRUCTION 5000.5X, STANDARD INSTRUCTION SET
ARCHITECTURES FOR EMBEDDED COMPUTERS" (MASAD-82-16)

DOD COMMENT

1. Ref: Letter report (page 1)

"--Dramatic advances have been made in software technology.
DoD has recognized that a lack of a standard programming language
is a major contributor to the high cost of developing and maintain-
ing software for military applications. DoD is to be commended for
its initiative to fill that void by developing a common high order
programming language called Ada. Ada very specifically aims to
readily adapt a very wide variety of DoD applications to most present
(and future) computer architectures. Ada can potentially encompass
the particularly useful aspects of future architectural advances and
make their gains available to users, without their having to learn
and worry about how the gains were realized. In other words,
aggressive pursuit of a standard high order language, such as Ada,
could alleviate the software proliferation problem and at the same
time permit the Government to fully capitalize on architectural
advances."

Response: Ada is indeed coming and, when implemented, will have major
impact on the software process. There have not been dramatic advances
in software technology and the inefficiencies of continuing the pro-
liferation of the past will live on for decades in specific systems.
What improvements have been made in commercial and military software
development and support processes have been both slow and inconsistent.

OUR EVALUATION

Contrary to DOD statements, dramatic software technological
advances have been made in the past few years. Structured pro-
gramming, implementation languages (Pascal and Ada) are now being
used. Industry accepted software tools for improving programmer
productivity, greater availability of systems utilities and li-
braries, better human interfaces, file structures, and systems
have become more widespread. Most all of the costs of these dra-
matic developments have been borne by the commercial computer
industry. All of these costs will have to be duplicated by DOD
for their unique architectures. However, we have serious doubts
that DOD could do this in an effective and justifiable manner be-
cause of the substantial costs involved in duplicating the private
sector.

DOD COMMENT

2. Ref: Letter report (page 2)

"--Likewise there have been many advances in computer technology. These advances are the result of demands made by the civilian sector for more reliable and rugged computers. And indeed, the civilian sector is starting to impose much stiffer reliability requirements on integrated circuits. These advances will be realized probably at little or no cost penalty because all integrated circuits will be made to the same high standards. There are computer companies already marketing highly reliable computers through the use of innovative architectures. These modern computers have substantially fewer parts and in many cases are a computer on a single board thereby reducing the need for extensive logistics support."

Response: By standardizing at the interface between software and the hardware upon which it runs, DoD can gain access to the best commercial processes without being locked to single suppliers. Although the commercial market does demand better reliability, their needs do not match those of the military environment. The "innovative" architectures used in the commercial world are at a system level and have little or nothing to do with ISAs. The computer-on-a-board is, in fact, an argument favoring ISA standardization because any computer instantiation must have a native ISA and for the logistics argument to hold, standard hardware is implied and hence a standard ISA is demanded, de facto. Working from hardware up implies restricted competition, by any practical measure; starting with the ISA first allows open and equitable competition so as long as the actual selection does not itself force restriction; i.e., so long as the Government has unlimited rights in that ISA.

OUR EVALUATION

DOD maintains that a standard architecture will provide a means of utilizing "the best commercial processes without being locked to single suppliers." We disagree with this position.

Our position is more accurately stated by Dr. DeLauer, as follows:

"* * * no longer are we buying individual computer hardware. We're buying complex data processing systems in which the processor hardware is only a small part. It makes as little sense to control the processor in an information management system as to control individual parts of a communication system--now the ratio is almost reversed with software the predominate cost. We ought to be concerned with the software--not hung up on the hardware issue." (Emphasis added)

DOD COMMENT

3. Ref: Letter report (page 2)

"--Improved competition using militarized versions of commercial computers will open up competition to many firms that would not bid on specifications with DoD-owned architectures. The resulting unit prices will be less because DoD will not pay for duplicating hardware development and control and utility software development as it proposed to do under Instruction 5000.5X. Lower hardware unit costs and high hardware quality are in fact available in the commercial market because of the technology and broader market base."

Response: It has been demonstrated that basing competition on a commercial computer restricts competition. Far more companies have bid on MIL-STD-1750 and MIL-STD-1862 based procurements than have ever been experienced with other approaches. "Commercial computers" is at best a shibboleth for restricted competition. Attachment 1 compares performance and cost of a representative "equivalent" commercial product to the Navy AN/UYK-43 and 44. The facts are contrary to the assertion.

"--DoD ownership of architectures would seriously inhibit competition by a significant portion of the computer industry, and therefore DoD would not have the flexibility to capitalize on advances in computer architectural technology in a timely fashion. The ultimate impact would result in DoD very likely running the risk of getting locked into obsolete architectures."

Response: Direct experience has demonstrated the converse of this assertion. Those who have not competed have made a conscious choice not to do so. Far more qualified bidders have competed when ISAs for which the Government has unlimited rights were used as the basis for the procurement.

OUR EVALUATION

DOD asserts "* * * that basing competition on a commercial computer restricts competition." We agree with this position because competition should be based on the military or users' functional specifications. Basing competition on any computer-- commercial or military--rather than functional specifications is inherently restrictive. For example, both the Army's MCF program and the Navy AN/UYK-43 and 44 programs have put DOD into the computer manufacturing business where DOD is specifying the architecture for military computers. This specification restricts competition and can place unnecessary demands upon the responding companies, because the computer architecture is arbitrarily specified. In a recent case, the Army terminated a major international supplier of commercial and military computers from the MCF program. This was as a result of projected cost overruns apparently incurred in trying to comply with a military architecture specification.

DOD COMMENT

4. Ref: Letter report (page 2)

"--DoD would not be able to efficiently utilize the new DoD programming language Ada and will not be able to fully capitalize on the anticipated software cost savings Ada was designed to yield."

Response: The ability to utilize Ada is not dependent upon the ISA, per se. The question is compiler and support software (environment) availability. It is more efficient and economical if the scarce national resources (personnel) are engaged in producing the best possible environments for a few ISAs than to partially optimize a large number of them. NEBULA is an efficient Ada target, despite claims of certain companies to the contrary.

The advantages of Ada will be muted if sound management of the environment-to-hardware interface (ISA) is not achieved.

OUR EVALUATION

We generally agree with DOD that "* * * the ability to utilize Ada is not dependent upon the ISA or architecture * * *."

DOD's statement that "* * * the question is compiler and support software (environment) availability" is partially correct. However, our position is that compiler and support software (environment) are furnished by the computer manufacturer or a software company. We disagree with DOD that it is necessary or economically justified for DOD to duplicate industry and develop and maintain compilers and support software for DOD specified architectures.

Further, we do not support the concept of DOD specified architectures because this unnecessarily locks DOD into a given point in time and precludes using technological advances.

DOD COMMENT

5. Ref: Letter report (pages 2 and 3)

"--The three Services have initiated efforts commensurate with Instruction 5000.5X; for example, the Army's Military Computer Family, the Navy's AN/UYK-43 and 44, and the Air Force's 1750 programs. In a previous report entitled "The Department of Defense's Standardization Program for Military Computers--a More Unified Effort is Needed" (LCD-80-69, June 18, 1980), we were critical of both the Army and Navy efforts. We made the following statements in that report and believe they are even more valid today:

"***some computer manufacturers are already designing computers with modern architectures that will have Ada compilers available.

These or other manufacturers will probably offer follow-on
computers that will directly carry out Ada instructions and sub-
stantially improve performance reliability. Because these changes
provide better support options, such as building more redundancy
into systems, they should compel the Department to further evaluate
the level of standardization to be achieved before allowing the Army
and Navy to commit themselves *** for the long term. (Emphasis added.)

        "We view the need for architecture standardization as a function,
in part, of the availability of Ada as the standard computer programming
language. Because Ada is being developed to be a machine-transportable
language with a relatively low life cycle maintenance cost, the need
for standard architectures may be diminished when it is available ***.
(Emphasis added.)"

Response: Some computer manufacturers are indeed producing modern
architectures for which Ada will be available. The direct-execution
machine is not available and practical feasibility is yet in question.

Had GAO completed the quotation it would have included:

        "...In the long term, Ada could become the standard architecture
when computers that can directly execute the language are developed.
However, in the short term, standard computer architectures are needed
to reduce life-cycle costs. We believe that those architectures
should be common across Service lines, compatible with Ada and the
minimum number required to meet common functional requirements and to
retain the older languages, such as CMS-2 and JOVIAL, until they are
phased out. These measures are necessary to minimize life cycle costs
and to facilitate the transition to Ada."

Truncating the quotation completely changed the context and leads to
misunderstanding.

OUR EVALUATION

        Computer manufacturers are marketing computers with inno-
vative architectures on which Ada is being implemented. We do
not believe that a direct execution machine is necessary in order
that high level standards for machine independent interconnect be
accomplished. If DOD would use the same resources necessary for
the apparent management commitment to hardware architectures and
apply them to supporting the voluntary software and interconnect
standards process, they would be further ahead.

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DOD COMMENT

Rolm MSE/800 vs AN/UYK-43 (A and B Versions)

	Rolm MSE/800	AN/UYK-43 (A Version)	AN/UYK-43 (B Version)
Max Program Size (using virtual memory)	4.3 Billion	16 Billion	16 Billion
Max Physical Size	8.0 M Bytes	5.0 M Bytes 1/	10 M Bytes 1/
Word Size (bits)	32	32	32
Package Size	46" x 17.5" wide 24 " deep	48" x 19.8" wide x 22.3" deep AN/UYK-7 Footprint 2/	Same as AN/UYK-7 Foot-print only 72" Height 2/
I/O Bandwidth (total)	18.20 M Bytes/Sec	>12.0 M Bytes/Sec	>24.0 M Bytes/Sec
Performance/Throughput	1900 KOPS	2500 KOPS	4540 KOPS
Cache Size (K bits)	16 K Bytes	16 K Bytes	32 K Bytes
Power (watts)(max)	3800 Watts	2500 Watts	5500 Watts
Cooling (type)	Air Only	Air/Water	Air/Water
MTBF (hours)	Undetermined 3/	>6000 4/	>6000 4/
MTTR (minutes)	<30 Minutes	<15 Minutes	<15 Minutes
Instruction Set (superset of)	Data General NV 8000	AN/UYK-7	AN/UYK-7
Cost	Approx. $500K	$400K 5/	$750K
Software Issues	DG operating sys Many HOL compilers Ada in 1983	MTASS-L support Ada in 1985	MTASS-L 4/ Ada in 1985
Production Deliveries	June 1982	Mid-1984	Mid-1984

1/   The capacity will grow as dynamic RAM density increases

2/   Fits through submarine hatch (circular)

3/   Rolm is now calculating MTBF, available in September 1981

4/   Although 6000 hours have been specified, >10000 hours can be expected (according to PMS-408 representatives).

5/   AN/UYK-7 with DDMFMs (1981 contract) ·512K

6/   A multi-tasking operating system should be developed

OUR EVALUATION

We believe that this comparison of one manufacturer's militarized computer, currently available, with the anticipated Navy computers is not a true reflection on an evaluation of commercial architectures. The Navy's computer will require continued investment in research and development funds by DOD; whereas, these costs for militarized commercial computers are supported by commercial sales. In addition, the Navy computers may or may not become available as specified and in the projected time frame. Also militarized commercial computers capabilities in the future will be substantially improved.

DOD Responses to Specific Questions
Regarding Proposed DOD Instruction 5000.5X

DOD COMMENT

What effect would Instruction 5000.5X have on the use of
competition in the Department of Defense?

Answer: The objective of proposed DoD Instruction 5000.5X is
to control and maintain the interface between MIL-SPEC (see
attached definitions) computer hardware and the software which
runs on it. This interface is termed the "instruction set
architecture" or ISA of the computer (a more rigorous definition
is given in Enclosure 5). An ISA may be implemented in hardware
using whatever design and components, processes, etc., which the
producer chooses. DoDI 5000.5X lists a small set of approved
ISAs, in all of which the Government has unlimited rights (i.e.,
can freely use).

When recent procurements have been based upon these ISAs, there
was a demonstrated increase in the numbers of qualified bidders
participating. In the recent competition for the Army's Military
Computer Family (MCF) based upon MIL-STD-1862 or the NEBULA ISA,
there were 12 bidders--more than had been experienced on any
similar procurement not based on ISAs in which the Government had
unlimited rights.

The Air Force has had similar, but more extensive, experience with
their procurements based upon MIL-STD-1750, another ISA on the
proposed 5000.5X list and in which the Government has unlimited
rights. There are currently 23 suppliers of equipment built to
the MIL-STD-1750 ISA, four of which are from England. Enclosure 1
lists these companies. Further, when MIL-STD-1750 was used as
the basis for the computers for the F-111 upgrade program, the
resulting competition allowed the opportunity for insertion of new
technology and reduced the price of the computers by almost 50%.
Prior to invoking MIL-STD-1750, procurements were sole source in
many instances, and otherwise restricted competition at best.

The net of it is that application of the principles of DoDI 5000.5X
has invariably enhanced competition and reduced cost--this is
demonstrated experience and not speculation on what the effects
might be.

What effect would Instruction 5000.5X have on the current computer
industry?

Answer: As noted above, the instruction encourages and opens up
competition. On any given procurement, a broader section of the
industry can compete on a more equitable basis than was possible
under earlier acquisition strategies. Of course, any given computer
manufacturer may choose not to participate because of a corporate

philosophy which permits it only to market in an environment which minimizes competition, or if it perceived that the competitive environment could negatively effect its eventual market share. How this will balance out over time is yet to be determined. Clearly, the proposed instruction will reduce the present extent of sole-source acquisitions of proprietary products, and that may be interpreted by some of the industry as negative; from the Government's perspective and that of the broader industry sector, it must be viewed as positive.

OUR EVALUATION

We do not agree that Instruction 5000.5X encourages and opens up effective competition. On any given procurement, a section of the electronics industry, which is primarily not the commercial computer industry, might compete on a specific procurement to meet military computer needs. This does not necessarily mean the total systems cost will be competitive with that provided by companies manufacturing either commercial equipment or military specifications equivalence of commercial equipment. Once again we are suggesting that by using militarized versions of commercial architectures, DOD can still gain effective competition and reduce its costs significantly.

DOD's comment regarding given computer manufacturers participating might be questioned. DOD should look at the number of commercial computer manufacturers that are presently building the MCF design. It should be noted that at this point in time there are none. It is not clear that the Army's plan to select a single vendor under the MCF program, for 5 years for use on all Army programs is any different than some of DOD's past actions regarding sole-sourcing equipment.

DOD should also look at three of the five standard architectures included in Instruction 5000.5X, the Navy's AN/UYK-7, AN/UYK-20, and AN/AYK-14. Each of these only has one vendor in production. The AN/UYK-43 and AN/UYK-44 development program, replacement for the AN/UYK-7 and AN/UYK-20, only had two vendors submit bids. We do not believe that this experience to date can be construed as encouraging and opening up competition nor can this be construed as "an established success."

DOD COMMENT

Would Instruction 5000.5X lock DoD into obsolete technology?

Answer: Recall that the ISA is the interface between software and hardware. Standardization at that interface has been demonstrated to allow and even encourage the injection of new technology. Although there are some performance parameters to be specified at that interface, both within and in addition to the ISA, there is essentially transparency at the ISA to the implementing technology. The expert opinion, upheld by experience, is that breaking the sole-source procurement syndrome or its handmaiden, weak competition, will accelerate the injection of technology--quite contrary to locking the Department in to obsolescence. That lock-in not only to technology but also to supplier, is precisely the lesson to be learned from earlier approaches.

OUR EVALUATION

There are numerous commercial computer suppliers which have been technologically innovative. These modern computer architectures will have a difficult time competing for weapon system development programs because of DOD's arbitrary specifications for computer architecture. If DOD was to put its efforts at the high level interconnect standards as previously discussed and move further away from the internal hardware design as recommended by Dr. DeLauer (as previously quoted), it would have a much better chance of accomplishing its goals for lower life-cycle costs of military computer systems.

DOD COMMENT

Are commercial off-the-shelf computers currently available that could satisfy DoD's major needs for embedded computers?

Answer: In some cases the answer must be "yes." And, in those cases where the logistics implications are tractable, where there is no need for militarization, and where there can be a fair and open competition, then some preference should be given to the off-the-shelf approach. Generally, "off-the-shelf" means a common, commercial product intended for the civilian marketplace and one designed and produced in a proprietary way. The need for any change in the physical or electrical characteristics of the machine will break the "off-the-shelf" model. In some instances, several manufacturers could start with their proprietary "soft" product and through redesign and modification provide acceptable militarized products--that would not meet the essential "off-the-shelf" test. Further, it is often true that existing software must, for reasons of economy, schedule or risk, be accommodated. Except in rare cases, the implication is sole-source procurement and the well-known consequences. Where those negative aspects are acceptable in the balance, off-the-shelf is a viable acquisition-strategy alternative and should be so considered. In no way can it be considered the predominant method.

OUR EVALUATION

Off-the-shelf does not necessarily mean a commercial product for the civilian marketplace. There are off-the-shelf military products as well offered by multiple vendors. These are military versions of commercial architectures which have been developed in the highly competitive marketplace as evidence by--Hughes production of Perkin Elmer equipment, Rolm production of Data General equipment, and Norden production of Digital Equipment Corporation equipment. In addition, the Air Force has recently concluded a contract with Intel to provide a license to DOD systems suppliers to produce the highly successful Intel 8086 architecture in militarized versions. This license, which restricts the use of the Intel architecture to militarized designs, was acquired from Intel for $1.00.

DOD COMMENT

Should standardization occur at the instruction set architecture (ISA) level or at the higher level languages, such as Ada?

Answer: Standardization is required at both the high order language (HOL) and instruction set architecture levels. HOL standardization improves the efficiency of applications code and the transportability. ISA standardization is necessary to allow reuse of systems and support software from system-to-system. Together they can provide significant productivity and economics. Either alone is, at best, a partial solution to these problems. Until the non-stop, never-fail true High Level Language (HLL) machine is practical and available, ISA standardization is the only way to enable application and system software reuse. It should also accelerate the availability of Ada, per se, and, hence, perhaps hasten the reality of the HLL machine.

OUR EVALUATION

We agree with DOD that "* * * HOL (high-order language) improves the efficiency of applications code and the transportability."

The following DOD statement on architecture standardization is incorrect and misleading. We quote DOD:

"ISA standardization is necessary to allow reuse of systems and support software from system-to-system."

First, commercial software companies provide certain support software for two or more different types of commercial computers. Second, there is no commercial architecture standardization necessary to use selected commercial support software from software companies on two or more different brands of computers.

We believe DOD's concept of architecture standardization vio-
lates the current concept of the commercial computer market that
each manufacturer and/or selected software companies provide the
system and support software. As mentioned, we know of no current
economic reason for DOD to invent architectures, require architec-
ture standardization, or insist upon duplicating the commercial
sector by developing system and support software for its own
architectures.

THE SECRETARY OF DEFENSE

WASHINGTON, D.C. 20301

2 APR 1982

Honorable Charles A. Bowsher
Comptroller General of the United States
Washington, D.C. 20548

Dear Mr. Bowsher:

This is in reply to your recent letter which provided a copy of
GAO letter report, "DoD Instruction 5000.5X, Standardization
Set Architectures for Embedded Computers," (MASAD-82-16), dated
January 27, 1982, (OSD Case #5889).

I must respectfully disagree with your conclusions that:

    o "...this (proposed) policy would lock DoD into the use
       of inferior technology."

    o "...DoD would not be able to take advantage of private
       industry's technical innovations."

    o "...it would severely restrict competition to those
       companies willing to help DoD implement obsolete
       technology."

Our experience to date has demonstrated the opposite effect.
Hence, we believe the proposed policy is an established success,
even before formal issuance.

The GAO was invited to observe meetings of the recent Defense
Science Board review of this subject. However, the two groups
reached quite different conclusions. Further, the conclusions
and recommendations of the GAO report do not track with their
earlier reviews of this same issue ("The Department of Defense's
Standardization Program for Military Computers--A More Unified
Effort is Needed," June 18, 1980, LCD-80-69).

One recommendation from that earlier report, and echoed in the
current letter report, is that Ada should be implemented as DoD's
standard programming language. We agree. We followed GAO's
recommendation to establish a tri-Service program office for that
purpose.

Experience with the principles of 5000.5X, although it has not
been formally issued, are:

- There were 12 significant bidders for the Army Military
  Computer Family (MCF) Program based upon the Government
  MIL-STD-1862 Instruction Set Architecture (ISA). Earlier,
  when the program was based upon a commercial ISA, there
  were only two.

- There are over 20 suppliers of computers built to MIL-STD-
  1750 including four from England (Enclosure 1).

- Significant cost avoidances have been demonstrated on the
  F-111 upgrade and the F-5GII aircraft as a direct result
  of this available competition.

- The Army is using MIL-STD-1750 equipment in at least two
  systems.

- There is a formal agreement for the Air Force to use the
  Army's MIL-STD-1862 ISA when available.

As we read the current report, there are two salient differences
in viewpoint between our position, which has evolved over the past
six years, and that of the GAO and a small segment of the computer
industry:

o Defense must be concerned with the acquisition of adequate
  equipment (minimum-essential with provision for realistic
  growth) and the life-cycle support of that equipment.
  Post-acquisition costs normally run from three to ten times
  original acquisition costs for hardware. Software costs
  for a system over its life also range to several times
  the hardware costs and the proportion dedicated to soft-
  ware is growing.

o We do not agree with the GAO assessment of "commercial"
  versus "military" technology in this field.

More specific discussions of the report and responses to the
specific questions voiced in its Enclosure I are given in
Enclosures 2 and 3, respectively.

The Defense Science Board Task Force on Embedded Computer Resources
Acquisition and Management has reported out to the full Defense
Science Board. Their findings and recommendations with respect
to proposed Instruction 5000.5X are summarized in Enclosure 4.
The Board, in accepting the Task Force results, recommends that
we proceed with 5000.5X and further recommends that we work with
industry to seek a means to add "commercial" Instruction Set
Architectures to its list. We will aggressively pursue that
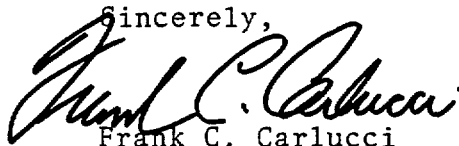added recommendation.

The Task Force's final report is in preparation and should be available by mid-April. I will have a copy provided to you as soon as possible.

GAO's second recommendation to limit our standardization efforts to programming language alone is not practical at this time. We do not agree that significant architectural innovations are nearby. We do not believe that a technological filibuster while awaiting breakthrough and production availability is sound. We will follow closely the results of industry-sponsored research as well as that sponsored by DoD and make every honest effort to select the most appropriate equipment for our needs.

We have explicitly designated the Under Secretary of Defense, Research and Engineering, as the Senior Official to be responsible for all computer acquisitions covered by 10 U.S.C. 2315.

Thank you, Mr. Bowsher, for your continued interest. I trust that we may work closely together to resolve any remaining concerns.

Sincerely,

Frank C. Carlucci
Deputy

Enclosures
a/s