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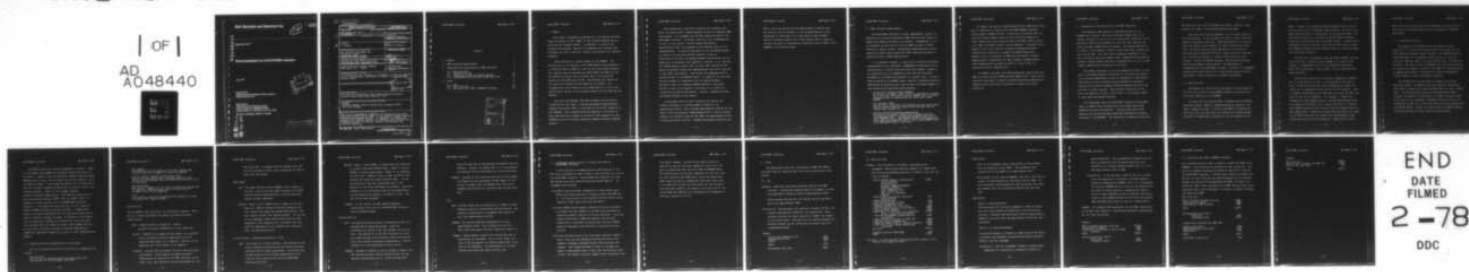
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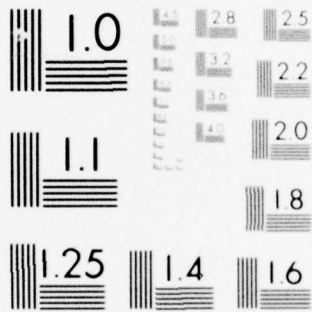
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Report No. 3727 ✓

**Recommendation for ACCAT/FNWC Interface**

June 1977

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## 1. Summary

This report recommends an approach for interfacing the Fleet Numerical Weather Center (FNWC) to the Advanced Command Control Architectural Testbed (ACCAT). In addition, it details the hardware and software required to accomplish the interface and estimates the cost to procure, install, and maintain the required hardware.

ACCAT operates as a secure subnet of the ARPANET. The problem here is to interface a CDC 6500 computer that operates in a classified mode at FNWC as a host on the secure ACCAT network. The required security between the ACCAT subnet and FNWC will be provided by a Private Line Interface (PLI) to be installed between the CDC 6500 and its IMP. The problem that remains is the connection between the CDC 6500 and its IMP/PLI. We recommend that this connection be accomplished by a "front end" machine which serves as an interface between the CDC 6500 and the IMP/PLI.

Two front end systems, both PDP-11-based, were seriously considered for this task: a system developed by Massachusetts Computer Associates (MCA) to interface Air Force CDC computers to the ARPANET; and, a system being developed by a collection of Navy laboratories to connect a variety of Navy computers to the ARPANET as part of the Navy Laboratory Computer Network (NALCON) project.

Both systems were carefully evaluated and (assuming each meets its design goals) judged adequate to meet the expected FNWC requirements. We recommend that the MCA system be used for the ACCAT-FNWC interface. The major reason for this recommendation is that, in our opinion, the MCA system represents a significantly lower risk because of the advanced state of its implementation. It should be pointed out the the NALCON system is likely to be the more flexible system in terms of functionality and that the NALCON hardware configuration can be expected to be somewhat less expensive. However, in our opinion, the NALCON system is more risky (at this time) because of the amount of software design and implementation work still required to meet FNWC requirements. This design and implementation is planned as part of the NALCON effort. In addition, we note that the MCA hardware is compatible with the NALCON hardware. Therefore, when the necessary NALCON software is available, should it prove to be superior, conversion to it would be a relatively straightforward matter. Section 3 compares the MCA and NALCON systems in more detail.

We estimate that the cost to procure and install the hardware necessary to interface FNWC to ACCAT will be approximately \$151K. This includes approximately \$142.5K for the PDP-11 front end hardware, approximately \$2K to install the MCA software in the PDP-11 and the CDC 6500, and approximately \$6.7K to ship and install the PLI. Hardware maintenance costs for the

PDP-11 front end system would be approximately \$11K per year. The cost for the PLI hardware is not included because, as we understand it, ARPA owns a PLI that could be used at FNWC. Section 4 presents these costs in more detail and, in addition, outlines the cost of interfacing a second CDC host at FNWC to the ARPANET in a non-secure mode.

## 2. FNWC Interface Requirements.

The ACCAT-FNWC interface is being implemented, in part, to determine the services provided by FNWC that are most useful for supporting command and control activities. Consequently, it is not possible at this time to list the FNWC services to which ACCAT will require access. Considerable experimentation can be expected as ACCAT users explore the FNWC resources and ways of exploiting them in ACCAT applications.

It is possible, however, at this time to identify functional requirements for the interface. ARPANET/host interfaces can be characterized in terms of the functions they support. Based on our experience with the ARPANET we find that the following breakdown of interface functionality is a useful one; it covers existing patterns of ARPANET usage, requires increasing levels of implementation sophistication, and involves increasing impact on host hardware and operating system software:

- Interactive terminal access (TELNET).  
The ability to support remote users at interactive terminals as if they were local users (server TELNET) and to provide terminal access to remote sites for local users (user TELNET).
- File transfer (FTP).  
The ability to move data files between the host file system and the network under the control of local (user FTP) or remote users (server FTP).
- General process-to-process communication.  
The ability to support communication between arbitrary programs executing on the host and programs executing on other ARPANET hosts. (The TELNET and FTP functions can be built upon this capability and, in fact, many ARPANET hosts have implemented them in that way.)

To support the sorts of experimentation with FNWC facilities that is expected, we believe that the FNWC ARPANET interface should support TELNET and FTP. Furthermore, we believe that the interface should support both the user and server aspects of these capabilities since access to ACCAT from FNWC (user) as well as to FNWC from ACCAT (server) can be expected. At present there appears to be little need for a general process-to-process communication capability to support the ACCAT objectives. However, after a collection of FNWC services useful in ACCAT applications is identified, the most flexible linkage between ACCAT applications and these services is likely to be via process-to-process communication.

In summary, the near term ACCAT objectives require that the FNWC interface provide TELNET and FTP capabilities. While not an absolute requirement, a general process-to-process communication capability may facilitate the pursuit of longer term ACCAT objectives.

### 3. Comparison of Alternatives for the FNWC Interface.

Two different approaches for interfacing hosts to the ARPANET have evolved. The first, and most widely used, is to connect the host (or one of its i/o controllers) "directly" to an IMP and to develop the software for the host that observes the various network communication protocols. The second approach is to insert a mini-computer, called a "host front end", between the host and the IMP. The front end is typically connected to the host through an existing hardware "port" supported by an existing software "access method" and acts to perform most (or all) of the network communication protocols for the host.

The primary advantage of the first approach is that, if well done, it provides maximal flexibility for utilizing the network; its principle disadvantage is that to accomplish it significant modification to host operating system software is generally required and a special hardware interface between the front end and host is often required. The principle attraction of the front end approach is that, if well done, it has minimal impact on host operating system software.

The requirement that the ACCAT-FNWC interface have minimal impact on FNWC's host software and on its normal operations mandates the front end approach. (We note that several CDC computers at Lawrence Berkeley have been successfully directly connected to the ARPANET. The connection is between an IMP and a

PPU which the various CDC machines can access. However, these machines run under a non-standard operating system).

Given that the front end approach is to be used, there are two alternatives: use an existing (or soon to exist) front end system or implement a new one. Since development of a reliable front end system can be expected to require several man years (2-5), we believe that the best approach is to utilize an existing system (possibly modified), should there be a suitable one. As noted in Section 1, there are two such front end systems: the MCA and NALCON systems. The following sections describe and compare these systems. The MCA system is recommended for the ACCAT-FNWC interface. Section 3.4 recommends several minor modifications to the MCA system which we believe would make it better matched to the FNWC requirements.

### 3.1 MCA Front End.

Development of the MCA front end system is being funded by the Air Force as part of the AFSCNet project to interface Air Force CDC computers to the ARPANET.

The MCA front end uses DEC PDP-11 hardware and the RSX11M operating system. RSX11M a standard operating system for the PDP-11 supported by DEC. A fairly large PDP-11 configuration (96K core plus cartridge disk) is required for the MCA system. The PDP-11 is physically connected to the CDC computer by two

paths: through a low speed terminal multiplexer port in which case the PDP-11 acts to emulate a CDC terminal; and, via a high speed interface which is connected to one of the CDC PPU's. The high speed interface is a product of the DEC Special Systems Group and is procured as part of the MCA system. A single PDP-11 configuration can be used as a front end for more than a single CDC computer although the MCA software does not currently support such multi-host operation.

The MCA front end supports user and server TELNET, and user and server FTP. Terminal access (TELNET) to (from) the CDC computer is supported by both the low speed and high speed PDP-11/CDC connections. File transfer occurs across the high speed connection.

The MCA front end has a file system (supported by RSX11M) and it is possible for a user to run programs on the PDP-11. Thus, the MCA front end acts like an ARPANET host rather than simply as a "transparent" front end for the CDC computer. That is, TELNET and FTP users must deal explicitly with the PDP-11 as well as with the CDC computer. For example, a remote user attempting to gain TELNET access to the CDC machine must first gain access to the PDP-11 (via a login) and then run a PDP-11 user TELNET program to gain access to the CDC computer where he must again login. Similarly, a remote FTP user must first login to the PDP-11 and then run a PDP-11 user FTP program to move files into and out of the CDC machine. While the Air Force

application may require this non-transparency, we believe that it will lead to unnecessary operational clumsiness for the ACCAT application.

### 3.2 The NALCON Front End.

Development of the NALCON front end system is being supported by a collection of Navy laboratories as part of the Navy Laboratory Computer Network project. The NALCON system is being developed as a transparent front end for a variety of different computers used in the Navy laboratories, including CDC machines. The idea is that the NALCON front end can be tailored to a particular computer (such as a CDC 6500) by the addition of an appropriate hardware interface and a small host-dependent software module to drive the special interface.

The NALCON front end uses PDP-11 hardware and the ELF operating system. The NALCON front end requires a moderately sized PDP-11 configuration (approximately 80K core plus a floppy disk). The ELF operating system was developed under ARPA funding. At present no organization is funded to maintain ELF. To the best of our knowledge, a hardware interface device for connecting the PDP-11 to a CDC host has not yet been selected for the NALCON system. However, we believe that the NALCON system could operate with the device used by the MCA system.

The NALCON front end is being implemented in phases. Phase I will provide user TELNET for terminals connected directly to the PDP-11. Phase II will provide server TELNET, enabling remote ARPANET users to gain terminal access to the host computer (e.g., the FNWC CDC 6500). In this mode the PDP-11 will be connected to the host through a standard terminal port (or ports) and act as a terminal emulator. Phase III will support general process-to-process communication. The basis for Phase III is a host-to-front-end protocol (HFEP) which is simpler than, but supports the same functions as, the ARPANET NCP host/host protocol. In this mode the front end will act as a converter between ARPANET host/host protocol and HFEP. A significant amount of software development will be required of each host in order to operate in Phase III mode; we estimate 6-9 man months will be required to develop this software for each host type. File transfer (FTP) and remote job entry (RJE) capabilities will be built upon the general process-to-process communication capability supported by Phase III as part of later implementation phases.

### 3.3 Comparison of MCA and NALCON Front End Systems.

We use the following criteria as the basis for comparing the systems:

- Functionality.  
How well do the capabilities of the system match the requirements of the ACCAT-FNWC interface?

- Host impact.  
How extensive are the changes to the host hardware and software required to support the front end system?
- Current status / Expected availability/ Risk.  
What is the expectation that a reliable version of the system will be available when the ACCAT-FNWC interface is to be installed?
- Maintainability.  
What level of support for the front end operating system can be expected? Similarly what level for the front end software itself can be expected?
- Cost.  
Only hardware costs are considered since software is being developed under separate funds.

#### Functionality.

FTP and TELNET (user and server) are definitely required. There may be a future requirement for general process-to-process communication.

MCA: TELNET and FTP are supported. General process-to-process communication is not supported.

NALCON: TELNET will be supported when Phase II is complete. General process-to-process communication will be supported when Phase III is complete. FTP will not be supported until after Phase III is complete.

Comments: The MCA front end meets the short term functional requirements. Should general process-to-process communication be required by the FNWC interface in the longer term, that capability could be developed for the

MCA front end. It appears that the NALCON front end will not satisfy the short term requirement for FTP for some time (see below).

#### Host Impact.

MCA: Low speed terminal access (TELNET) has no impact on the host. Use of the high speed interface for TELNET and FTP requires modifications to the CDC operating system (already completed).

NALCON: Phase I and II TELNET have no impact on the host. Phase III (general process-to-process communication) will require host operating system modification. FTP will require further host system software. To the best of our knowledge, these modifications have not been designed for CDC computers yet. We expect that they would be comparable to, but somewhat more extensive than, the MCA modifications.

#### Current Status / Expected Availability / Risk.

MCA: The system is in final checkout. Two systems (of the three originally procured by the Air Force) have been installed and are nearly operational. We believe that the MCA system will be reliably operational at the three Air Force sites by the time the ACCAT-FNWC installation occurs.

NALCON: Phase I (user TELNET) is operational and installed at three of the seven NALCON sites. Phase II (server TELNET) is nearly operational. Phase III is scheduled for June 1977. However, there is some indication that October 1977 would be a more realistic date. It must be pointed out that the June/October date is for delivery of the front end Phase III software. Matching software for the CDC machine must be developed before the CDC machine can operate as a Phase III host. FTP has not yet been designed.

Comment: In our opinion the MCA system represents significantly less risk for the ACCAT-FNWC interface than the NALCON system.

Maintainability:

MCA: The RSX11M operating system is maintained by DEC as a standard PDP-11 operating system. Plans for maintenance of the MCA front end software are not yet firm. One possibility is for MCA to maintain it until any lingering bugs are corrected at which time the Air Force would assume maintenance responsibility. The CDC software is to be maintained by the Air Force.

NALCON: Although at present no one is funded to support the ELF operating system, several projects which use ELF maintain various parts of it. We do not know what

plans the Navy has for maintaining the NALCON front end software. However, we assume that if it is successful, the software will be maintained on a continuing basis.

Comment: Because of the relatively low level of ELF support at present and the uncertainty of ELF support in the future, we expect that the NALCON front end will be somewhat more difficult to maintain than the MCA front end.

#### Cost.

MCA: The MCA system can be configured in a number of ways depending upon site requirements and preferences. The hardware configuration we recommend (see Section 4) will cost approximately \$142.5K.

NALCON: The standard NALCON configuration will cost approximately \$101K. This includes the cost of a PDP-11/CDC high speed interface required by Phase III.

Comment: These hardware costs do not include the cost of maintaining the equipment. As a rule of thumb, the cost of DEC maintenance is roughly proportional to the cost of the equipment. Dec maintenance for the MCA configuration would cost about \$11K per year.

### 3.4 Recommended Modifications to the MCA Front End for ACCAT-FNWC Interface.

In this section we recommend several modifications to the MCA front end system in order to make it more suitable for use as the ACCAT-FNWC interface. As we become more familiar with the MCA system other minor modifications may become apparent. We recommend the following:

- The PDP-11 should be made transparent to remote ACCAT users. ACCAT users should be able to directly access the FNWC CDC 6.00 for interactive or file transfer service without being required to deal explicitly with the PDP-11.
- The user TELNET should support character-at-a-time terminals. At present the user TELNET for the MCA front end does not adequately support character-at-a-time operation. Since the primary ACCAT hosts (TENEX and TOPS-20) operate most effectively in character-at-a-time mode, the user TELNET should be upgraded to provide better character-at-a-time service.
- The front end NCP should to use "new style" IMP/host leaders. About a year ago the addressing conventions used in the leaders of message exchanged between IMPs and hosts were changed. This change was made in order to increase the number of addressable hosts to well over the previous limit of 256. The network currently supports both "old style" and

"new style" leaders. The NCP in the PDP-11 should be modified to use the new style leaders so that it will be able to communicate with the full range of ARPANET hosts. This modification will be more important for the front end for the non-secure CDC 6500 which, unlike the secure CDC 6500, should be able to communicate with every other host. It is important to point out that since the PLI currently uses old style leaders, the change in the front end for the secure FNWC CDC 6500 must be coordinated with changeover to new style leaders by the PLI.

4. Costs.

The approximate costs for interfacing an FNWC CDC 6500 to the ACCAT facility using the MCA front end are outlined in this section.

4.1 PLI.

Hardware: ARPA owns a PLI which could be used for the FNWC interface. Packing and shipping costs to transport this PLI from Cambridge to Monterey would be approximately \$250.

Cables between IMP and PLI, PLI and KG, and PLI and PDP-11 would cost approximately \$850.

Installation: BBN personnel are required to install the PLI. We estimate approximately \$5850 for the installation. This estimate includes the labor required to "shape" the signals on the PLI-KG cable; this work will be required because the distance between the PLI and KG will be greater than the recommended maximum.

Summary:

Packing and Shipping of PLI	250.
Installation of PLI	5650.
Cables	850.
TOTAL	6750.
Maintenance (per year)	6000.

## 4.2 MCA Front End.

Hardware: The following is the PDP-11 configuration we recommend. Exact prices and part numbers will depend upon DEC pricing and packaging policies in effect at the time the order is placed.

1 PDP-11/45-DW Computer consisting of 11/45 processor 32K parity core Hardware memory management Bootstrap (M9301) Line Frequency Clock LA36 - DECwriter II DECwriter II Interface Cabinet	41800.
1 DD11-B Small peripheral controller mounting panel	350.
1 BM873-YB Bootstrap	720.
1 H324 Bootstrap Switch Panel	310.
1 KW11-P Programmable Clock	770.
1 H960-DH Cabinet with 9 SU slots	3630.
1 MF11-US 64K words parity core memory	16500.
1 DB11-A UNIBUS repeater	1540.
2 RK11J-DE 1.2 M word disk cartridge disk drive, controller and cabinet.	23100.
1 DH11-AD Programmable asynchronous 16 multiplexer	6600.
1 IMP11-A PDP-11 interface to ARPA IMP	8800.
1 BA11-KE Five SU expander box	2420.
1 DRHCD CDC 6000 to PDP-11 channel interface	28200.
1 DU11-DA Full/half duplex synchronous interface	1500.
Sub-total	136922.
Shipping Insurance @\$5/\$1000	685.
TOTAL	137607.

Delivery: At this time DEC is quoting delivery times of 11-12 months from receipt of order.

**Installation:**

Cost of the equipment covers installation of the hardware with the exception of the DRHCD. DEC estimates field installation of the DRHCD to be approximately \$5K.

We estimate it will require somewhat less than 1 man week to install the MCA software for the PDP-11 and CDC 6500. Air Force personnel would probably be best suited for this task. We estimate that this installation should cost less than \$2K.

**Maintenance:****Option 1: DEC Maintenance.**

DEC maintenance for the above equipment is \$941 per month. The first three months of maintenance are covered by the warranty. Therefore DEC maintenance would be approximately \$8469 for the first year and approximately \$11292 per year thereafter.

**Option 2: In House Maintenance.**

In house maintenance is feasible if FNWC has both the desire to maintain the equipment and qualified hardware personnel familiar with DEC equipment.

**Sub-Option A:** DEC will recommend a supply of system spare components for installations choosing to perform in

house maintenance. The recommendation depends upon the exact configuration but the spares generally cost 40%-50% of the original system hardware cost or in this case appriximately \$54K to \$68K.

Sub-Option B: If the decision is made to procure a second front end system for a non-secure interface between a second CDC 6500 and the ARPANET, and if it is acceptable to interrupt ARPANET service on one of the systems while the other is being repaired, a significantly smaller stock of spare components would be required since parts could be interchanged between the two front end systems. FNWC and ARPA must decide if this is a viable option.

Comment: We recommend DEC maintenance for the FNWC installation as the most cost effective, trouble-free approach to maintenance for the front end system.

Summary:

PDP-11 Hardware for MCA front end	137507.
Installation of DRHCD	5000.
Installation of MCA PDP-11 and CDC 6500 software	2000.
TOTAL	144607.
DEC Maintenance for PDP-11	
First year	8469
Subsequent years.	11292.

4.3 Non-secure CDC 6500 / ARPANET Interface.

This interface would be used to connect a second CDC 6500 to the ARPANET. A PLI would not be required for this connection. The front end hardware configuration would be identical to that for the ACCAT-FNWC interface. A distant host connection between the IMP and the front end would be required because of the distance between the IMP and the unclassified CDC 6500. To handle the second CDC 6500 a host interface on the FNWC IMP would have to be converted from a local interface to a distant interface to handle the second CDC 6500.

MCA front end:

PDP-11 Hardware for MCA front end	137607.
Installation of DRHCD	5000.
Installation of MCA software	2000.
TOTAL	174607.

DEC Maintenance for PDP-11	
First year	8469.
Subsequent years	11292.

Distant Host Interface for FNWC IMP:

Distant host driver	7300.
Additional drawers and cables	5825.
Installation	1830.
TOTAL	14955.
Cable IMP to front end	650.

ACCAT-FNWC Interface

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Summary:

MCA front end	144607.
Distant host interface for FNWC IMP	14955.
IMP to front end cable	650.
TOTAL	160212.