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SUMMARY OF CAMAC: STATUS AND OUTLOOK

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Introduction

CAMAC has made a number of quantum jumps forward during the past two years. One occurred in March 1969 when the CAMAC Description and Specification were published.<sup>1</sup> Another jump took place in March 1970 when the U.S. NIM Committee endorsed CAMAC.<sup>2</sup> Yet another step was made in October 1970 when the ESONE Committee in Europe approved the concept of the Crate Controller and Branch Highway.<sup>3</sup>

The Nuclear Science Symposium held this week constitutes another quantum jump in this country. Designers, users and manufacturers have all had an opportunity to discuss CAMAC in depth. Inevitably one wishes to ask: Will it really work? Where can I get hardware? How much will it cost? How is CAMAC better than a crate full of logic cards? We trust that many of these questions have been answered during this session.

Implementation

Extensive plans have been described for employing CAMAC in the control of accelerators at the National Accelerator Laboratory in Illinois and at TRIUMF in British Columbia. Also, data acquisition systems have been reported for use at Argonne National Laboratory, Florida State University, National Accelerator Laboratory, Stanford Linear Accelerator Center, Los Alamos Meson Physics Facility, Lawrence Radiation Laboratory-Berkeley, Yale and IBM-Yorktown Heights.

In Europe one can say that essentially all new digital instrumentation for nuclear research in Great Britain, France, Germany and Switzerland is being designed in CAMAC.

Hardware

A CAMAC crate and module has been designed at LRL-Berkeley (see Fig. 1).

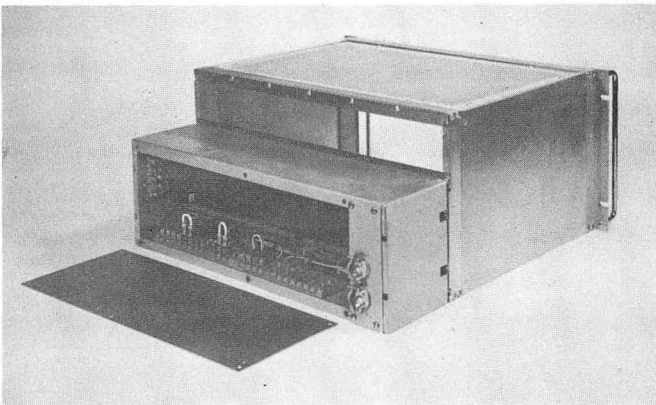


Fig. 1  
CAMAC Crate - Rear View

Crates and modular hardware are available from one domestic source; another manufacturer with a crate under design expects to make deliveries in mid 1971. Several European manufacturers are importing crates to the U.S. and Canada. Over 400 crates have been delivered in the U.S. and Canada, and over 100 of these were furnished wired with connectors and dataways.

Power Supplies

Powering CAMAC crates still poses a problem. Both the NIM and ESONE committees recommend the employment of bus voltages of  $\pm 6$  V and  $\pm 24$  V. The use of  $\pm 12$  V power is discouraged. Specifications for a typical power supply are being prepared. Current thinking is for a supply with the following current ratings:

+ 6 V @ 25 A	) Load sharing may be employed; total current availability need only be 25 A.
- 6 V @ 12 A	
+ 24 V @ 1 A*	

- 24 V @ 1 A*		
Specification	$\pm 6$ V Outputs	$\pm 24$ V Outputs
Line and load regulation plus ripple and noise components	) $\pm 1.0\%$	) $\pm 0.2\%$

Voltage changes due to ambient temperatures from 0° to 50°C	) $\pm 0.5$	) $\pm 0.5$
Long-term (6-mo.) stability effects	$\pm 0.5$	$\pm 0.3$

In addition, bus voltage drops between the power supply and modules should not degrade the regulation of the  $\pm 6$  V outputs by more than an additional  $\pm 0.5\%$  and the  $\pm 24$  V outputs by  $\pm 0.1\%$ .

Four companies are known to be designing power supplies specifically for CAMAC applications; however, at present power must be obtained from proprietary models available from various manufacturers. In some cases NIM supplies can be adapted.

Ventilation

Ventilation may be summarized by the simple statement: Use it! We have made tests on a single rack-mounted crate with two different internal power dissipations both with and without forced-air cooling. Table I lists the highest temperature rise measured in any module.

\* This current rating has since been increased to 3 A.

Table I  
Temperature Rise

Power Dissipation	Without Forced- Air Cooling	With 2 x 35 CFM Cooling
144 W	27°C	10°C
200 W	44°C	16°C

Thus it may be seen that integrated circuits with a 70°C maximum temperature rating can safely be used if adequate cooling is employed.

#### System Components

Two U.S. companies are presently manufacturing scalars, registers, gates, time-to-digital converters and analog-to-digital converters.

Numerous European companies are supplying CAMAC modules as well. In fact, 29 organizations exhibited CAMAC units at the ESONE General Assembly held at CERN in October.

The Crate Controller Type A is available domestically on 45 days delivery; a number of European manufacturers are also offering the CC Type A.

Branch Drivers will be available for the PDP 15, HP 2114, 2115 and 2116 and the Nova and Supernova computers early in 1971. There are definite plans to construct Branch Drivers for the PDP 8 and PDP 11. The PDP 15 Branch Driver is also expected to operate with the PDP 9 computer.

#### Relation of NIM Equipment

A number of manufacturers and laboratories have substantial investments in NIM equipment. The question arises, what of its future employment? In the U.S. we have every intention of continuing to employ the NIM system for analog and fast-logic instrumentation for several reasons. The usage of CAMAC is complimentary to NIM. The NIM system is more appropriate to use where front panel access for controls, readout and interconnecting cables is desirable; CAMAC is more appropriate where access to a dataway is required.

Another factor to be considered is the basic cost of the opening into which an experimenter plugs a NIM or CAMAC module; this may be considered the module rent or overhead. A powered NIM bin costs between \$500 and \$1000; if this figure is divided by the number of module positions (12), the overhead cost runs from \$40 to \$80 per module. The cost of a CAMAC crate, power supply and crate controller divided by the number of available module positions (23) runs at least \$120 per module. If the additional expense of a Branch Highway and Branch Driver is included, the cost is considerably higher.

The moral to this story is that if you need a dataway, use CAMAC; if you don't need a dataway, NIM is much less expensive.

#### Applicability of CAMAC

In CAMAC the computer, issuing commands via the Branch Driver and Crate Controller, addresses a module in a particular crate location or station rather than

addressing a module with a particular function no matter where it may be plugged in. Either system could be made to work; in CAMAC however, the decision was made to be primarily address locatable rather than function locatable. In discussing these options with Professor Owen Chamberlain recently, he expressed his preference for the CAMAC decision.

Trading equipment among experimental groups is becoming more popular. Almost every large laboratory has its HEPP, SHELF or equipment pool. The interchangeability of CAMAC components is a strong argument in its favor. Our experience with user groups trading NIM equipment has been most favorable at Berkeley. We expect CAMAC components to be traded every bit as much.

#### Bookkeeping

In line with the interchangeability of modules, crates and branch drivers, who is going to see that compatibility is a fact rather than a fiction? Can physicists at the University of Hawaii interchange modules with experimenters from Florida State? We believe that this can only be accomplished through the efforts of several working groups. Fred Kirsten has been named chairman of the U.S. Dataway Working Group. This committee in conjunction with manufacturers and other users will provide the "system" coordinating function in North America.

What about software? Will everyone need to write his own programs? Can they be purchased? Can some routines be supplied gratis? Some of each will be true.

The major emphasis on CAMAC in Europe is now on software. In this country Dr. Satish Dhawan is chairman of the U.S. Software Working Group. Those interested in this aspect of the program are urged to contact him. Nat W. Hill of Oak Ridge National Laboratory is chairman of the Analog Signals Working Group, and I am chairman of the Mechanical and Power Supply Working Group.

#### Summary

Is everyone going to use CAMAC? Probably not. Does CAMAC represent the latest thinking in data handling? Again the answer is no. However, one must remember that the time from conception to delivery of a computer makes it partially obsolete before it is ever used. This is the price of progress. A similar gestation time is inevitable for CAMAC. If we were to begin today, CAMAC would be different, but at this point in time we cannot start over. CAMAC is the only system with any chance of wide-spread acceptance in the near future. We intend to take advantage of its opportunities right away.

#### References

1. CAMAC, A Modular Instrumentation System for Data Handling, EURATOM Report EUR4100e, March 1969.
2. CAMAC, A Modular Instrumentation System for Data Handling, Aug. 1970. (Information requests to Louis Costrell, National Bureau of Standards, Washington, D.C. 20234.)
3. CAMAC, Organization of Multi-Crate Systems, Specification of the Branch Highway and CAMAC Crate Controller Type A, EURATOM Report EUR 4600e, September 1970.

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