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AN ANALYSIS OF THE COST OF CONVERTING THE LEBT LINE TO EUROCARD FORMAT

Internal Distribution

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The upcoming LEBT instrumentation upgrade is a good time to evaluate the cost of transforming the present NIM packaging standard at the AGS to the newer Eurocard standard. There are some necessary initial costs but some long term savings are possible, too. This proposal describes the Eurocard standard in the form that it may take both for LEBT instrumentation and future AGS instrumentation. It analyses the cost differential between NIM and Eurocard and calculates the cost of Eurocard packaging in the LEBT line as a preliminary standard.

The Eurocard packaging system is a mechanical specification for rack-mounted electronics. The specification creates dimensional standards from the printed circuit board grid up to sub-rack and rack dimensions. It differs in detail from the NIM standard, and the differences are important for assessing the costs of a proposed transition from the existing NIM to Eurocard. The mechanical details being different, a Eurocard system implies changes in electrical shielding and noise immunity, structural strength, and thermal properties. Finally, price and labor estimates for the two systems differ.

The Eurocard standard alone is a packaging standard. However, it is intimately associated with the VME bus as a companion electrical standard. This will be important in determining the versatility of any future mechanical specification. The Eurocard system defines a basic height and width by the variable dimensions U and HP. A standard 19" wide NIM bucket is an 84 HP wide Eurocard sub-rack. The standard NIM height corresponds to a 6U Eurocard height; the single width NIM module corresponds to a 7HP wide Eurocard module. The most common Eurocard heights are 3U,6U,and 9U. The module widths are usually in multiples of the 7HP width, although single pc boards can mount in one HP with no external module. There may or may not be an associated backplane for the sub-rack, but if there is, Eurocard specifies the backplane connector positions. The printed circuit board uses a .1 inch grid and the rear connectors can have 32, 64, or 96 pins apiece. The sub-rack depth and printed circuit board depth do not have to match, but the commonest depths for board and module assemblies are 100, 160, and 220 mm. Non-standard depths are available and their effect on the assembly of Eurocard standard sub-racks is minimal.

For use at the AGS, a module should be at least the quality of current modules. The NIM modules at the AGS have metal sides which provide some electrical shielding, so any Eurocard module would have to be an enclosed type. There are more options for enclosed modules in Eurocard than there are in NIM, but a reasonable replacement for the current NIM style is either a printed circuit mounting kit with a metal shield on each side or a seamless aluminum extrusion module, known as an rf module. The mechanical properties of these modules are either indistinguishable or superior to NIM modules at the AGS. The shielding properties of the kit

module are similar to the present NIM style, the only apparent difference between them being their slight size difference. The rf module is an extrusion from a single piece of aluminum, so it is mechanically stronger than the kit and provides better shielding. One knows this qualitatively, even though manufacturers do not publish noise immunity levels in db, the noise source being unknown. The cost of these modules is about the same as the corresponding width NIM module and a summary appears in Table 1.

Module Size	Avail.	Price
PC Mounting Only	10 da.	$22
PC Mounting, Al Sides	10 da.	$45
RF Module	2 wks.	$35
Standard AGS NIM	2 wks.	$35

Table 1. Module Prices

The Eurocard sub-rack differs in several ways from the NIM crate at the AGS. Although the two are mechanically similar, the major difference is the backplane connector. The NIM connector is an insertable pin type which requires hand-wiring and insertion of the pins. The Euro-card connector is usually either a mass termination type or a wire-wrap type. The mass termination backplane of course implies the existence of some bus on which the module resides. The wire-wrap connector allows free inter-connection of signals from a module more easily than the NIM system. Actual estimates of the time to wire a NIM crate (the SWIC scanner crate, common at the AGS) is about two days. This estimate includes pin insertion into the connector and alignment of the pins with a jig. Unaligned pins will reliably cause malfunctions of the module. Technicians routinely hammer with their hands the fronts of modules to seat the connectors. The time to wire and assemble the NIM connector is about two hours per connector.

Eurocard connectors contrast with the NIM style by being mounted on the printed circuit board. The mating connector usually is on a backplane assembly, which in turn is part of the sub-rack assembly. Eurocard specifications control the connector assemblies tightly enough to ensure mating of all the pin connections. If the module does not insert into the backplane easily, something is wrong. The connector pins align with the printed circuit grid to provide pin densities of 32,64,or 96 pins per connector. However, the specification allows for options in the type and number of pins per connector. What changes with each option is the use of a grid to match the printed circuit

board to the pins, but the grid is optional in these cases. Clear advantages of this format are the availability of various mass termination techniques and an increase in pin density of about 20 to 100 percent.

Eurocard sub-racks and NIM crates are essentially the same mechanically except for the backplane on the Eurocard style. The NIM standard crate at the AGS is stronger than most Eurocard sub-racks, but one can always buy heftier sub-racks. The Eurocard sub-racks also have available shielding panels of aluminum for the open spaces at the back and top. The solid side panels are standard. The important difference, and the most costly for the sub-rack, is the backplane. A fully wired and assembled backplane in a form usable at the AGS would cost about $600. This form is a four-layer printed circuit board with twenty-four connectors of ninety-six pins apiece. Twelve of the connectors can be part of the VME bus and twelve can stand alone, or all twenty-four can stand alone. Table 2. is a comparison of the prices of various sub-racks that closely match the NIM crate in use at the AGS.

Crate Style	Avail.	Price
No Backplane	10 da.	$100
Non-VME	10 da.	$400
VME	6 wks.	$1000
NIM	3 wks.	$330

Table 2.
Crate Prices

There are also engineering implications due to the differences in format between the Eurocard and NIM systems. The NIM system is firmly in place at the AGS, and the electronic assemblies all fit the NIM module footprint. The artwork and schematics for these assemblies do not exist on the CAD system, although future designs will. Eurocard packaging exists as a natural companion to the VME bus, and any consideration for changing to Eurocard implies that one develop some auxiliary bus to VME for use at the AGS. If there were no such auxiliary bus, there can be many sub-racks that look alike but are not alike. Lastly, the Eurocard printed circuit card footprint that most closely matches the NIM printed circuit card footprint is, unfortunately, transverse to the NIM footprint. Figure 1. compares the two shapes.

Engineering qualities of the Eurocard system and what is available in it vary widely. Properties such as noise immunity, thermal conductivity from the electronics to the ambient atmosphere, electrical shielding, and mechanical stability vary somewhat among vendors. However, Eurocard is fast becoming popular enough that there are many more vendors selling it than NIM. There is always a Eurocard module that can well replace any NIM module. From the direct comparison of module prices, Eurocard replaces NIM for about the same cost as well.

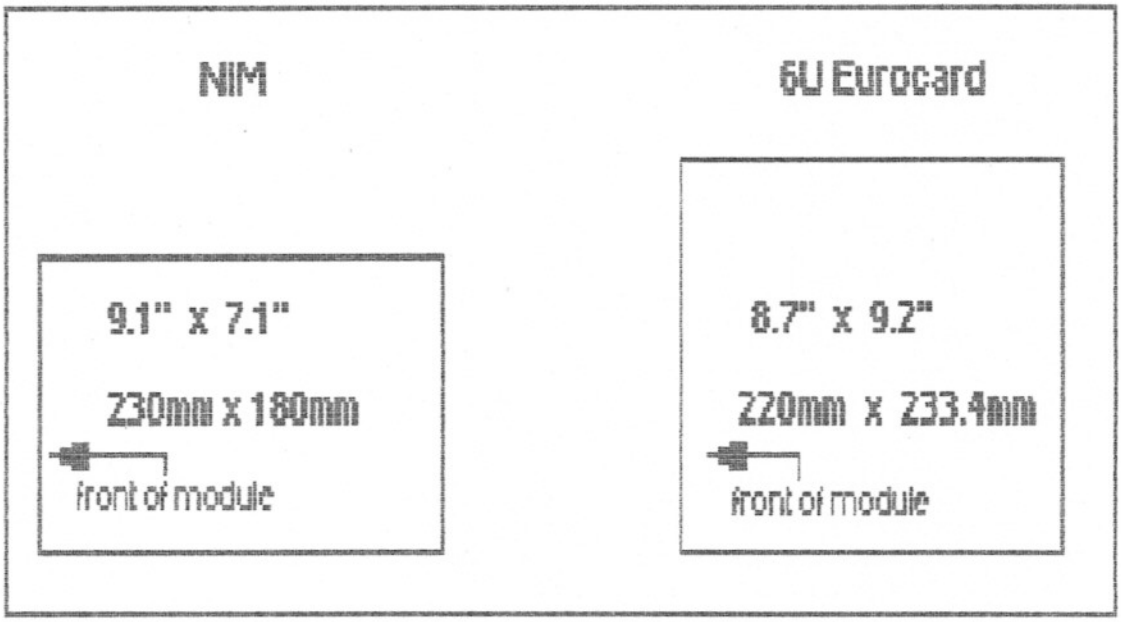

Fig. 1. Printed Circuit Board Sizes

A LEBT line Eurocard standard will require several engineering changes. The different size and configuration of the modules implies an initial cost in drafting time to convert NIM format electronics to the Eurocard shape. The estimate by drafting of the time to lay out a Eurocard board from an existing schematic is about one week. For some modules, there is a need for only one or a few in the entire LEBT line. These modules have printed circuits which one may conveniently turn ninety degrees and rewire to Eurocard front and back panels. The turned boards would sit on a carrier board with a Eurocard outline. Drafting estimates the carrier board design to take one day. The use of a Eurocard backplane requires at least an attempt to define a bus for the analog signals that will travel across the backplane. A good attempt at a prototype analog bus should take one week of engineering time. An intangible benefit from a switch to Eurocard will be the transferral of some artwork from its present form to CAD files.

The new LEBT instrumentation consists of about five buckets of electronic modules. There are twelve different types of module, seven of which exist presently as designs. Since the complexity and necessary quantities of these modules vary, the estimate of the cost of switching to Eurocard depends on how these modules become Eurocard modules. Some require redesigning the artwork, others, simply mounting on an adapter board. Finally, some modules do not yet exist and require original design. For extant electronics, there is a penalty for switching the artwork format, and there is the difference in price between the two packages. However, there is a savings in assembly time beacause of the lack of a NIM connector. For as yet undesigned electronics, there is no labor penalty, since it takes no longer to design to a Eurocard format than it does to design to a NIM format. There is still, however, the package price differential. The total unique cost of a LEBT Eurocard system, that is, the cost increase over the same system in NIM, is the cost of the Eurocard system minus the cost of the similar NIM system, costs being both prices and labor.

Of the twelve types of electronics modules, five types require the NIM to Eurocard packaging flip. The estimate for converting one module is a half day savings of electronic technician time. For the sub-racks, there is a labor savings of two hours per sub-rack over the NIM bucket, if one uses the previous estimate for NIM connector wiring time. Counting duplicates, the actual number of modules is about forty-five. The five types requiring repackaging come to about twenty modules, again counting the duplicates. From these numbers, one can now estimate the cost of switching LEBT to Eurocard. Thus:

Total labor cost = (Drafting + Assembly + Engineering - Sub-rack savings) x $280/day

or

Labor cost = (4 - 10 + 5 - 1) x 280 = -$560;

Total packaging cost = Sub-rack premium x no. of sub-racks + Module premium x no. of modules

or

Packaging cost = $70 x 4 + $10 x 45 = $730.

So the total cost of using Eurocard instead of NIM for LEBT electronics comes to about $170. This expense is an added charge for using Eurocard, but is so small in proportion to the budget for this project that it is negligible.

Some final advantages of switching now are that Eurocard is quickly becoming popular in the United States. This implies lower prices as more competitors enter the market with products. The VME bus is an apt choice for a future instrumentation standard, and if that bus were to become a standard or just become common at the AGS, hundreds of VME products become available. This large selection expands the potential of the instrumentation we use, which is the purpose of an upgrade.