

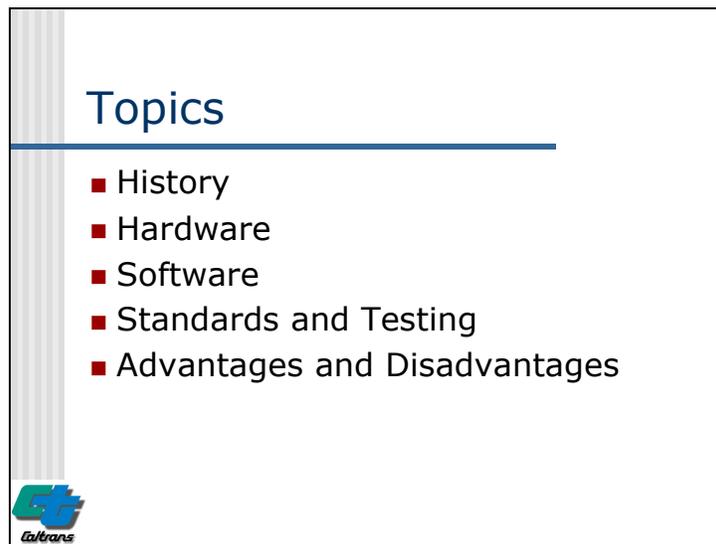
The Advanced Transportation Controller Model 2070



AN OVERVIEW OF THE MODEL 2070 SIGNAL CONTROLLER STUDENT GUIDE

April, 2002

Slide 2



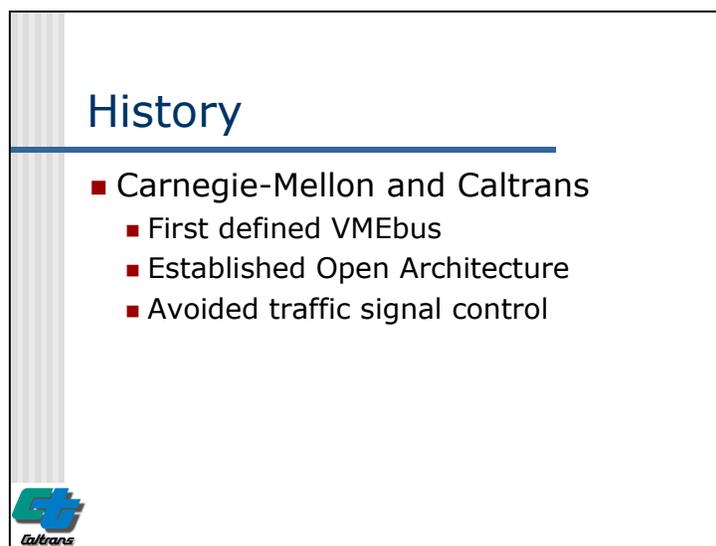
Slide 2: Topics

- History
- Hardware
- Software
- Standards and Testing
- Advantages and Disadvantages



The presentation will start with the history of the development of the 2070. Then it will discuss the hardware options, which are many because of the 2070's standard interfaces, and will also cover some software issues. As with the 170, the software is purchased separately, which means that the functionality needed in the controller is included in the software procurement rather than in the hardware bid documents.

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Slide 3: History

- Carnegie-Mellon and Caltrans
 - First defined VMEbus
 - Established Open Architecture
 - Avoided traffic signal control



The initial interest in an Advanced Transportation Controller was the hope of establishing a more powerful processor, while still maintaining the open architecture that was the hallmark of the Model 170. At first, many of these efforts seemed like attempts by the 170 manufacturers to incrementally change the specification to carve for themselves an exclusive niche. This is, of course, opposed to the concept of open architecture, where

parts and interfaces are standardized, and ultimately these attempts were rejected in the market.

One of these efforts was called the SBC-68, built by Safetran in cooperation with the New York State DOT. It was a 179 controller with an extra processor bus. It had the advantage of being able to run 170 software directly, but that was the only advantage.

Signal Control Company, which was the other major supplier of 170 controllers at the time, also had their own advanced controller, based on their interface bus which they called Transbus. This product was abandoned when Signal Control Company was acquired by Peek Traffic.

The only effort, which was being pursued by a public-sector consortium, was the VMEbus-based Advanced Transportation Controller. Carnegie-Mellon University performed a software and hardware development effort for Caltrans in cooperation with the Federal Highway Administration. The original concept was for a 6U VMEbus, which would have made a controller twice as tall as a 170. The software was object-oriented, following a process-control algorithm that allowed the user to connect inputs, outputs, and processes graphically. The software concept was never implemented, but the hardware ideas became the basis for the 2070.

Initially, Caltrans avoided signal control, because they did not want to compete with the 170 or other commercial offerings. Ultimately, though, the effort changed from the research folks at Caltrans to the electrical specification people, and a 170 form factor emerged as a requirement. Caltrans convened a panel to develop a specification for a traffic signal controller, and that panel included representatives from Caltrans, the City of Los Angeles, and academia. The 2070 specification was their product. Maintenance of the standard for users outside California is handled by the Joint Committee on the ATC. The Joint Committee provides input to Caltrans, but the changes in the standard appear in the Caltrans specifications first. The presentation will include more about the Joint Committee further down.

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History

- Caltrans
 - The first Model 2070
 - The first test
 - City of Los Angeles
 - In-house software



The first proof of concept for a 2070 signal controller was performed by the City of Los Angeles. Sean Skehan acquired the hardware to construct a prototype signal controller, and developed software from scratch to test it out. That software is still being used in Los Angeles. It emulates their 170 software and operates within the ATSAC system. They have also enhanced it to include adaptive signal control, including new central software to go along with it.

The first 2070 started operating traffic signals in Los Angeles in about 1992.

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History

- The ATC Steering Group
 - Consortium of NEMA, AASHTO, and ITE
 - 2070 Hardware
 - ITS Cabinet
 - 2070 Software Application Program Interfaces
 - <http://www.ite.org>



The Joint Committee on the Advanced Transportation Controller is sponsored by the Federal Highway Administration, and is a joint effort of the Institute of Transportation

Engineers, the National Electrical Manufacturer's Association, and the American Association of State Highway and Transportation Officials. The organization of the steering group is similar to the NTCIP Joint Standards Committee, on which it was modeled.

The products of the steering group include specifications for the 2070 hardware, which are identical to the Caltrans specification, except that the Caltrans-specific language has been generalized. Most agencies use the Caltrans specification directly, because it is more up to date.

The more useful products of the steering group are specifications for the ITS Cabinet and for Application Program Interfaces for the software.

This presentation will discuss some information about the ITS Cabinet further down.

An application program interface is a set of C function calls that allow a portion of the software to send data and commands to other portions of the software in an open, standard way. This means that the traffic control software can work with the hardware control software within the controller by following a set of known rules. This allows those two software components to be developed by different people without having to be integrated.

At present, 2070 software is self-contained, working only with the operating system of the controller. This follows the 170 model, where the traffic software must also include the operating system services. By separating these software components, the manufacturer can provide device management software, the system supplier communications software, and the controller software house the software that actually times the traffic signals.

More information about the work of the steering group can be found at their web page, which is part of the ITE web page.

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Hardware

- Open architecture
 - All components interchangeable
 - Interfaces defined in standard—not manufacturer-specific
 - Compatible with all existing cabinets
 - VMEbus option for multi-processor architecture
- Common Operating System Software: Microware OS-9
- Hardware spec only; no application software (like Model 170)



The 2070 is an open-architecture controller. What does that mean? Open architecture occurs when the interfaces, both hardware and software, are publicly available and managed by *responsible* and *responsive* agencies.

Responsible means that the standards-setting agency must hold the best interests of the users at large as their foremost objective. Individual manufacturers have had difficulty maintaining this position, though several have tried. Users generally will not trust a single manufacturer with this responsibility. Manufacturer organizations do better, but the most user trust comes when users are involved in the management of the interface standards. This is the reason for a steering group consisting a consortium of organizations.

Responsive means that the managing agency must be willing to solve problems and make changes as they are necessary. Consequently, there must be a process by which problems are noted and solved, and the solutions incorporated into the specifications, in an open and orderly manner.

The Joint Committee on the ATC meets both of these requirements. Caltrans has done a good job with keeping the users' interests at heart, but is not formally responsive to needs emerging outside California. Despite this, Caltrans has worked closely with agencies implementing 2070s outside California in an effort to ensure the success of the specification.

Publicly available means that the specification is equally available to all manufacturers and users.

The 2070 meets standards of open architecture in a variety of ways. All the hardware components in a 2070 are standardized and interchangeable. An Eagle power supply will reside successfully in a US Traffic chassis. In fact, Iteris, who maintains the Detroit



Freeway Management System, installed Eagle power supplies to replace a faulty design in an early Matrix 2070 that was used as a communications hub in Detroit. This has also been done by Harris County (Houston) in Texas.

This presentation go through each of the components in a 2070, and show you how they fit together, a little later on.

The 2070 is also open-architecture in that it can be adapted routinely for all standard cabinets. 2070's can be easily configured for shelf-mount NEMA cabinets with three round-plug connectors, and also for rack-mount 170-style cabinets with a single square plug connector. The 2070 also includes the serial interface needed for the ITS cabinet and the NEMA TS-2 Type 1 Cabinet Bus Interface.

The 2070 specification includes the operating system. Microware OS-9 is supplied by the controller manufacturer, not by the software supplier. Many controller makers also use Microware to provide low-level device control and support software. In addition to the operating system, the manufacturers are required to provide hardware device drivers, and a program used for verifying and troubleshooting features, called the Validation Suite. Valsuite runs separately from the traffic software.

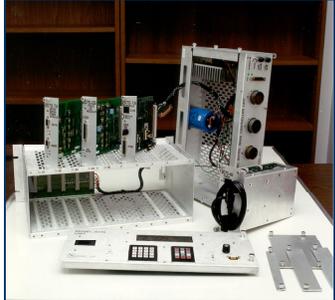
The front panel on a 2070 is configured just like a serial terminal, so it can display anything that can also be displayed on a separate terminal. The separate terminal plugs into the front of the controller using a standard serial port. Software is copied into the controller's memory using this separate terminal, and the traffic software can also be manipulated there.

The hardware specification does not provide software for traffic control. Traffic control software is purchased separately (just as with the Model 170), though it may be supplied by the manufacturer if so specified. Most larger agencies consider this an advantage, because they can purchase the software on an agency-wide license and duplicate it as needed, which allows them to purchase it using an engineering services contract. This gets the traffic control features out of the hardware spec, and opens up the hardware purchasing process.

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Hardware Components

- Chassis
- CPU
- VMEbus
- Field I/O Unit
- Serial and Modem Units
- Power Supplies
- Front Panels
- NEMA Interface Module



All the hardware components of the 2070 are modular and interchangeable. In the picture, the chassis is on the left, with a processor card, a communications module, a field I/O unit resting on top. The NEMA cabinet interface and the power supply are on the right, but it is only used by agencies who have NEMA-style cabinet into which they are retrofitting a 2070. The chassis shown does not include a VMEbus card cage, which is optional.

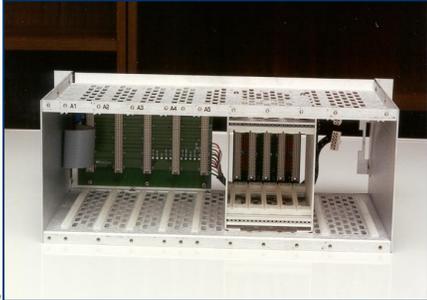
Any of these parts can be replaced with the same part from another manufacturer.

The presentation will discuss each of these modules.

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Chassis

- Same chassis for any configuration



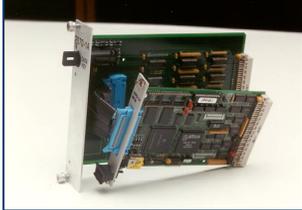
The chassis is a standard design. It has a 170 form factor, meaning that it is rack-mountable with a 7-inch height. All of the cards that plug into the chassis do so from the rear, and it is the rear of the chassis that is shown in the picture. Only the front panel connects at the front.

Unlike the chassis in the previous picture, this one includes a VMEbus card cage.

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CPU

- VMEbus version (2070-1A)
- 2070 Lite no-VME version (2070-1B)





Two processor cards are described in the 2070 specification. The processor on the left, which is called the 2070-1A, is designed for mounting in a chassis that provides a VMEbus card cage. It consists of two cards: A processor card for the VMEbus (called the Main Controller Board), and a transition board to connect the processor to the I/O bus in the chassis. Note the plug-in datakey. The datakey stores information about this controller on the key, and the key must be installed before the configuration of the controller can be changed. Different software suppliers use the datakey in different ways.

The card on the right is designed for a chassis with no VMEbus card cage. A 2070 without a VMEbus card cage is called a 2070 Lite, or 2070L, and is considerably less expensive than the 2070.

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CPU

- Based on 68360 Motorola processor
- 4 MB Volatile RAM (or more)
- 512 KB of SRAM
- 4 MB Non-volatile Flash RAM
- 7 CPU ports, ranging from async serial to optional Ethernet
- 4 or more serial ports connected to outside world



The CPU is specified to provide a Motorola 68360 processor at a speed of 24.576 MHz, though faster processors are acceptable. The memory is divided into at least 4 megabytes of dynamic RAM, paged through 512 kilobytes of high-speed static RAM, plus 4 megabytes of non-volatile flash memory. Each of these three memory types are organized in their 16 megabytes of flat-file address space.

Traffic control software and all timings and parameters are stored in flash memory, while run-time data structures and temporary data are stored in normal RAM. The processor card is designed for extensive communications, and comes with 7 defined ports, including one Ethernet port. The 2070 specification does not implement all of these ports. The standard 2070 provides two serial ports for systems communications, one for an external terminal, one for the front panel, and one or two for the field I/O (one of which is the RS-485 NEMA TS-2 Cabinet Bus Interface).

The processor includes two timers. One is derived from the line frequency supplied by the power supply, and the other one is based on a quartz clock read by the operating system. Traffic software typically uses the line frequency signal for routine clock operations, unless outside power is interrupted. This allows controllers using time-based coordination to stay synchronized more precisely.

The operating system software is Microware OS-9, which is a general-purpose industrial control operating system that includes most typical services, such as device management, clock management, file management, multi-tasking, procedure startup (called forking), and the like. It has similar features to Unix, but in a real-time environment that is guaranteed to respond to external interrupts within 100 microseconds.

The FLASH memory is organized as a disk drive, and is where OS and traffic control software is stored.

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VMEbus (2070-5)

- Motorola-derived Versa-Module Europe standard (IEEE)
- VMEbus is optional (required for 2070-1A processor)
- Allows multiprocessor environment
 - Bus-arbitrated
 - Other processors can share resources
 - Used at present only for Gardner's RHODES adaptive-control algorithm



The original plan for the 2070 included an industry-standard processor bus to open the architecture of the controller's backplane. Originally, the design would use the VMEbus for all backplane activities. In practice, this proved too expensive, which is why only the processor uses the VMEbus.

VME stands for Versa-Module Europe, and is based on the old Motorola VersaBus design, as standardized by the IEEE. As a computer bus, it provides two key features: shared memory and other resources, and bus arbitration. Bus arbitration means that multiple processors can be installed on the bus, and the bus itself will direct the turn-taking between the processors. This makes it easy to add processors for specialized tasks. For example, Siemens Gardner Systems uses an additional processor to implement the RHODES adaptive signal control software. Originally, that additional processor was based on an Intel Pentium, which meant that the Motorola 68360 chip and the Pentium were shared the same memory and other resources without a hitch. That's the beauty of bus arbitration.

There are many potential applications for a multi-processor environment in the controller. An additional processor might be use for video detection, for example.

The VMEbus card cage is an expensive component, adding as much as \$1000 to the cost of the controller. Because its application is limited to multiprocessing, it is an option in the 2070 specification. A 2070 without the VMEbus card cage is called a 2070 Lite, or 2070L. If the chassis has a VMEbus card cage, however, the 2070-1A processor must be used, and the more powerful power supply must be included.

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Field I/O Unit

- 170 cabinet version (2070-2A)
- NEMA cabinet version (2070-2B)
- 2B connects to NEMA Interface Unit



The 2070-2A Field I/O Module (pictured left) is designed for 170-style cabinets. The main connector to the cabinet backpanel is the C1S connector, which is identical to the C1 connector on a Model 170 controller. This Field I/O Model is self-contained.

The 2070-2B Field I/O Model (pictured right) operates along with the 2070-8 NEMA Interface to be compatible with NEMA TS-1-style shelf-mount cabinets. It contains a parallel connector (C12S) that communicates with the NEMA module only.

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Serial Comm Units

- Async Serial Ports (2070-7)
- Modem Cards (2070-6)



The 2070-6A is a 1200-baud modem which modulates using Phase-Coherent Frequency Shift Keying (FSK). The 2070-6B uses the same technique, but supports speeds up to 9600 bits per second.

The 2070-7 includes two standard asynchronous serial ports.

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Power Supplies

- 10-amp version VMEbus (2070-4A)
- 3.5-amp version for 2070 Lite (2070-4B)





The power supply comes in two versions. The more powerful version is designated the 2070-4A Power Supply, and supplies sufficient power to operate a VMEbus card cage. The 4B power supply is designed for chassis without the VMEbus card cage. The current 2070 spec does not require labeling the A and B options as shown in the pictures, and otherwise they look very similar. It is important, therefore, for agencies to either standardize on a single version, label the supplies themselves as they are received, or require the manufacturer to label them.

The power supplies include capacitive hold-up to keep the power alive to the controller during service-voltage dropouts of up to 600 seconds (at 600 micro-amps drain).

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Front Panels

- Act as standard terminal on OS-9
- Oversized 4x40 display (2070-3A)
- Miniature 8x40 display (2070-3B)
- No display or keypad (2070-3C)



The 3A front panel includes the front-panel controller (which emulates a VT-100 terminal under the OS-9 operating system), a numeric input keyboard, the C-50 asynchronous serial port, a software control keyboard, an AUX switch, an alarm bell, and a backlit oversized 4 line by 40 character liquid crystal display.

The 3B front panel is identical to the 3A panel, except that it has a backlit miniature 8-line by 40-character display. The 2070-3B is pictured here. So far, software products currently available do not make use more than four lines of display, to maintain compatibility with the 3A panel.

The 3C module is for applications where front panel controls are not necessary, and is a blank panel with a serial port configured as the C-60 port.

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NEMA Interface Module (2070-8)

- Attaches to bottom of chassis
- Interfaces with NEMA cabinet
- Requires 2070-2B FIO Module
- NEMA TS-1 and TS-2 cabinet compatible
- All 2070's include TS-2-style Bus Interface Unit
- Optional back cover (2070-9)

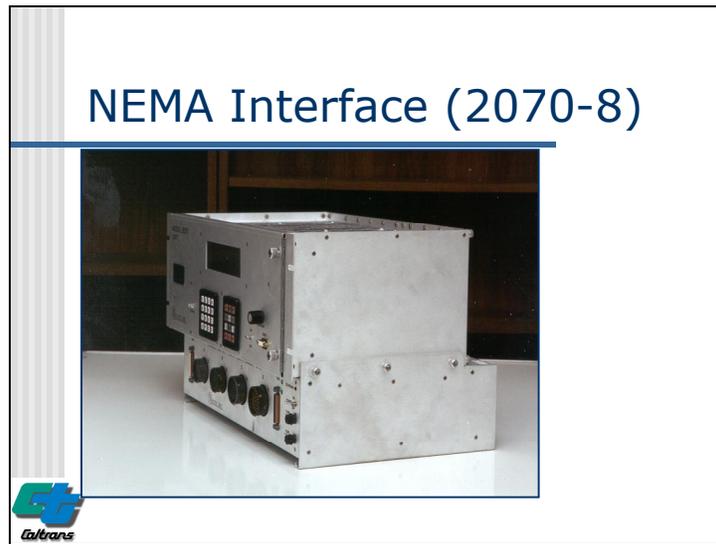


The NEMA Interface Module (2070-8) requires the 2070-2B Field I/O Module, to which it connects using the C12S parallel harness. Of course, the NEMA interface harness is option and only needed when retrofitting controllers in existing NEMA-style cabinets.

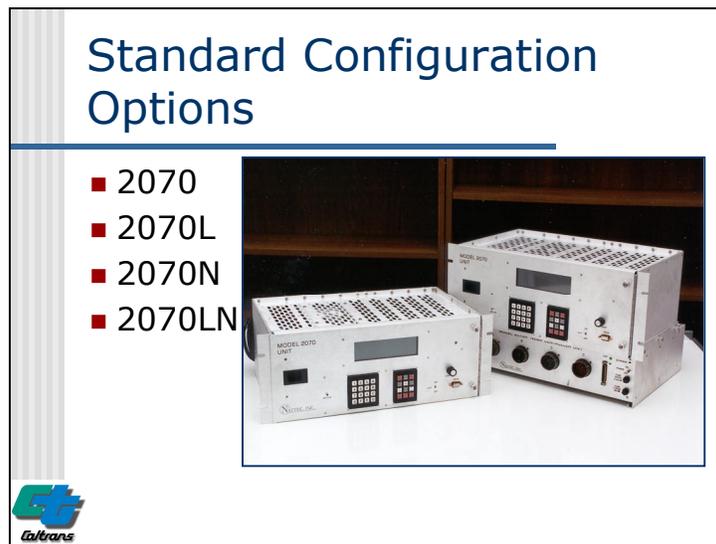
The NEMA Interface Module includes the standard NEMA TS-1 A, B, and C connectors for compatibility with TS-1 cabinets. The Module also contains a D connector with the Caltrans standard pinout. It has two external serial ports and a Cabinet Bus Interface port. The two serial ports are connected to a 2070-7 Asynchronous Serial Module which is installed in the 2070 Chassis, using harnesses that feed out the back of the interface box. The 2070-8 also includes a duplex receptacle, to which the 2070 power supply is plugged, and which is powered by the standard power connections coming through the A connector.

The 2070-8 connects directly to the bottom of the 2070 chassis using screw holes that are provided in all chassis configurations. Any chassis can therefore be used in a NEMA cabinet application.

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Slide 18



The 2070 controller is designed to be an open-architecture controller. One requirement of this approach to be usable in all currently available cabinet configurations with the same software.

In addition to 170-style and NEMA cabinet configurations, the 2070's cost can be reduced by eliminating the VMEbus card cage. This will limit the controller's flexibility for advanced applications, but is probably the configuration most useful for normal traffic signal control applications. Without the VMEbus card cage, the 2070 is designated 2070L, for 2070 Lite. The 2070L is expected to cost as much as \$1000 less than a

standard 2070. The Lite version is also available for NEMA cabinets, termed the 2070LN.

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2070 Full Version

- Chassis
- 2070-1A VMEbus Processor
- 2070-2A 170-style Field I/O Unit
- 2070-3A or B Front Panel
- 2070-4A 10-Amp Power Supply
- 2070-5 VMEbus card cage
- Comm modules as specified



These are the modules required with a standard 2070 for advanced applications within 170-style rack-mount cabinets.

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2070L, The Low-Cost Version

- Chassis
- 2070-1B single-board processor
- 2070-2A 170-style Field I/O Unit
- 2070-3A or B Front Panel
- 2070-4B 3.5-Amp Power Supply
- Comm modules as specified



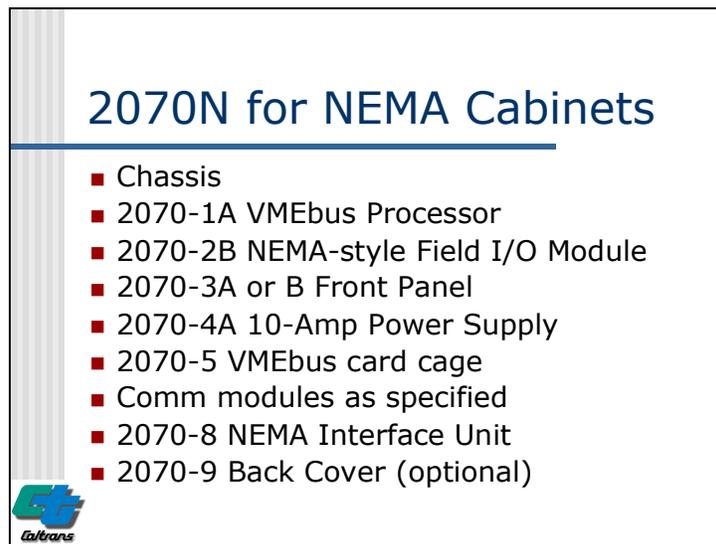
These modules are required for a 170 cabinet for routine applications.

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These images show front and rear views of a 2070 set up for 170-style cabinets.

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These modules are required for controllers intended for advanced shelf-mount applications.

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2070LN, Low-Cost NEMA

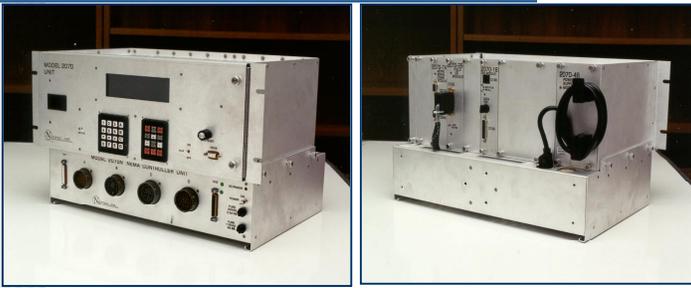
- Chassis
- 2070-1B single-board processor
- 2070-2B NEMA-style Field I/O Module
- 2070-3A or B Front Panel
- 2070-4B 3.5-Amp Power Supply
- Comm Modules as specified
- 2070-8 NEMA Interface Unit
- 2070-9 Back Cover (optional)



And these modules are required for routine NEMA cabinet applications.

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2070 NEMA Version



The NEMA-compatible 2070, shown without the optional back cover. Note that the chassis gets its power from the NEMA A connector via a duplex receptacle mounted on the NEMA module. Note also the wiring harness that connects the NEMA connectors to the 2070-2B Field I/O Module.

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Two Examples

- 2070 Assembly Sequence
- 2070LN Assembly Sequence



The presentation will now show two examples of how the components of a 2070 can be assembled in various ways. First, it will show the assembly sequence of a standard VMEbus-equipped 2070 for 170-style cabinets, and then it will show the sequence for a NEMA-compatible version without the VMEbus card cage.

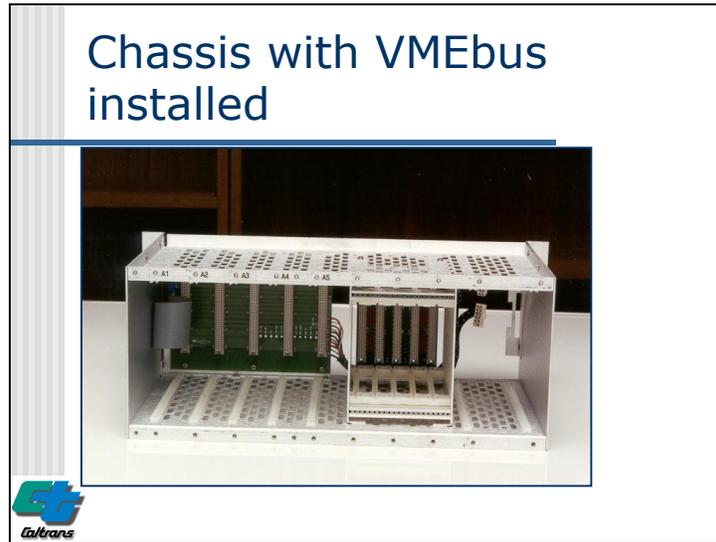
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2070 Assembly Sequence



The first sequence describes the standard 2070.

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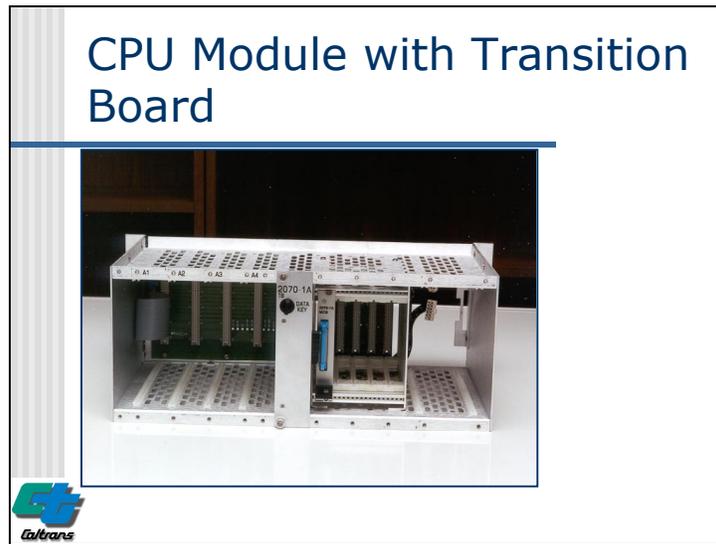


This is the standard chassis, with a VMEbus card cage installed. The card cage can be removed—it is held in place by screws that go through holes provided in all 2070 chassis. If you look through the cavity to the right of the VMEbus card cage, you'll see a power plug, and just a bit of the second plug. One plug is for the chassis bus on the left, and the other plug supplies power to the VMEbus card cage.

Note the loop of ribbon cable at the back left of the chassis. This is the connecting cable for the front panel, and sufficient slack is provided to allow the cable to be reversed in case the front panel is replaced with a different manufacturer's product.

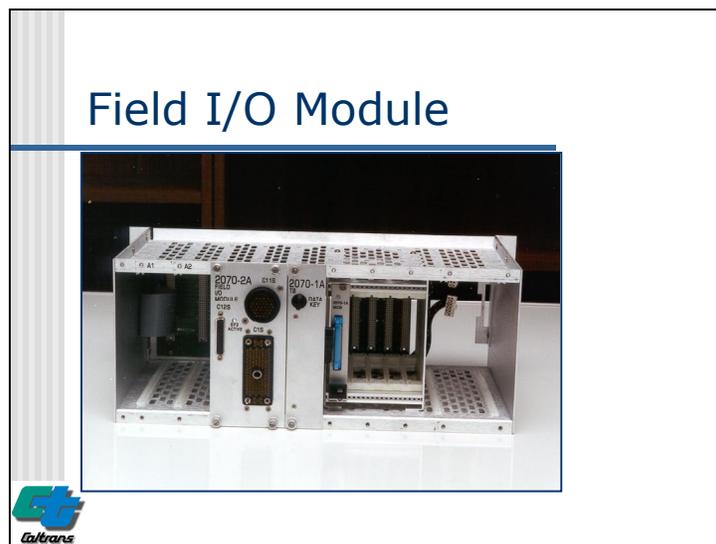
This picture and those that follow show the back of the controller. All cards in the 2070 are installed in the rear of the controller.

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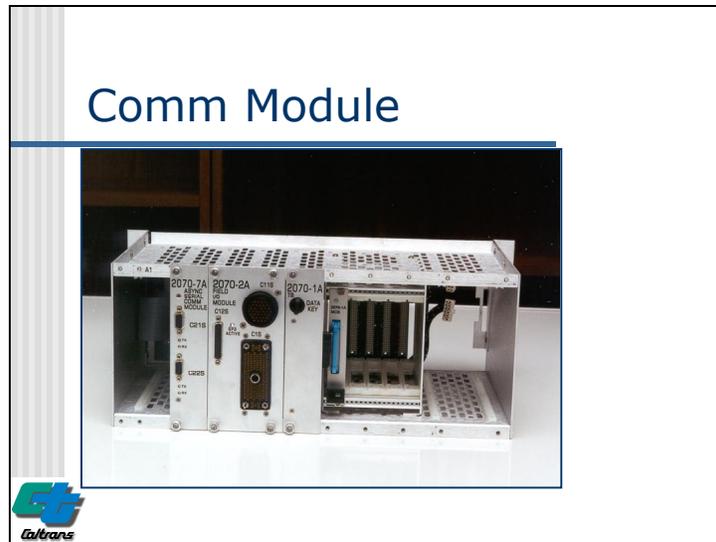
This image shows installation of the 2070-1A processor components, including the VMEbus-based Main Control Board, the transition board (which connects the MCB to the chassis bus), and the harness that connects the two. Note that four remaining slots are unused in the VMEbus card cage. Additional processor cards can be installed there for advanced applications.

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The 2070-2A Field I/O Module is installed next. Note the C1 connector, which provides the standard interface with 170-style cabinets. The round connector above the C1 connector provides additional pinouts for application within the new ITS cabinet. This additional plug is not required for routine use.

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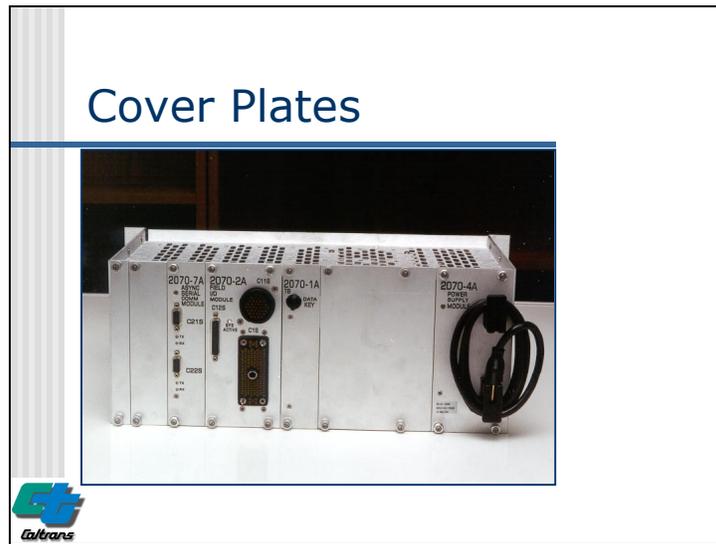
Here, any required communications modules are added.

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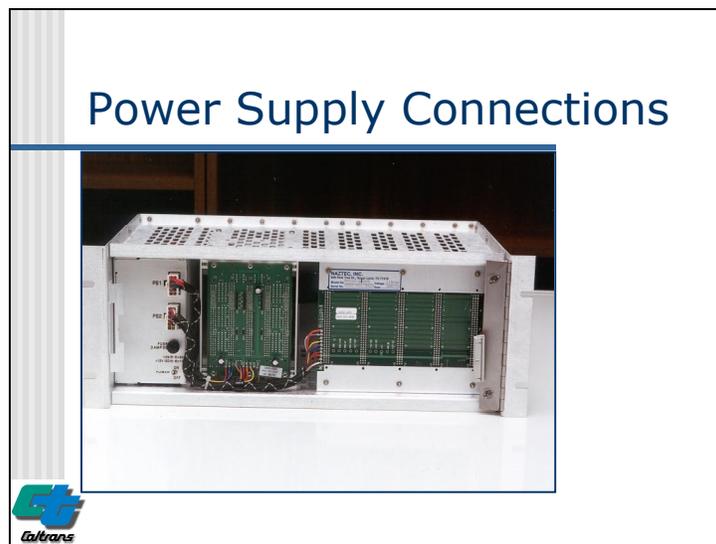
Next, the 2070-4A power supply is installed. The power cord will plug into standard receptacles supplied in the cabinet.

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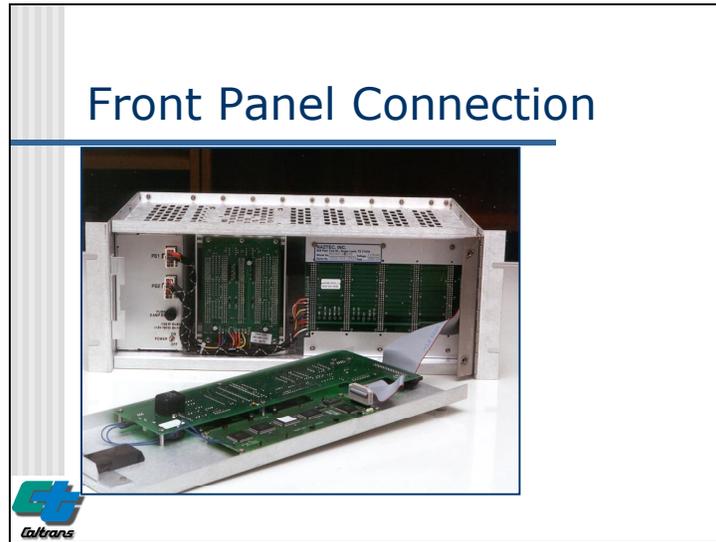
Once all the needed modules are installed, the gaps are filled in with cover plates to make a neat and tidy controller.

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This image shows the controller turned around to face forward, with the connections made to the 2070-4A Power Supply (now on the left). Again, one connector supplies power to the chassis bus, and the other to the VMEbus card cage.

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The front panel serial connection is made, and

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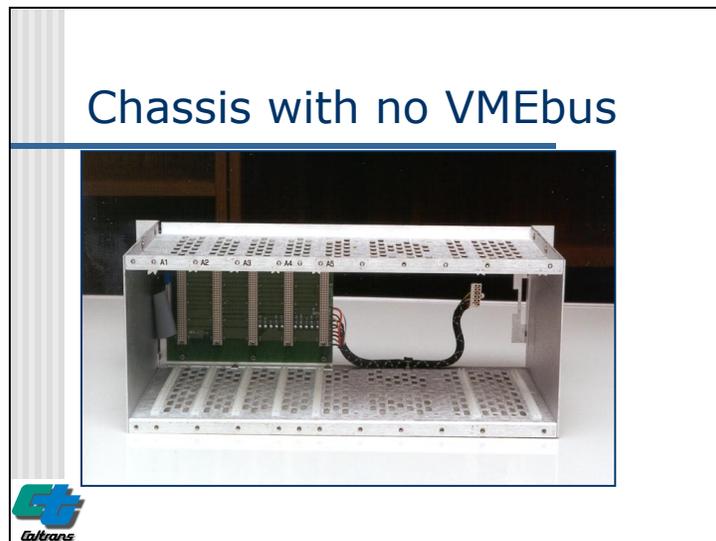
the front panel is attached, completing the assembly.

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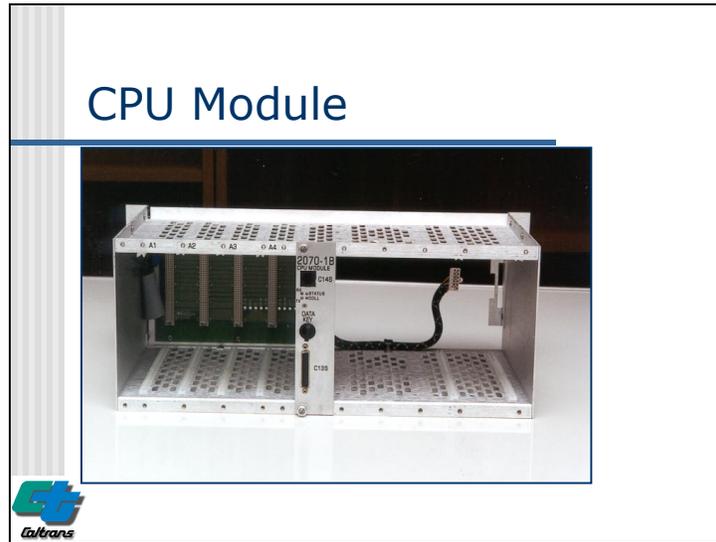
The second example will show the assembly of a 2070LN such as might be installed by a local agency in California in an existing shelf-mounted cabinet. Note that the NEMA adaptor is optional, and this assembly sequence also illustrates the non-VME version of the Model 2070.

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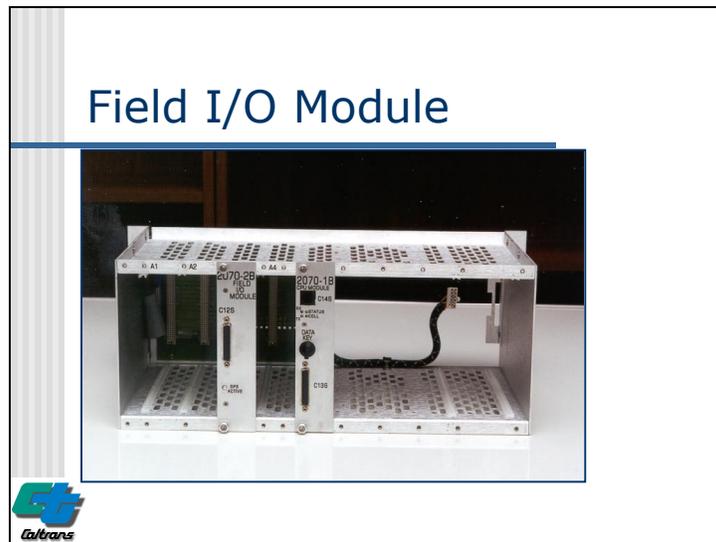
Once again, the sequence starts with a bare chassis. In this case, no VMEbus card cage is provided, and there is only one power supply connected for the chassis bus. This is the same for the 170-compatible 2070 Lite.

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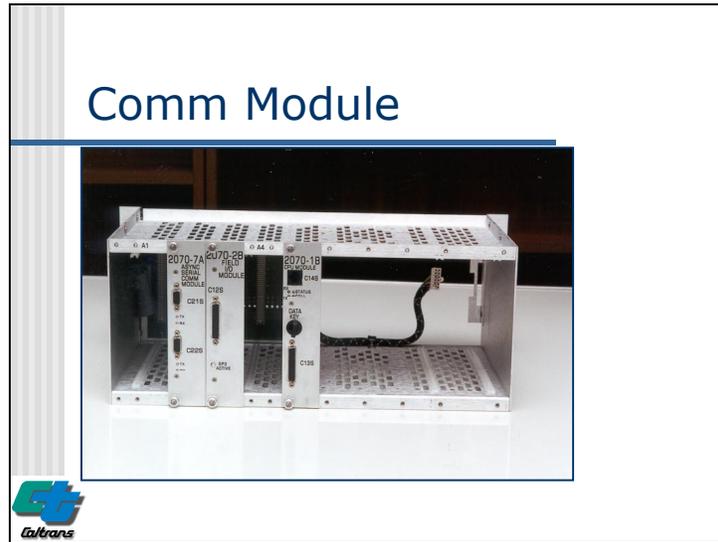
This image shows the chassis with an installed 2070-1B single-board processor. Again, this is the same as for the 170-compatible 2070 Lite.

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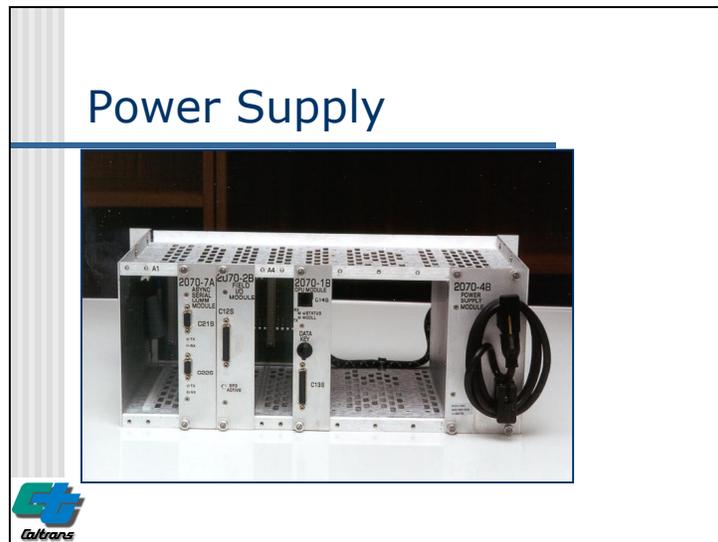
The 2070-2B Field I/O Module is installed next. This module interfaces the chassis bus to the NEMA Interface Module. In a standard 2070 Lite, a 2070-2A 170-compatible Field I/O Module would have been installed.

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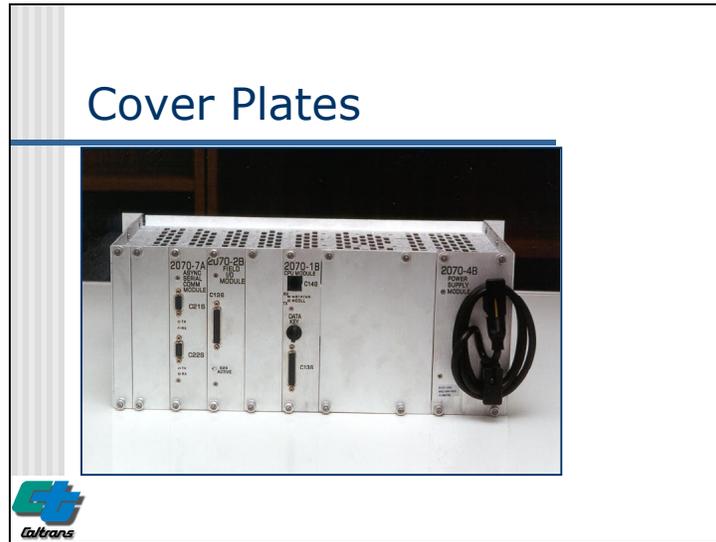
Communications boards are now installed. These are the same for any version of the 2070.

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This chassis uses the 2070-4B 3.5-amp power supply for applications that do not provide power to a VMEbus card cage.

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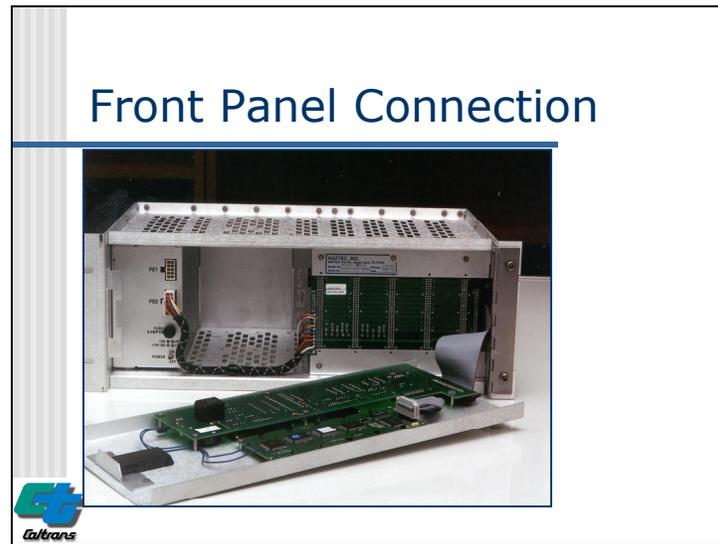
Once again, gaps are filled with cover plates.

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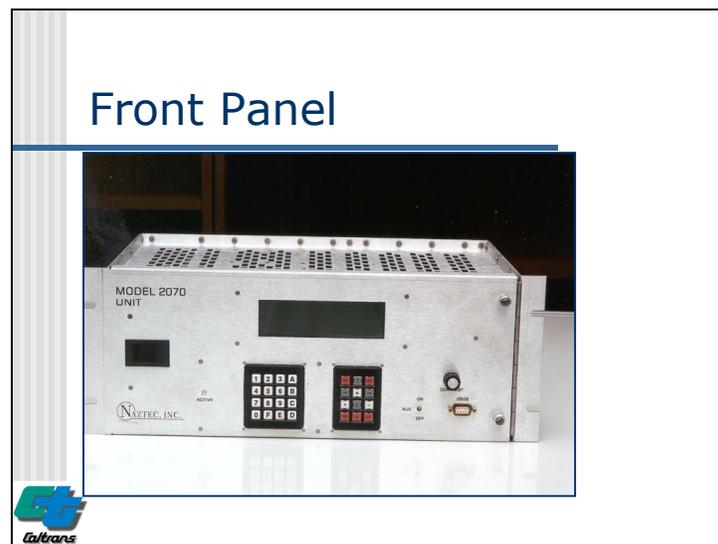
This images shows the front of the chassis to illustrate the power-supply connections. Note that the power supply provides a connector for the VMEbus card cage, but it is not used. This is a mistake in the specification, as approved in mid-1999. This power supply has no need of the connector for the VMEbus card cage, and does not provide sufficient power for it anyway.

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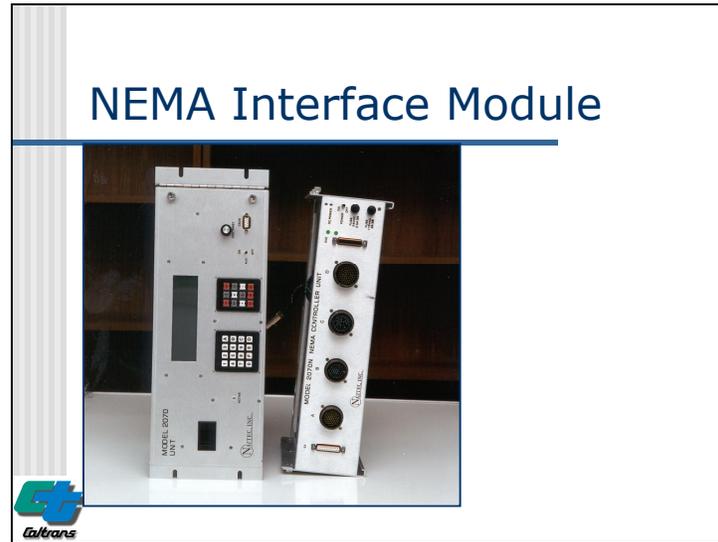
The front panel is installed next. The specification does not specify the orientation of the header connector on the front panel. Hence, the cable must be long enough to allow it to be reversed if necessary. This was an error in the specification, but various manufacturers have built front panels differently, and it was decided to allow the variation by providing a longer cable.

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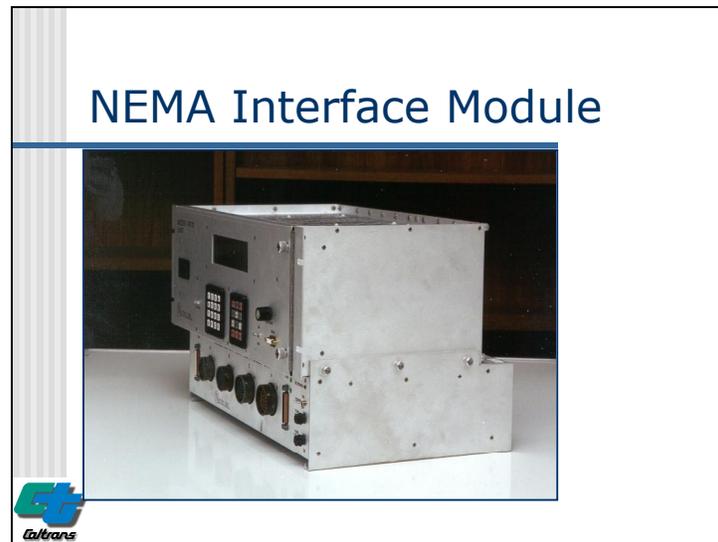
The front panel is attached.

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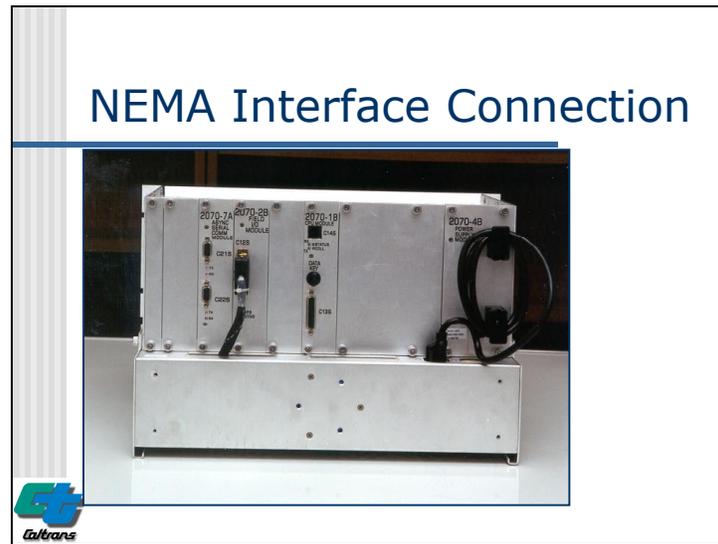
This picture shows the NEMA Interface Module being lined up for installation on the bottom of the chassis.

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The NEMA Interface Module is held in place with three thumbscrews on each side. As with all screws used in the 2070, these are hand-operable, though a small screwdriver is more convenient, and are held in place even when the components are disassembled.

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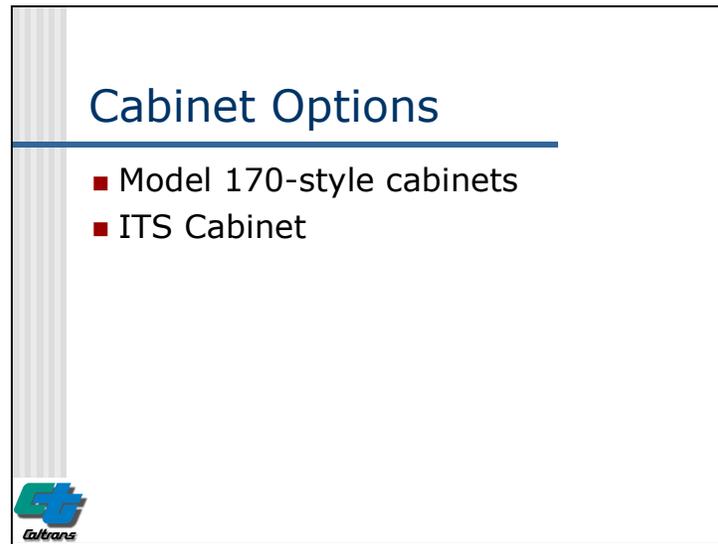
The power supply cord is plugged into the receptacle on the NEMA Interface Module, and the parallel C12S connector is attached to the Field I/O Module. If the serial connections on the front of the NEMA Interface Module were to be used, harness provided inside the NEMA Interface Module enclosure would be connected to the serial communications module.

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The completed 2070LN is cabinet-compatible with all NEMA TS-1 and TS-2 cabinets. TS-2 compatibility may or may not, however, be supported by the software, depending on the agency specifications for the software.

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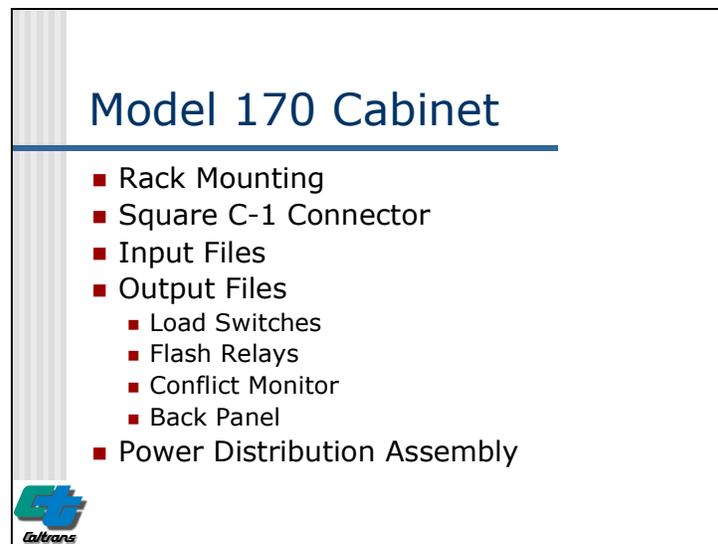
Cabinet Options

- Model 170-style cabinets
- ITS Cabinet



We will go through each of these briefly. The 2070 can be configured for each of these cabinets. It can also be configured for shelf-mount cabinets, but these are not used by Caltrans.

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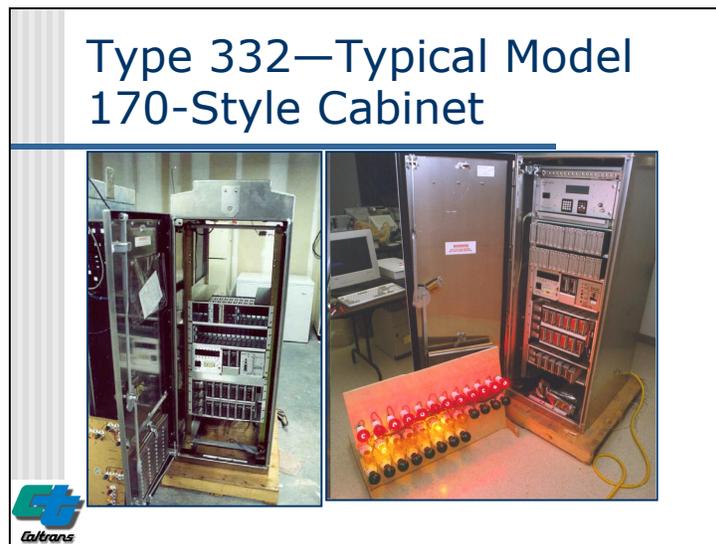
Model 170 Cabinet

- Rack Mounting
- Square C-1 Connector
- Input Files
- Output Files
 - Load Switches
 - Flash Relays
 - Conflict Monitor
 - Back Panel
- Power Distribution Assembly



The 170-style cabinet includes the same modularity as the 170 controller.

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This is a typical cabinet originally designed for Model 170 controllers, but that works well with a Model 2070. The cabinet on the left is a 12-phase configuration, with two card cages for detectors directly beneath the controller tray. Below that is the power distribution assembly which contains the circuit breakers, a low-voltage power supply, NEMA standard flashers, and a switch for invoking cabinet flash. Finally, the load switches and flash transfer relays are below that. In this cabinet, 12 NEMA standard plug-in load switches are provided. The vertical slot to the right of the two rows of load switches houses the card-mounted conflict monitor.

The cabinet to the right is also a Type 332, but it is configured a little differently. This cabinet has a Model 2070 controller at the top. Below that is a documentation drawer that acts as a work shelf. The detector card cages are next, followed by the power distribution assembly. This cabinet also has the standard 12-switch output file, but also an additional auxiliary output file, providing 18 load switches total. This cabinet is being tested by Iteris with Gardner NextPhase software running in the 2070.

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ITS Cabinet

- Rack Mounting
- TS-2 Cabinet Bus Interface (serial bus)
- Detection Unit
- Malfunction Management Unit
- Terminals and Facilities Unit



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The New ITS Cabinet



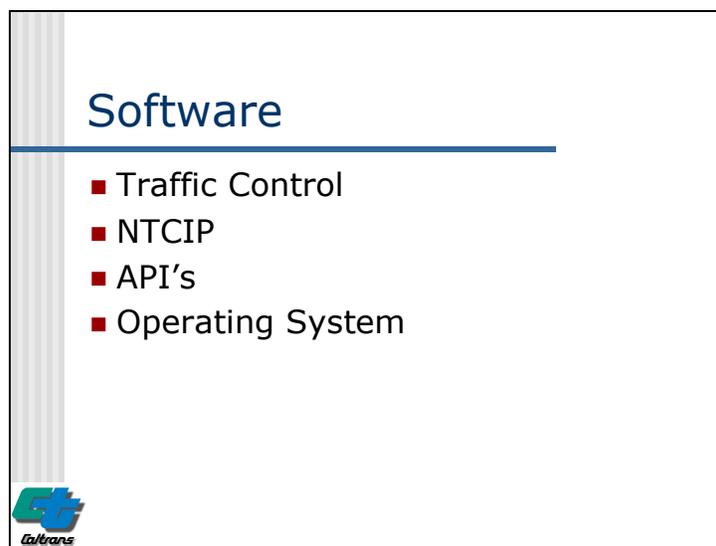
The ITS cabinet is an emerging cabinet standard designed especially around open-architecture concepts. The cabinet uses rack-mounted components, and provides space for more than one controller. These cabinets are intended for many more uses than just traffic signal control. For example, this cabinet might be used at a freeway diamond interchange for signal control, video surveillance control, ramp meter control, and as a communications hub, all in one cabinet.

This particular cabinet has not been assembled yet. The controllers will be installed at the top of each rack (or just the rack to the right if only one is used). Outputs (load switches)

are on the left rack, and inputs (detectors) are on the right rack. The power distribution assembly is at the bottom left. Most of these components are the same as used in 170-style cabinets.

The real innovation in this cabinet is the serial bus. The ITS cabinet is designed around an SDLC-protocol synchronous serial bus that connects the major cabinet components instead of discrete hard-wire connections. This serial bus is compatible with the RS-485 Cabinet Bus Interface defined in NEMA TS-2, and 2070's have the hardware to communicate on this bus. Not all software, however, makes use of the Cabinet Bus Interface at the present time.

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Software

- Traffic Control
- NTCIP
- API's
- Operating System



Up until now, most of the discussion of the 2070 has centered on the hardware. Because it is an open-architecture controller, however, the hardware is only half the story.

The limitation of the Model 170 controller is that it is a special-purpose processor application with no available operating system. So the traffic control software must vertically integrate all services that would normally be distributed to the operating system, the device control software, and the communications software. This has left software for the 170 in the hands of a very few providers, all of whom are overbooked.

The 2070 takes this concept further. In addition to developing a standard for hardware, the Joint Committee on the ATC is developing standards for software modularity.

A common operating system is already specified to be supplied by the hardware manufacturer—Microware OS-9. This is equivalent to purchasing a PC from Dell with Windows 2000. The steering group is also defining application program interfaces—API's—that will define the software interfaces between the operating system, the traffic control software, the device control software, and the communications software. With

these API's in place, agencies will be able to buy traffic control software from a local controller software provider, communications software from a system provider, operating system software from the processor manufacturer, and device control software from the device (e.g. communications module) manufacturer.

At present, a number of companies are providing or developing software for the Model 2070 controller. At least three signal control products are currently available, but not are yet available that take advantage of the emerging API standards. These will be available within about a year. Most current providers are able to provide an upgrade path to the new standards by agreement.

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Standards and Specs

- The 2070 Steering Group:
 - Hardware (based on Caltrans)
 - Software API's
- Caltrans
 - The Transportation Electrical Equipment Specifications (TEES) for the 2070 and 170 controllers
 - Other specs for cabinets and other hardware



Most agencies are using the TEES directly for purchasing, or are developing their own in-house specifications closely based on the TEES. The TEES is frequently updates by collective action throughout the community of 1070 users, and is generally considered the best and most current specification for the 2070. Caltrans, of course, uses the TEES, coupled with a Qualified Products List, to specify hardware and to identify those manufacturers that have been determined to be compliant with the specification.

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Testing

- Testing to standards is more difficult than testing to specifications
- No industry-wide testing program is available
- Caltrans maintains a Qualified Products List



Because of the modularity and interchangeability of components in the 2070, some testing is required to assure that interchangeable parts really are interchangeable. Without this assurance, many of the main advantages for using the 2070 may be lost. Open architecture shifts testing away from features, which will be associated with the software, to interchangeability standards, for downstream ease of maintenance and upgrade. Testing against standards determines not only if the hardware provides the functionality required for a current project, but also that the components conform to the standards such that their interfaces will maintain interchangeability in future configurations.

Caltrans maintains a Qualified Products List for all traffic control equipment used by their agency. The Caltrans QPL has a number of commercial requirements in addition to technical specifications.

Most agencies outside California are doing their own testing, either in-house or using a third-party agency or consultant. Las Vegas, for example, provided their own testing in shop. Houston hired a consultant to provide testing of prototypes and production models.

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Disadvantages of the Model 2070

- Interchangeability adds initial cost
- Agencies usually must purchase software by separate agreement
- Careful specifications are a must to assure proper configuration of modular components
- New technology requires testing
- New technology requires patience



The mechanical requirements of interchangeable hardware components makes the controller initially more expensive. It is anticipated that these costs will be easily and recouped in reduced maintenance costs.

Because it is a standards-based controller, the 2070's must be tested against the standards, not just against the specification, to make sure the product meet the standard. Caltrans is familiar with this approach and has followed similar principles with the use of a Qualified Products List for Model 170 controllers.

The Model 2070 is still a new product, and will require more testing at present while the manufacturers get tooled up. This problem will diminish steadily over the next year or two. New technology also requires patience as manufacturers and software houses work out their bugs. Again, this disadvantage is fading quickly, and will not be an issue at all in the next year or two.

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Advantages of the Model 2070

- Open architecture eases maintenance and ensures future compatibility
- Negotiated software purchasing
- Simple, competitive hardware purchasing
- Compatible with all cabinets, existing and proposed
- Upgradeable (usually with new software)
- Specification is now mature and stable



The open architecture of the Model 2070 allows Caltrans to replace internal hardware components from any supplier.

Controller components can be easily reconfigured for different cabinet applications just by replacing a few components rather than by replacing the whole controller. The processors are common to all applications, and they are the most expensive component in the controller.

The open architecture of the software allows future hardware upgrades to be backward compatible with current software. Investments in hardware and software will be usable until their investment is recovered rather than having to be retired early because of incompatibility with future requirements.

Traffic control features and software costs are negotiated with a software supplier without tying up the hardware bidding process.

As with the 170, hardware can be purchased from low bidders with confidence—the functionality is in the software.

The 2070 is a bridging technology—it closes the rift between NEMA and 170-style cabinets. Consequently, it is an inexpensive alternative in many system installations that might otherwise require cabinet replacement. Caltrans standardized on the 170 many years ago, but this bridging capability makes it convenient for local agencies in California that have NEMA-style cabinets on the street to upgrade to a controller technology that is compatible with Caltrans signal systems.

Because the software can be replaced without replacing the hardware, new systems, communications, and control concepts can be implemented without an expensive



hardware replacement process. This lowers the cost of future system improvements and makes it much easier for agencies to keep their system technologies current.

The 2070 specification is at the end of a long process of development and refinement. There will be changes in the future, but those changes are down to minor details—the lengths of screw threads and the like. In addition to Caltrans, the 2070 has been implemented by a number of public agencies on the street, including the Las Vegas Area Computer Traffic System (using Eagle), Harris County (Houston, using US Traffic and Eagle), Houston Metro (using Naztec) and Georgia DOT (using Eagle).