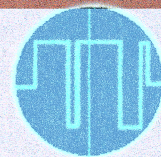
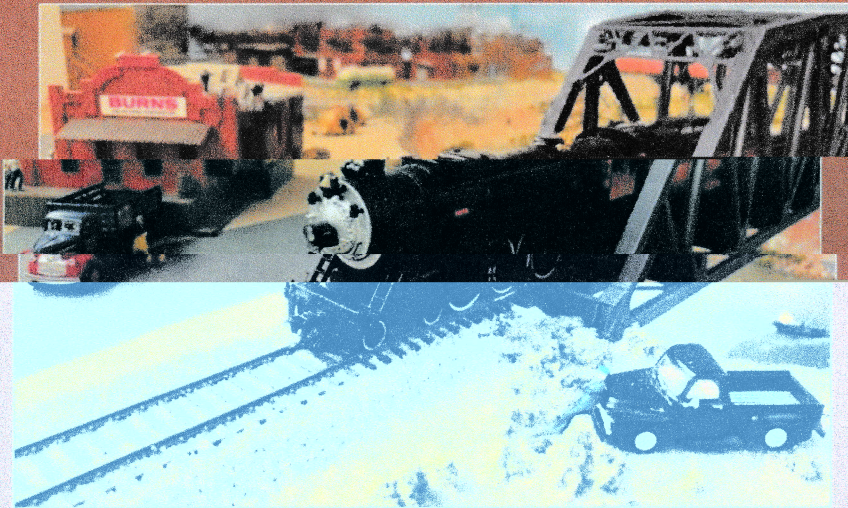


What we learned building a new layout with LCC



Electrical
Impulses

Model Railroad Hobbyist | March 2022

A Southern Pacific freight crosses the Colorado River in Yuma, entering the state of Arizona. This is one of the few areas where we have completed scenery.



VIEW READER
COMMENTS

JESSE POOLE AND **DAN KUBARYCH** DISCUSS THEIR EXPERIENCES WITH LAYOUT COMMAND CONTROL ...

IN OUR OPINION, LCC is the future of model railroading! LCC works well, is reliable, adaptable, and opens the possibility for all types of new innovations.

The Arizona Railroad Historical Society (ARHS) has the good fortune of building a new 1,000-square-foot HO layout in the Arizona Capitol Museum. Our layout is to represent all major cities in Arizona and depict the Five Cs of the state's economy: cotton, copper, cattle, citrus, and climate. That is a lot to pack in a small space [1].

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When we started the layout just over two years ago, we decided to use the new Layout Command Control (LCC) system pioneered by the NMRA. We were the first to attempt to design and build a large public layout from the ground up with LCC, so we were concerned about the availability of technical support.

None of our members had significant electronic, computer, or IT skills. Because we were among the first to try LCC on a major layout, there was not much of an experience base we could draw on. RR-CirKits LCC was the only major supplier at the time, so we were concerned about their motivation to provide the support we'd need.

Two years into the project, we can report that the system designers have provided support when requested, the manufacturer provides an outstanding product, and the



1. After 18 months of construction, the ARHS layout was running in December 2019. The trackwork on the benchtop level, representing the Southern Pacific from Phoenix to Tucson and Yuma, is mostly complete. The upper level representing the ATSF from Phoenix to Flagstaff is still in work. Yes, there is one place on the layout that is four levels high!

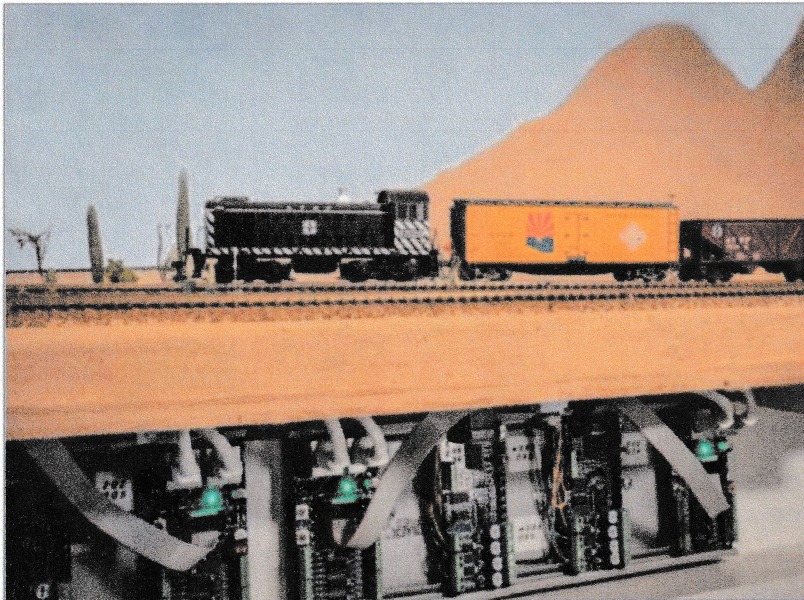


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2. The ARHS layout is still under construction, but the LCC system is almost all installed and working well just below the layout surface.

experience base is expanding with many others now using LCC. Our lack of experience has not proven to be an issue.

Today, the ARHS exhibit layout has a system comprised of 70 Signal Cards, 63 BOD4-CP cards (Block Occupancy Detection-Control Point), and an assortment of Tower, SMD8 (stall-motor Driver), and RB4 (Relay Board) cards, all housed in purpose-built troughs under the layout [2].

A central computer running JMRI connects to the LCC via a CAT-5 cable and to the NCE command station via a serial line. All operator interfaces are wireless; tablets command the LCC, wireless throttles operate the trains and cell phone applications can interface with both LCC and DCC.

Although we struggled over six months discussing whether to adopt LCC, it turned out to be our single best decision. We learned a lot installing this system, and felt that it was important to share those experiences with the rest of the model railroading community. If the ARHS can successfully install LCC, you can too!



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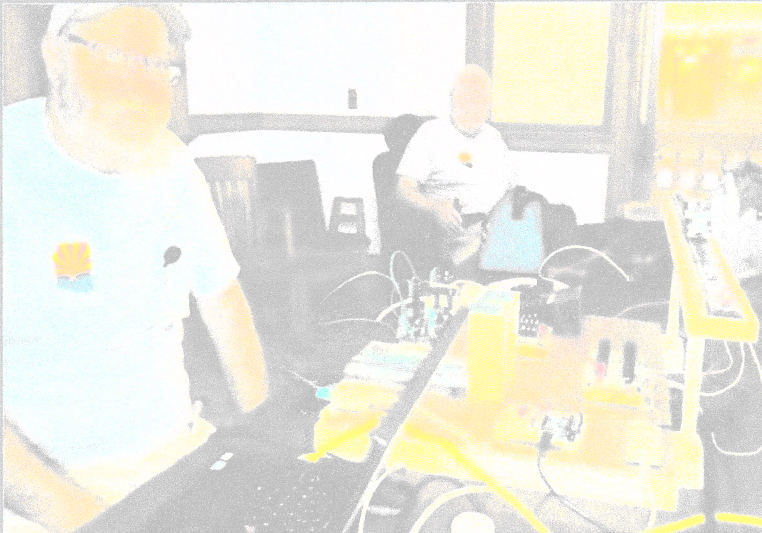
J. Poole

AN LCC DEMONSTRATOR MODULE IS A VALUABLE TOOL

The best way to learn about LCC is to try it out. RR-CirKits offers a Starter Kit that includes a Buffer-USB to connect the LCC system directly to your computer, two LCC Terminators to give you terminal readouts, an LCC Power-Point to power and monitor the system, and a cable for less than the cost of a new locomotive.

This Starter Kit, combined with a Signal LCC card and a BOD4-CP card (Block Occupancy Detection for four Control Points), is enough to set up a demonstrator module with four detectable blocks and controls for two Tortoises and four signals. This system went together easily and convinced us to incorporate LCC in ARHS's exhibit layout [3].

Not only was the LCC demonstrator module a great tool to get us started with LCC, but it remains useful for testing new features before incorporating them in the layout.



3. ARHS members Dan Kubarych and Jack Wade with the LCC Demonstrator Module.

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UNDERSTANDING THE BUILDING BLOCKS OF LCC

Planning is the most important step in setting up LCC. We discovered that designing an LCC system is a matter of adding “building blocks” – electronic cards – for each desired feature. You need to understand what each electronic card does, how to hook it up, where to place the card on the layout, and how it works with the rest of the system.

The first and most important component is the LCC Buffer-USB. Your system needs one to provide an interface with your computer and JMRI. Once set up, you can run LCC without a computer connected, but you need a computer for that initial setup [4].

Signal and Tower boards provide the logic or “brains” for the LCC system, both capable of internally processing up to 32 conditional statements. These cards receive input and provide



4. Every LCC system needs a LCC Buffer-USB module to interface with a computer. RR-CirKits photo



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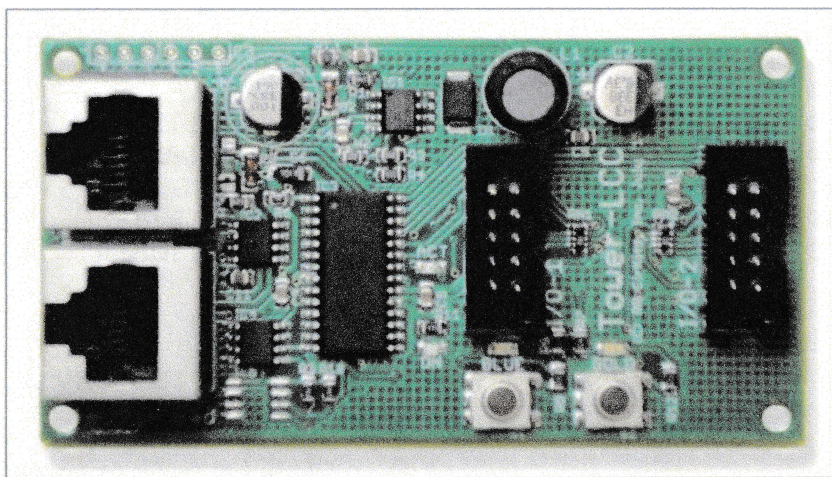
output to function boards in the system. They also communicate with each other and the central computer on the LCC communications bus; all communications pass through these two types of cards.

Tower-LCC cards have 16 lines of input/output and logic. Each can support two “daughter” input/output boards that provide actual layout functions. If your layout does not have any trackside signals, then you only need the Tower-LCC cards [5].

Signal-LCC cards have eight lines of input/output and will support only one daughter board. The Signal-LCC card provides logic for controlling up to four signal masts with four different LED aspects each.

The process of selecting Tower vs. Signal cards will become more obvious when we discuss the system installation. All Tower and Signal cards daisychain together with CAT-5 cables that should be a minimum of 12 inches long.

Input/output “daughter” boards connect to the Tower-LCC or Signal-LCC cards via 10-wire ribbon to accomplish the layout functions. The letters and numbers associated with each board spell out their function.



5. Tower-LCC cards provide logic to your LCC system. RR-CirKits photo

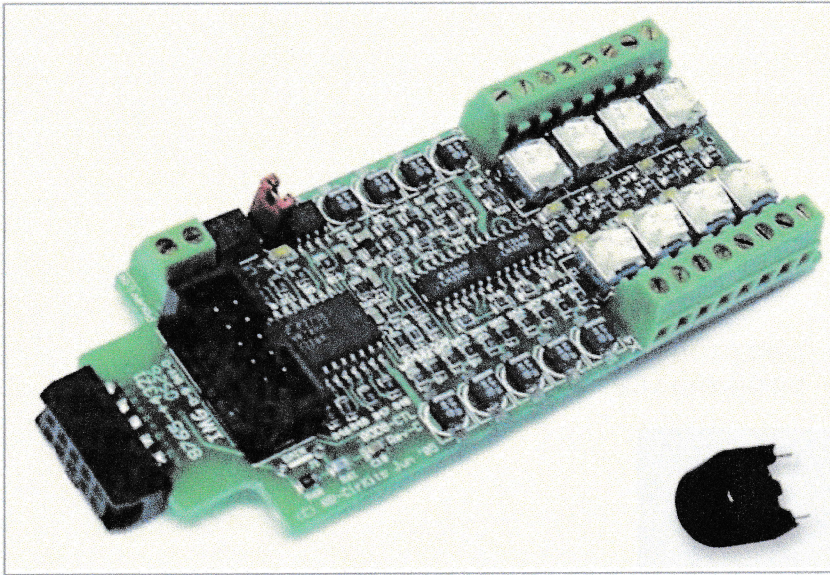


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7. BOD8 boards provide block occupancy detection for up to eight blocks using CTs (Inset). RR-GirKits photo

BOD8 boards provide block occupancy detection for up to eight blocks using current transformers (CT) that you can connect. The CTs are coils that go over one bus wire somewhere between a circuit breaker and the first track feeder. The coil detects to current flowing through a passing train, and the BOD sends the signal that the block is occupied [7].



J. Poole

CTs CAN BE LOCATED ANYWHERE

We set up a test using four blocks with lengths from 10 to 35 feet. Each block had two CTs: one at the circuit breaker and the other close to the first track feeder in the bus. We wired the two CTs for each circuit to a BOD8 card in positions directly opposite each other so we could watch when the occupancy lights came on.

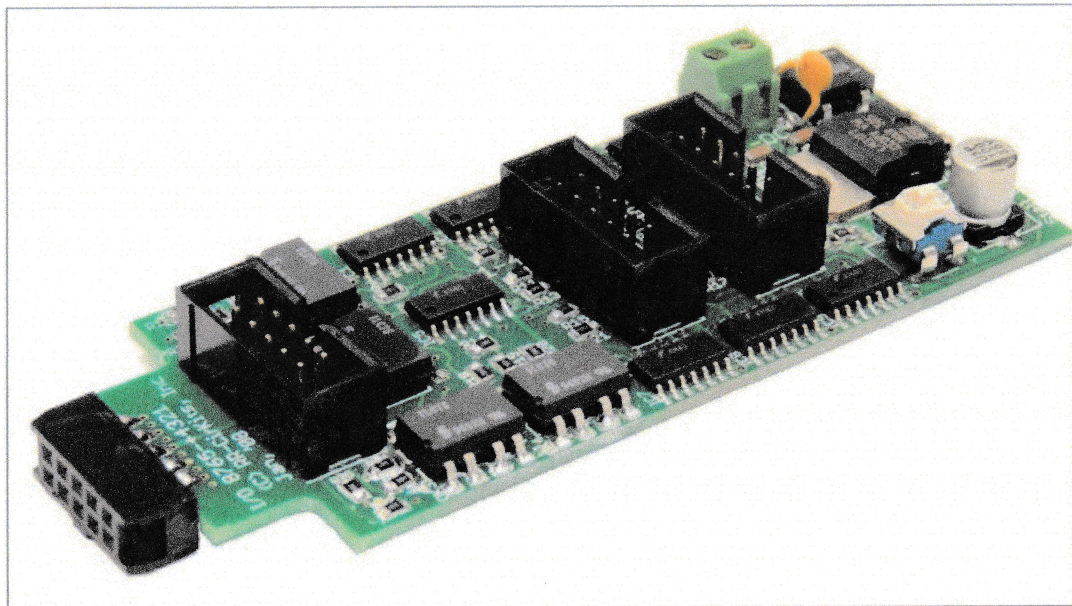
Although the distance from the power source meant we had to adjust the BOD card's sensitivity potentiometer slightly, we found both CTs detected a train simultaneously once calibrated. From this, we concluded that we could locate CTs anywhere on the track bus. This means they can be grouped near the BOD card.

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BOD cards have a PowerLok feature that holds the last block occupancy status if track power is cut, rather than revert to a false “clear” signal because current is no longer flowing to an occupying train. When the track power is restored, the BOD card resumes reading the occupancy state.

Because of the Power-Lok feature, all blocks on a single BOD card must be from the same circuit breaker for proper reading. If blocks from two or more circuit breakers share a BOD and power is cut to one, the PowerLok feature will activate for both. The BOD will not respond to changes in occupancy for the blocks still receiving power.

SMD8 boards are function modules with stall-motor drivers for up to eight turnouts each [8]. SCSD8 boards are similar in function, though they provide single-coil solenoid drivers for up to eight solenoids to control four turnouts.



8. SMD8 boards can control eight tortoise-type stall-motor turnouts. *RR-CirKits photo*



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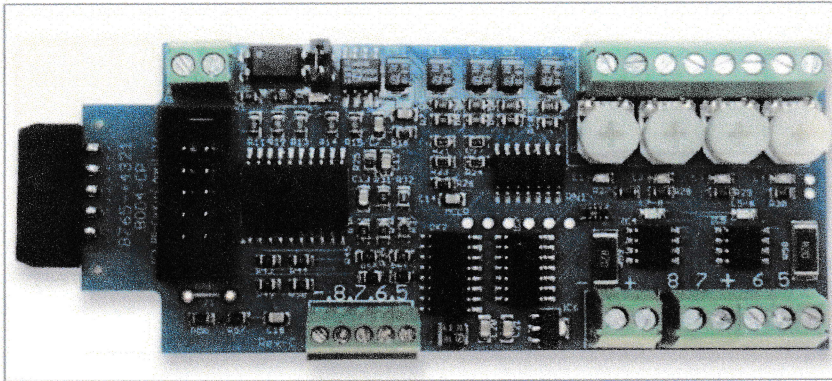
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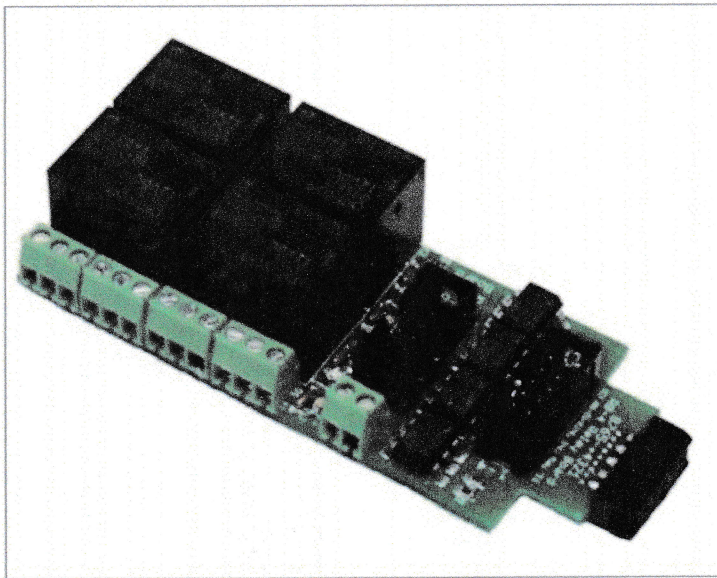
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BOD4-CP boards provide occupancy detection for up to four blocks with a control point function that operates everything necessary for a single-siding control point. It has dual turnout drivers for two turnouts. When connected to the Tower-LCC or Signal-LCC boards, it can receive discrete input and output from four pins [9].

The RB4 is a relay board with four independently controlled SPDT 10-amp relays. Each relay has its own LED indicator. The board is useful for switching high-current items including track busses or major lighting circuits [10].



9. BOD4-CP board. *RR-CirKits photo*



10. RB4 boards have four SPDT relays. *RR-CirKits photo*



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The RR-CirKits website (www.rr-cirkits.com) describes these and many other components and provides manuals for each. In addition to the “cards.” described above, there are a few others worth noting.

- **Power-Points:** These inject 15 VDC for operation of the cards. (Not to be confused with the Microsoft program PowerPoint which will be referenced later in this article).
- **TYCO Mounting tracks:** These are used to mount the cards. We used part number 3TK2-4W, which is a four-position, wide-spaced mounting track.

LCC COMMUNICATIONS IN BRIEF

LCC is a messaging protocol that sends messages (EventIDs) to LCC cards (nodes) on a network about things (events) occurring on the network. The nodes can send or receive EventIDs, and in some cases both.

For example, a block detector sends an EventID in response to a train’s position. Another node receives the same EventID as an instruction to throw a turnout. This, in turn, may trigger the node controlling the turnout to send another EventID into the network that other nodes respond to.

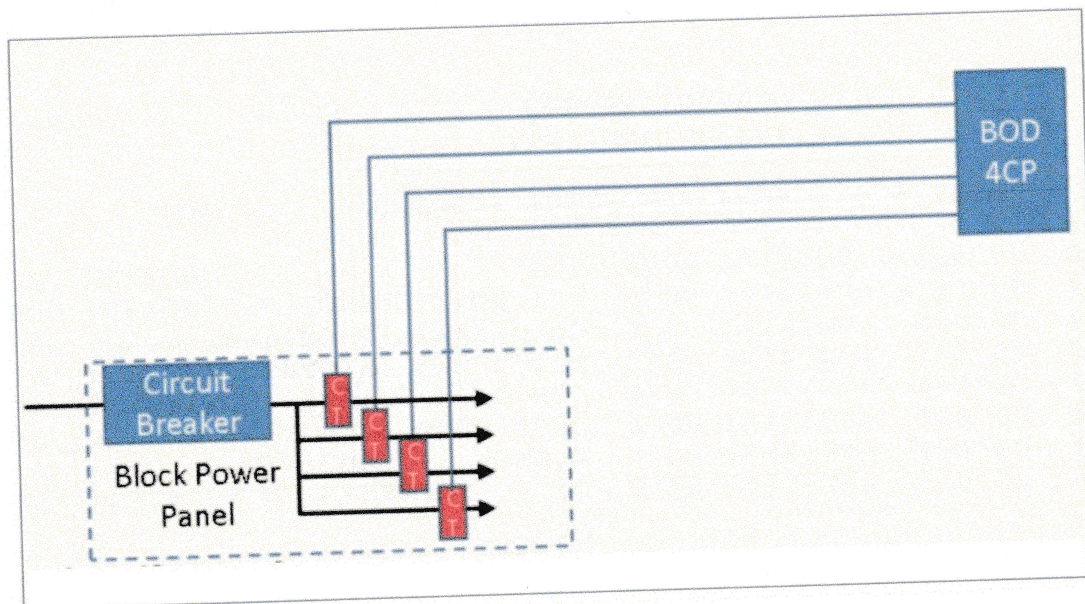
The key difference between LCC and DCC is in how each sends information to the layout. While DCC sends a direct command to a specific address, LCC transmits all EventIDs to all nodes on the layout. The nodes respond to messages based on their configuration.

Think of DCC as a cell phone call to one person in a crowded room. While others might hear the phone ring, only the person with the phone knows what the call is about. In a DCC setting, you send a set of commands to a specific locomotive or consist address to turn the turn on the headlight or proceed down the track.

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If DCC is a cell phone call, LCC is a public address system that lets everyone in the room know that a blue chevy sedan in the parking lot has its headlights on. Those with blue Chevy sedans will respond. In a layout LCC setting, a node detecting a train occupying a block sends an EventID into the system that might trigger multiple responses from multiple nodes:

- JMRI Panel Pro registers the movement and changes the color of the rail on the dispatcher panel to indicate occupancy.
- The signals in the occupied block change to red.
- Surrounding block signals also change to indicate the next block is occupied.
- Perhaps a turnout or other device will also activate if so directed, and the turnout will report its actual position.
- Nodes not affected by the information in the EventID will not respond.



11. In the Associative approach, all block wires emanate from a single panel and CTs are centrally located.



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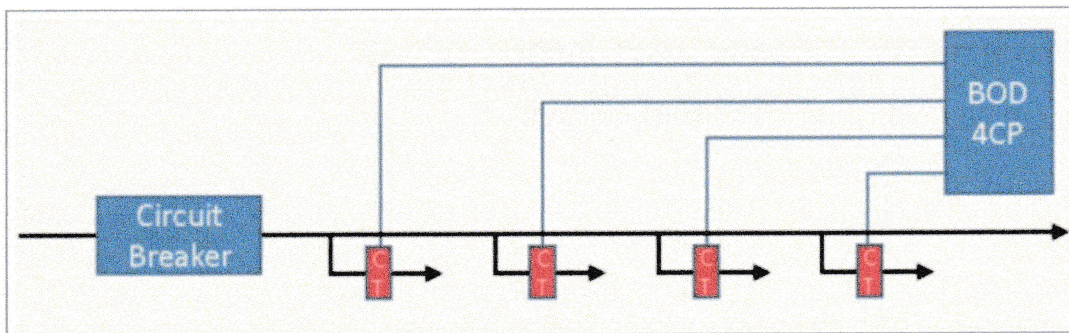
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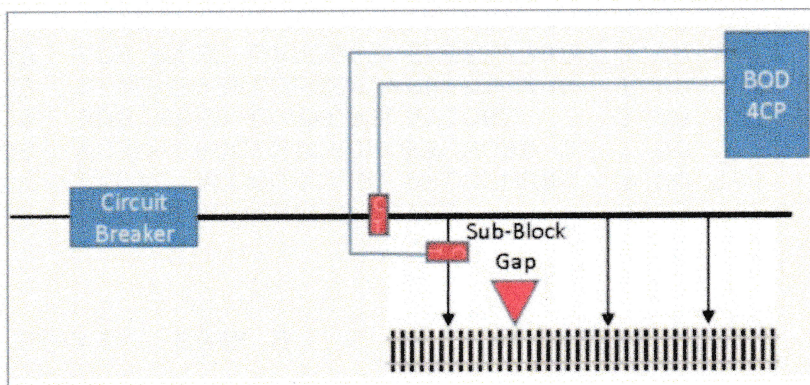
The availability of all information to all devices on a layout makes LCC a powerful system. Once you have the concept of sending/receiving data down, you will be well on the way to being an LCC expert.

TRACK BUS APPROACHES

Planning the track power block wiring with LCC presents the same choices and dilemmas as with DC or DCC wiring, with the additional consideration of the CT locations. The basic approaches for track busses are Associative, Distributed and Sub-Block [11, 12, 13].



12. In the Distributed approach, each block “splits” off from a central bus wire. CTs are located around the layout.



13. The Sub-Block approach is used within a block to trigger another function such as a grade crossing, turnout, or other animation.



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The ARHS used the Associative approach for most of the track power wiring because it keeps all the wire junctions and the CTs for detection on the power panel in one easily identifiable location.

We used WAGO lever-action reusable connectors for the bus mains, which allows us to easily disconnect individual bus wires from a circuit. If there was a short during construction, we could easily fault isolate to a block rather than an entire circuit breaker.

We used the Distributed approach in a few cases, such as where we needed an additional block for trackside signaling.

The Sub-Block wiring approach allows a subsection of a block to be sensed separately from the rest of the block. This was important for automatically throwing a turnout. If the train is approaching from a long block, it is desirable to throw the turnout only as the train approaches it.

NAMING BLOCKS AND TURNOUTS

Planning the names and numbers for the turnouts and blocks is important because LCC requires each to have a unique identifier. The names are easy, as they identify the train location. The numbers are where a process is helpful.

For the ARHS, we assigned powered turnouts on the mainlines two-digit numbers from 01 to 99, and assigned track power blocks numbers in series from 100 to 800.

The first place of the three-digit track block numbers refers to each of the eight independent loops on the exhibit, i.e., Southern Pacific Loop 1 is SP1 and uses the 100 series, SP2 uses the 200 series and so on. The second digit refers the circuit breaker (or auto-reverse card) in that loop and the third digit to the actual block number used on the exhibit.

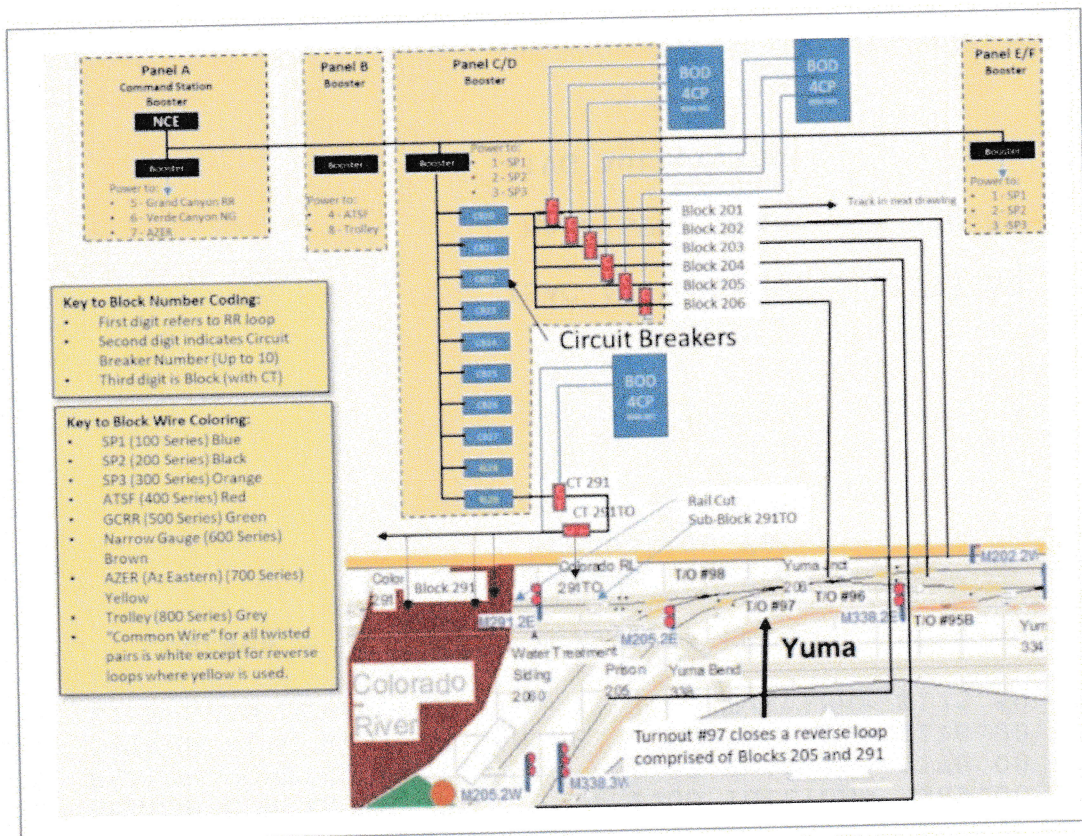
Figure [14] shows a high-level (single line drawing) track power distribution schematic with details for Circuit Breaker 20 and Reverse Loop 29. Circuit Breaker 20 has six blocks numbered

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201 through 206 each with its own CT. The CTs are mounted on the power distribution panel and report to BOD4-CPs number B090.091 and B092.093.

Block 291 in [14] is a reverse loop, but it has two CTs associated with it. The first is CT291, which detects occupancy in the entirety of Block 291.

The second is CT291TO which is a Sub-Block and used to automatically throw Turnout 97 (thus the TO postscript). We cut a rail about three feet (or one flex track length) from Turnout 97 and added CT291TO to the drop only (not the main bus wire) in this one section of track.



14. Track Plan of SP2 and SP3 on the 25-inch level in Yuma, AZ showing the Track Power assignment from Circuit Breaker 20 to Blocks 201 thru 206, Reverse Loop 291 with the associated CTs, and BOD4-CP cards detecting block occupancy.



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A train anywhere in Block 291 will show occupancy on the JMRI panel. When a train is in the last three feet of the block, it will trigger Block291TO, which will position turnout 97 to the “closed” position.

If the train is entering the reverse loop through Block 291TO, then the command from 291TO to “Close” simply commands the turnout to the position it is already in. If the train is exiting the reverse loop through Block 291TO, then Block 291 is already showing occupancy, and when the engine reaches Block 291TO, the turnout reacts to the signal from Block 291TO, aligning the turnout to the proper position. Block 291, 291TO and Turnout 97 will be used as an example of configuring an LCC card later in this article.

THE RULE OF TWOS DRIVES LCC DESIGN

We found the “Rule of Twos” worked best when designing for LCC. The cards all have even numbers of inputs/outputs, and we found it easiest to design with an even number of features.

For example, using the SMD8 card for a staging or switching yard with up to eight tracks makes logical sense. A nine-track staging yard may be a delight to have, but it would complicate the LCC card layout. If you have choices in your design, keep things in multiples of two.

A corollary to the Rule of Twos is that you should group four Signal-LCC or Tower-LCC cards around a single Power-Point. Each Power-Point can theoretically drive up to eight LCC/BOD cards, but the precise number of cards varies based on the functions they drive. Distance from the Power-Point is also a factor, as the 24 or 28 AWG wires in the CAT-5 cable produce significant internal resistance that drops available voltage.

The “cluster of four,” with one device on each side of the Power-Point is a simple solution to guarantee plenty of voltage for all boards and functions. Power-Points are relatively inexpensive, so this assurance is well worth the cost.



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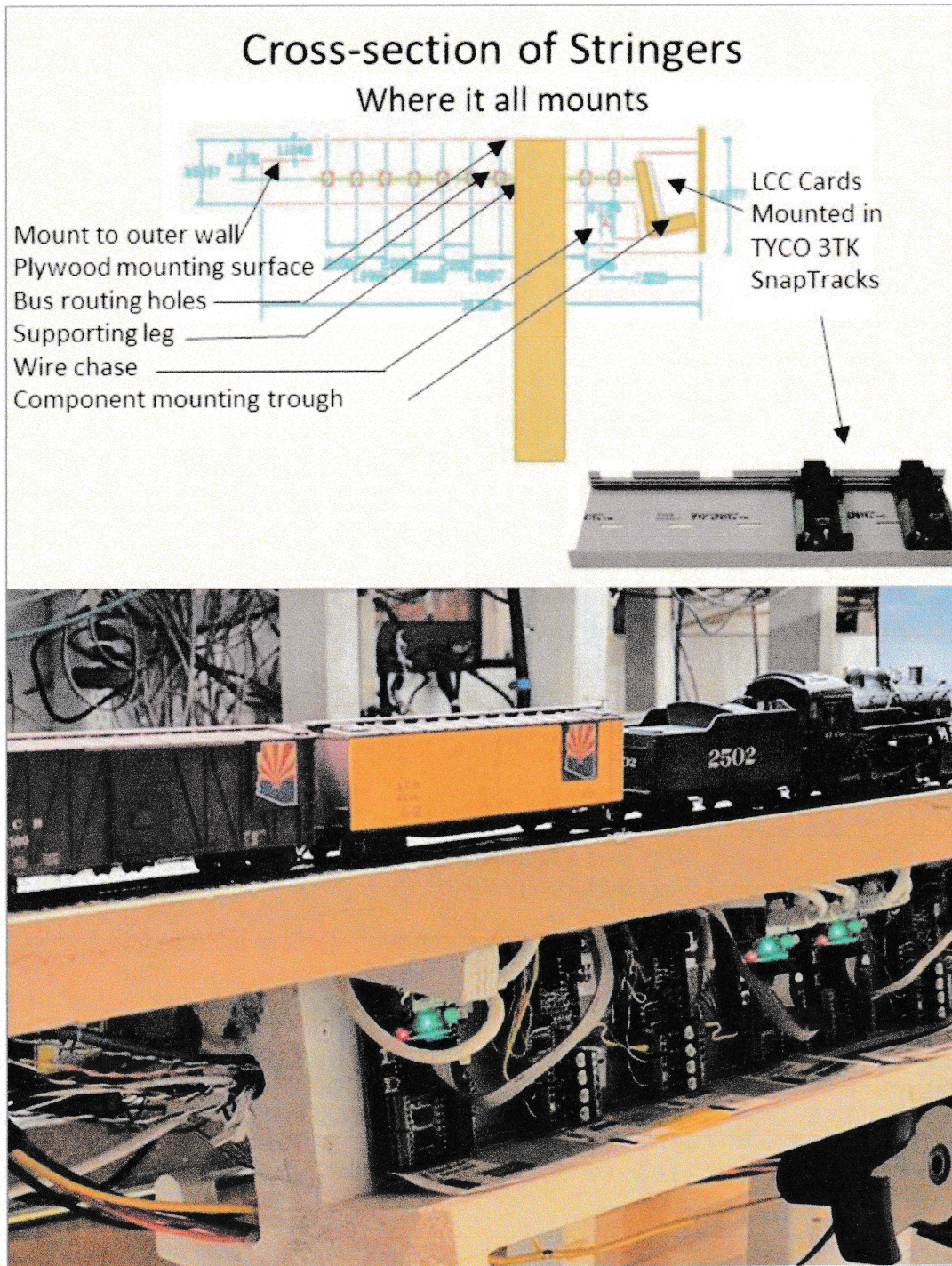
PLAN “OTHER THAN LCC” FEATURES IN ADVANCE

While planning for LCC, make sure you consider other features around the layout. The use of Wi-Fi-equipped touchscreen tablets was a design decision that made wiring the ARHS exhibit much simpler and took maximum advantage of LCC capabilities.

The tablets are mounted around the exhibit and interface with JMRI Panel Pro to display panels showing the entire exhibit or any local section desired [15]. The panels use track color to indicate block occupancy and provide full turnout control with a screen tap.



15. This operator throws a turnout ahead of a train approaching Tempe on the layout. Turnouts can be thrown by touchscreens located trackside or on the dispatcher computer screen.



16. Construction details of the LCC circuit board “troughs” on the ARHS layout, making mounting of the boards easy.



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Because of the tablets, the layout has no use for toggle or pushbutton switches on the fascia or the complicated wiring that goes with them. The tablets only need power cables to keep them charged. The tablets made wiring easy and provide a clean looking fascia on the exhibit.

We knew that lying on our backs was no way to hook up the large number of electronic components the exhibit would require. We machined the horizontal layout support beams from plywood as part of the original design. These beams had provisions for a trough and wire chase behind the trough for mounting the LCC or any other electronic components [16].

This allowed for easy mounting of the LCC cards and simplified the wiring. All control wires come in over the top of the card, and the wires run in a chase behind the card and in front of the layout leg. An unplanned benefit of this approach is that the design moved the support legs about a foot back from the front edge, giving the illusion that the exhibit is suspended in midair!

LOCATE THE SIGNAL-LCC AND THEN BOD CARDS

The next step is planning the physical location of the required LCC cards on the layout. This really involves two steps; first, where should the card be located to be near the function it controls, and second, is there a space in that area of the layout to mount it? Referring to the “Rule of Twos” and the “Clustering” of four LCC cards is an important consideration.

Most of the ARHS layout has trackside signals, and we found that the Signal-LCC card was the most critical. We located these cards as near as possible to the trackside signals they would control. We added a BOD4-CP card to most Signal LCC cards based on the number of nearby turnouts, and assigned blocks from a single circuit breaker to each BOD4-CP card.

In areas that ran dark (i.e., no signals), we used almost the opposite approach. First, we assigned either a BOD4-CP or



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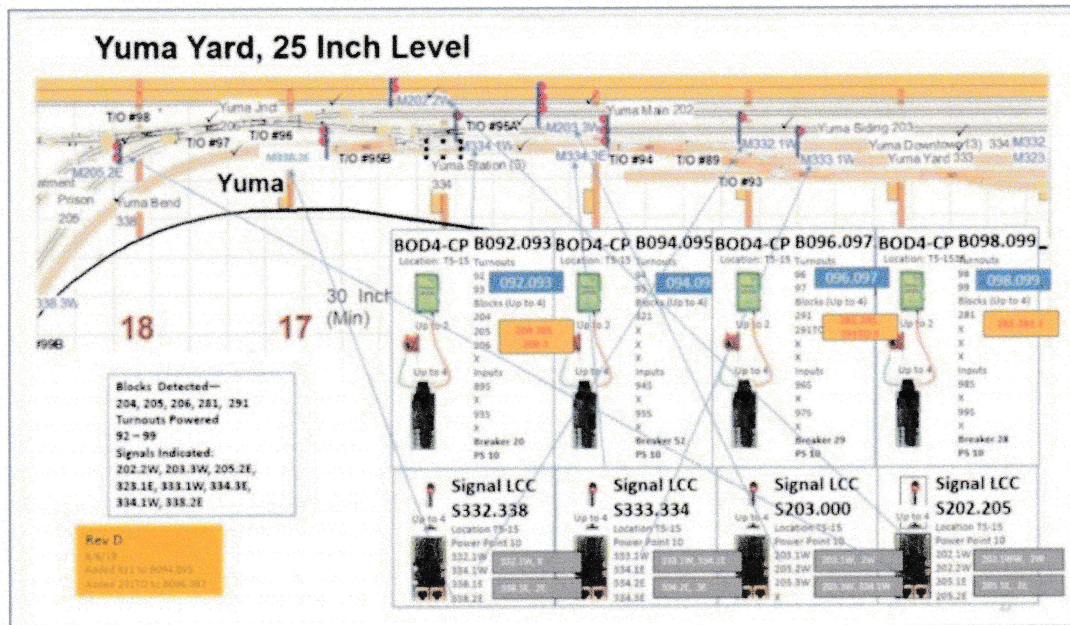
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combinations of SMD8 and BOD8 cards based on the number of turnouts, and added sufficient Tower-LCC cards to support these function boards.

An example of the ARHS approach is shown in [17], which is a segment on the lower level of the layout at Yuma, Arizona. A graphical representation of the Masts (Signals), Turnouts, and Blocks was extracted from 3rd PlanIt and templates of individual LCC cards were superimposed in Microsoft PowerPoint. Each signal mast could have up to three "targets" where a target is defined as a possible track route.

In [17] the masts are shown as vertical blue lines and the targets are round red circles attached to the mast. Three factors identify the mast: the block number it controls, the number of aspects and whether it is at the East (E) or West (W) end of the block. Thus,



17. This is an actual page from the ARHS design file showing the allocation of Turnouts, Blocks and Signal Masts to BOD4-CP and Signal cards around Yuma, AZ. Each BOD4-CP card is shown with its associated Signal LCC card.

most number M334.3E is located on the East end of Block 334 and has three aspects. This one mast requires three of the four outputs of Signal Card S333.334. The number assigned to the Signal Card is derived from number of the Masts the yard controls.

In this case, Mast M333.1W occupies the first position and M334.3E occupies the other three positions so the card number uses an S to identify it as a Signal Card and then the two Mast numbers resulting in S333.334.

In the (rare) case that all four positions on the Signal LCC card are not populated, the digits 000 are used for the unoccupied position. So, the next card to the right in [12] has mast 203.3W in three positions, but there wasn't another single mast in the area, so this card is S203.000.

A single BOD4-CP is shown above each Signal Card and the two are connected by a 10-wire ribbon cable (not shown). Each BOD4-CP is assigned a maximum of two turnouts and four CT detection circuits.

The identification convention used for the BOD card is simply a B indicating that it is a BOD card and the numbers of the two turnouts that it controls. B096.097 is a BOD card that controls turnouts 96 and 97. The CTs providing input to this board are entered on the graphic (on this case blocks 291 and 291TO) as well as the position feedback from each Tortoise (numbers 96 and 97).

There are three other items noted as information on the graphical representation of the BOD4-CP card: location, breaker, and power supply. The location is simply a description of where to find the card on the exhibit (which in this case is T5-15, or Trough 5 at the 15th frame).

One of the advantages of LCC is locating the cards near the point of use, so it is good to have "map coordinates" for finding them when troubleshooting is required. The breaker is the breaker number that will activate the PowerLok feature (in this case

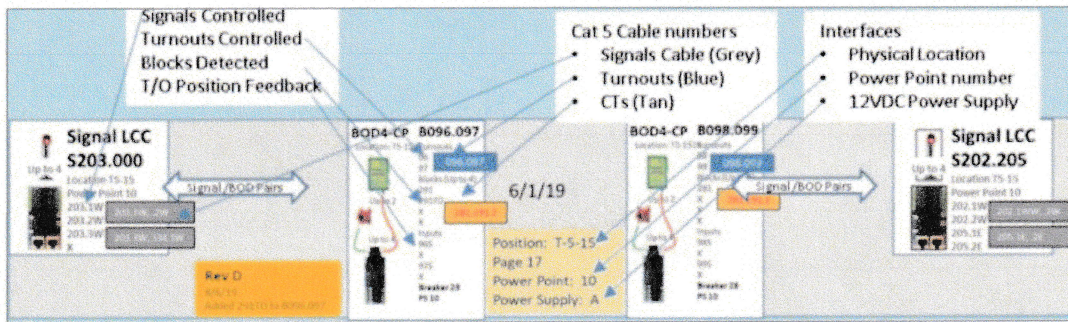


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18. As an installation aid, we rearranged the drawings of the cards in [17], and placed them on strips representing their arrangement on the layout in the TYCO 3TK mounting strips to assure fit. We installed the components and wires as shown on the strip.

number 29 which are the first two digits of the blocks which can be assigned to the card), and finally, the power supply is the number identifier (in this case number 10) of the LCC Power-Point supplying up to 15V to the card.

The final planning step is assuring there is a physical space to mount each LCC card. For this step we took each of the local LCC Layouts as shown in [17] and rearranged the Signal and BOD4-CP cards into the positions they would occupy in the mounting troughs.

The Signal LCC and BOD4-CP were laid out in pairs to fit in TYCO 3TK mounting strips (which are separately supplied by RR-CirKits and hold up to four cards of any type) [18]. Notice that the associated pairs of cards (such as S203.000 and B096.097) were kept together. This strip was then printed, and all the strips were arranged in the troughs to determine where each card would be located.

When the strip locations were satisfactorily spaced (and Power-Point adequately arranged), the actual card installation could begin. After we installed the cards, we used the "strip" as a wiring guide. Every wire and cable is shown on this strip, simplifying the

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wiring installation. We found it was easier to configure the Signal- and Tower-LCC cards on a separate computer prior to installation.

CONCLUSION

The obvious question at the end of all of this is “Would you choose LCC if you had it to do all over again?” The answer is a resounding YES! For a large layout and/or a club layout, LCC is clearly the way of the future.

A second question might be “Is it right for my layout? Only you can answer that question. Using an analogy to DCC, installing a decoder in a poorly functioning engine will not make it a stellar performer. However, if you have a good-running engine that simply needs modernization, then upgrading is certainly the way to go. The larger and more complex the layout, the more you will appreciate LCC and the capabilities it provides.

Hopefully, this article has lowered any angst you may feel about jumping into something new and provided the confidence to try LCC. Fear not, others have now been before you, and more and more modelers are succeeding!

If you are in the Phoenix area, come and visit our layout. You will have a visible demonstration of LCC in action with some incredibly happy LCC users!

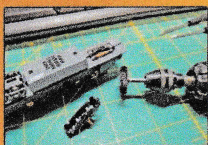
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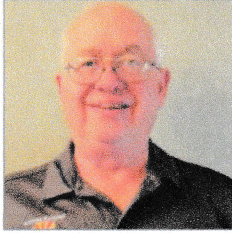


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JESSE POOLE



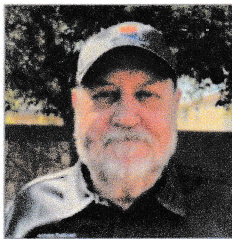
Jesse Poole is native to Washington DC, and grew up in the Maryland suburbs within earshot of the B&O tracks.

He built his first layout while in fourth grade and ran it for many years. In college he earned a degree in aerospace engineering, and is currently retired in Arizona.

He was in a train club that lost its modeling space, and the Arizona Capitol Museum offered an opportunity. The design phase and, the management of the project is well underway, until COVID intervened.

He has raised three daughters, and has had the chance to introduce his grandchildren to the wonders of the hobby. ■

DAN KUBARYCH



Dan has been addicted to modeling since the age of six, with American Flyer trains. He earned a degree in anthropology, and worked toward a career building museum exhibits.

Now he is working in a museum with the Arizona Railroad Historical Society building a train layout. He has been heavily involved in getting LCC to control lighting, sound and automation effects. He is scratchbuilding a model of a Blaisdell Slow Sand Filtering machine used by the Yuma Water utility to filter Colorado River water. ■