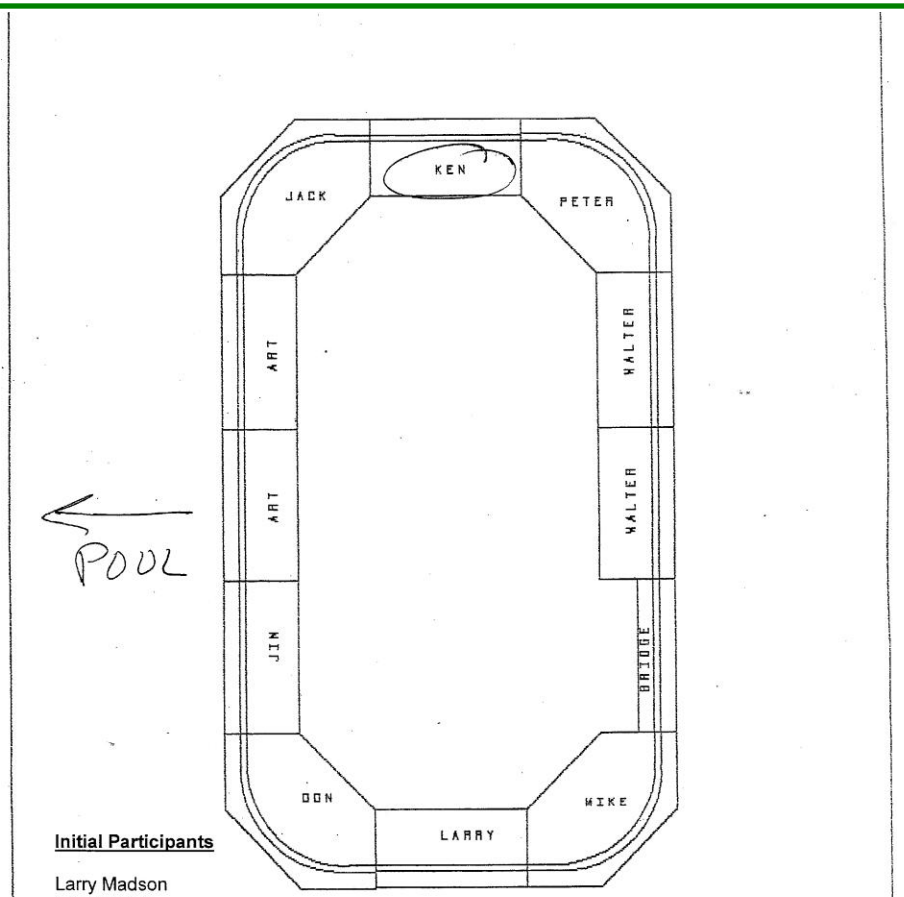
Signaling a Modular Layout

Dick Johannes
& the HUB Division Signal Committee
July 2014

The HUB Division
Signal Committee Members

Humble Beginings



Hoosac, Upton & Boston RR

- Now over 65 members
- David Haralambou is the current Co-ordinator
- Very large setups including the annual Amherst Railway Society Show & our New England Model Train Expo
- Annual displays at Children's Hospital Boston & the National Heritage Museum in Lexington, MA
- Shown internationally: Canada, Germany, Netherlands
- Very early adopter of DCC (after all, Stan and Debbie Ames are members) Has always been Lenz driven
- 1st Place awards at NMRA Nationals both in individual modules and modular railroad categories.

You Can Learn a Lot in 8 sq ft

- At the outset we had:
  - 5 bus wiring harness supports 2 mainlines buses, a local track bus, an accessory DCC bus, and an18 volt AC accessory bus
  - 2 Cat5 buses: XpressNet bus & a 2nd unused Cat5 bus
- Replete with high-end craftsman structures and scratch-built structures
- Numerous experiments with scenic techniques
- Remember, the overarching goal is to serve our members
- Why not Signaling next??

The R³C³ Approach

- Research, research, research
  - Reading
  - NMRA Convention Visits
  - Formed a Signaling Committee
  - Created a Requirements Specification
- Communicate, communicate, communicate
  - Spring Training
  - RailFun nights
  - The "*Headlight*"
  - Get a master involved (Dr. Bruce Chubb)

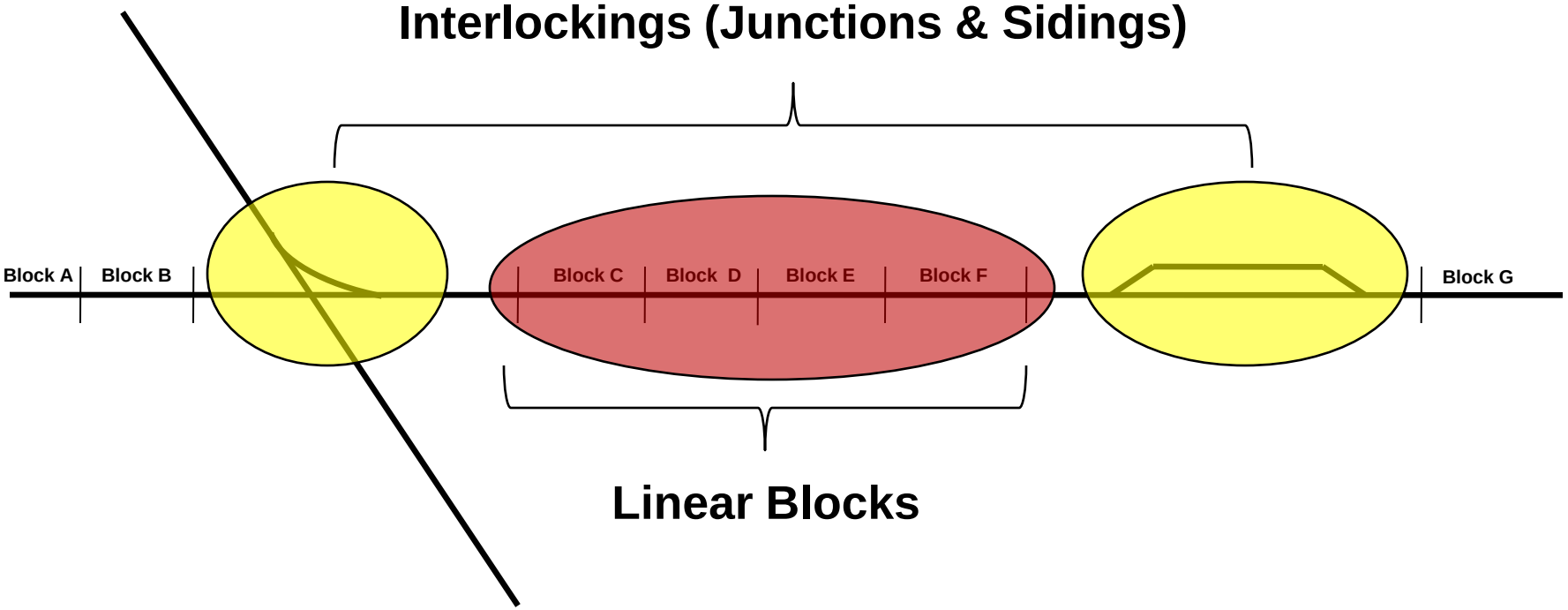
Goals & Rationale

- Increase the knowledge and curiosity in signaling within HUB Division members
- Add a new level of operating interest to the modular layout
- Enhance the viewing experience for spectators of the layout
- Sounded like fun!!

Key historical events

- 1840: Ball signals: LTC Rolt
- 1841: Semaphore – Charles Gregory
- 1851:Telegraph – Chas Minot
- 1870: Track Circuit – William Robinson
- 1871: Disk (Banjo) Signal – Thomas Hall
- 1904: Color light signals – William Churchill
- 1915: Position-light signals – Arthur Rudd
- 1920: Searchlight Signals – Hall Signal Co.
- 1924: Color Position signals – Frank Patenall
- 1925: Tri-color (G type) signals - GRS

Two types of “regions”



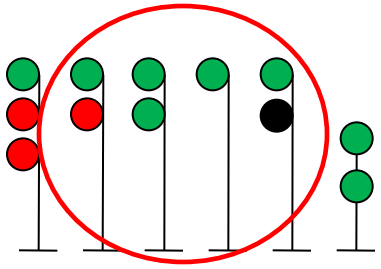
The Distinctions

- Linear blocks
  - **Unsupervised** (e.g. totally automated)
  - Default is “clear” or “green”
  - ABS (Automatic Block Signaling)
  - APB (Absolute Permissive Block)
- Interlockings (Junctions & Sidings)
  - **Human operated** (e.g. human controlled)
  - Default is “stop” or “red”
  - Mechanical interlocks
  - US&S panels
  - Computerized CTC

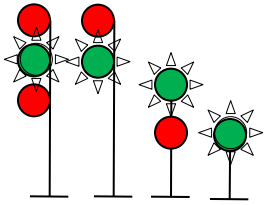
Aspect Combinatorics & (NORAC)

UPPER HEAD	LOWER HEAD	Signal	RULE (Aspect)
GREEN	GREEN		**281**
GREEN	YELLOW		**Not Used**
GREEN	RED		**281**
YELLOW	GREEN		282
YELLOW	YELLOW		284
YELLOW	RED		285
RED	GREEN		283
RED	YELLOW		290
RED	RED		291

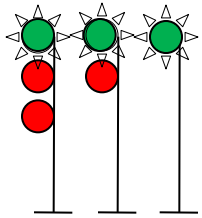
Aspects: NORAC*



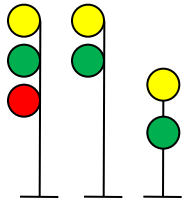
Rule: 281
Name: Clear
Indication: Proceed not exceeding Normal Speed



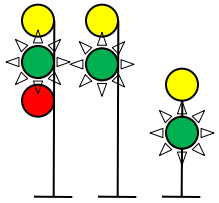
Rule: 281c
Name: Limited Clear
Indication: Proceed at Limited Speed until entire train clears all interlocking or spring switches



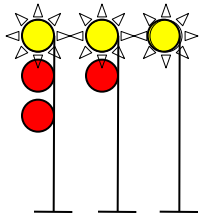
Rule: 281a
Name: Cab Speed
Indication: Proceed in accordance with cab signal indication



Rule: 282
Name: Approach Medium
Indication: Proceed approaching the next signal at Medium Speed



Rule: 281b
Name: Approach Limited
Indication: Proceed approaching the next signal at Limited Speed

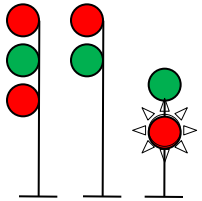


Rule: 282a
Name: Advance Approach
Indication: Proceed prepared to stop at the second signal. Trains exceeding Limited Speed must reduce to Limited Speed as engine passed the signal

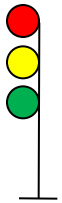
*** 9th Edition, 2008**

- Flashing

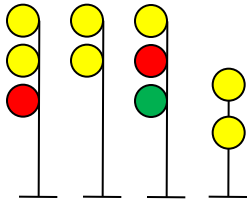
Aspects: NORAC* (cont)



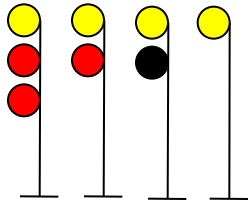
Rule: 283
Name: Medium-Clear
Indication: Proceed at Medium Speed until entire train clears all interlocking or spring switches, then proceed at Normal Speed



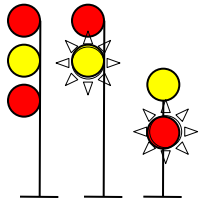
Rule: 283a
Name: Medium Approach Medium
Indication: Proceed at Medium Speed until entire train clears all interlocking or spring switches, then approach next signal at Medium Speed



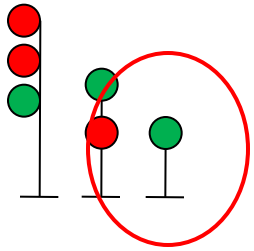
Rule: 284
Name: Approach Slow
Indication: Proceed approaching the next signal at Slow Speed



Rule: 285
Name: Approach
Indication: Proceed prepared to stop at the next signal. Reduce to Medium Speed as engine passes signal



Rule: 286
Name: Medium Approach
Indication: Proceed prepared to stop at the next signal. Reduce to Medium Speed as soon as signal is clearly visible



Rule: 287
Name: Slow Clear
Indication: Proceed at Slow Speed until entire train clears all interlocking or spring switches, then proceed at Normal Speed

*** 9th Edition, 2008**

- Flashing

Advice We Were Given

- Pay attention to modeling details just as you would in any other aspect of model railroading
- Separate the signaling bus from train control
- Solve occupancy then move to signals
- You won't regret using either C/MRI or Digitrax
- Largely, we took this advice but made some compromises

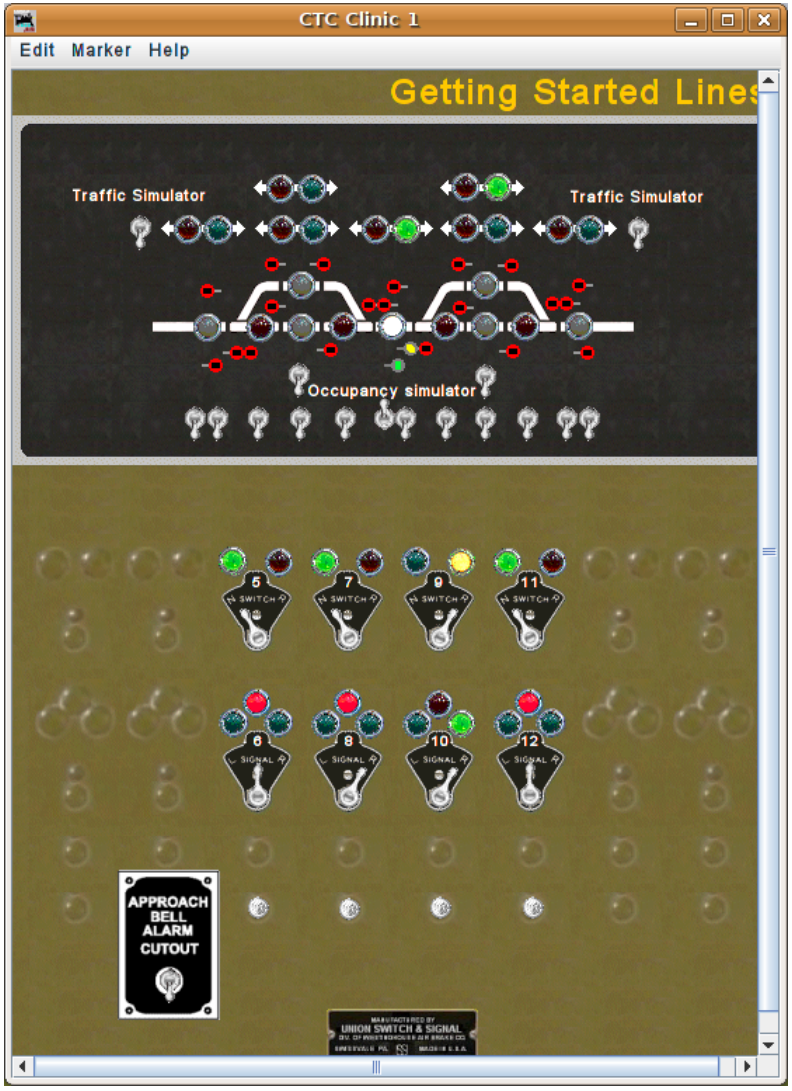
Frame the Issues

- This is a classical data processing issue
  1. What are the inputs and where do they come from?
  2. How do we process the incoming data transforming it into information?
  3. How do we output the processed information?
- We were looking for a hardware *AND* a software solution

Experiment, Experiment, Experiment

- We adopted JMRI early
  - Broad support for multivendor solutions
  - Already had experience with DecoderPro & WiThrottle
  - We got to the point where we could build US&S style panel using PanelPro.
    - JMRI website
    - Dick Bronson's NMRA online clinics

US&S CTC Panels

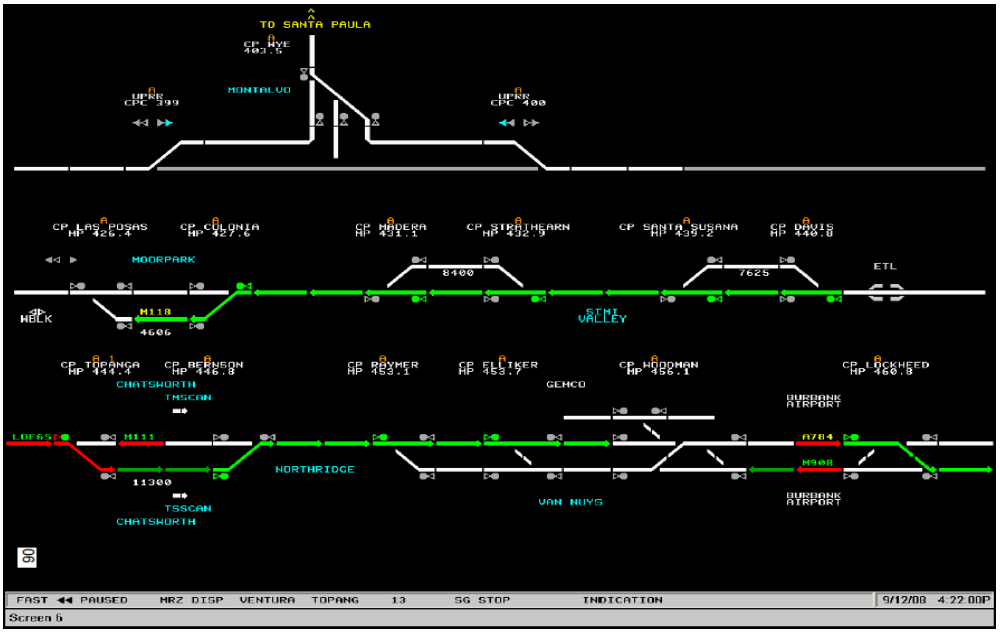


Screen shot from Dick Bronson's Hartford National Clinics

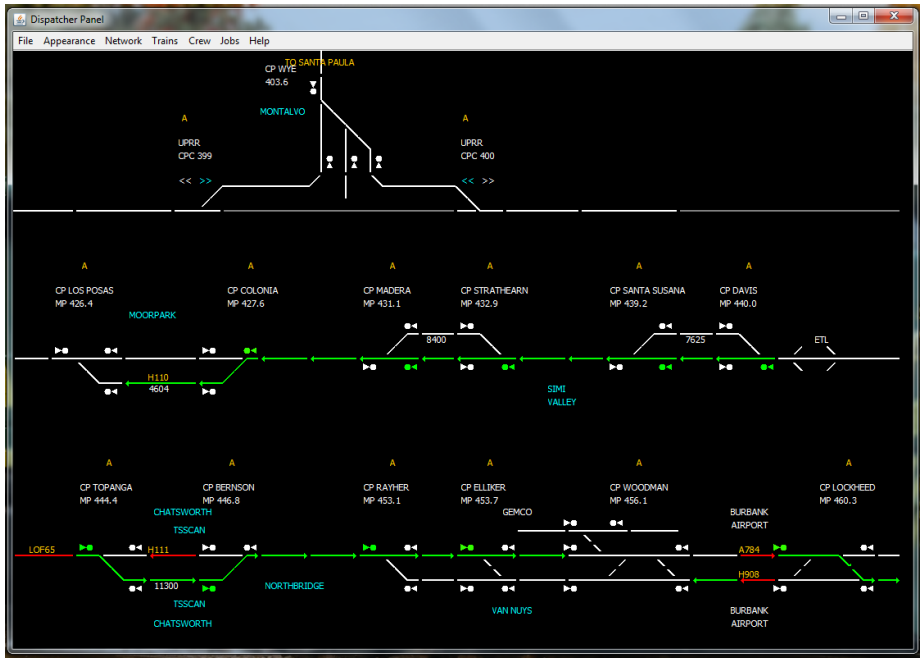
But There Was Interest in a Modern CRT-based Panel

- We looked at the Layout Editor
- Using the JMRI Website, we found CATS (Computer Automated Traffic System)
- Open Source JAVA software layered atop PanelPro
- Written by Rodney Black. Like JMRI, it has an online user forum
- Based upon prototype Digicon system

Direct Comparison

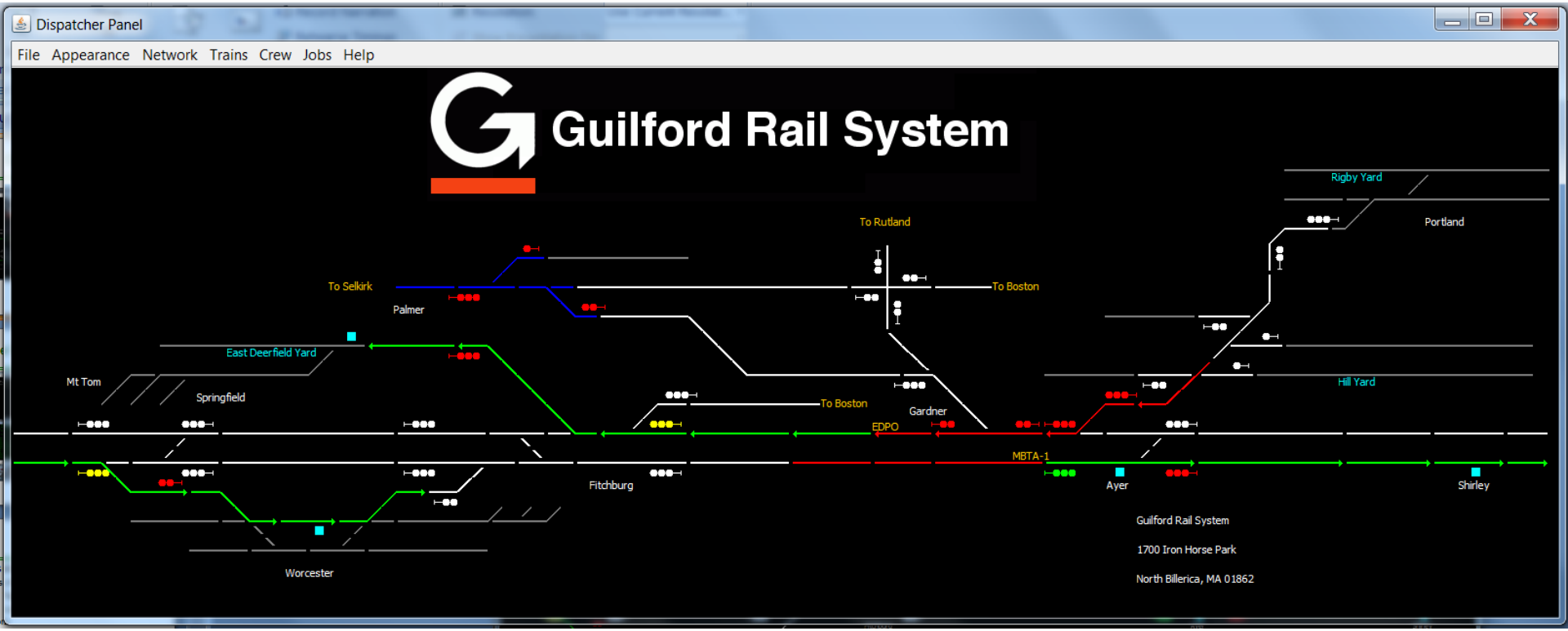


Screenshot of the Digicon Prototype



CATS Rendering of the Prototype

CATS Screen Shot



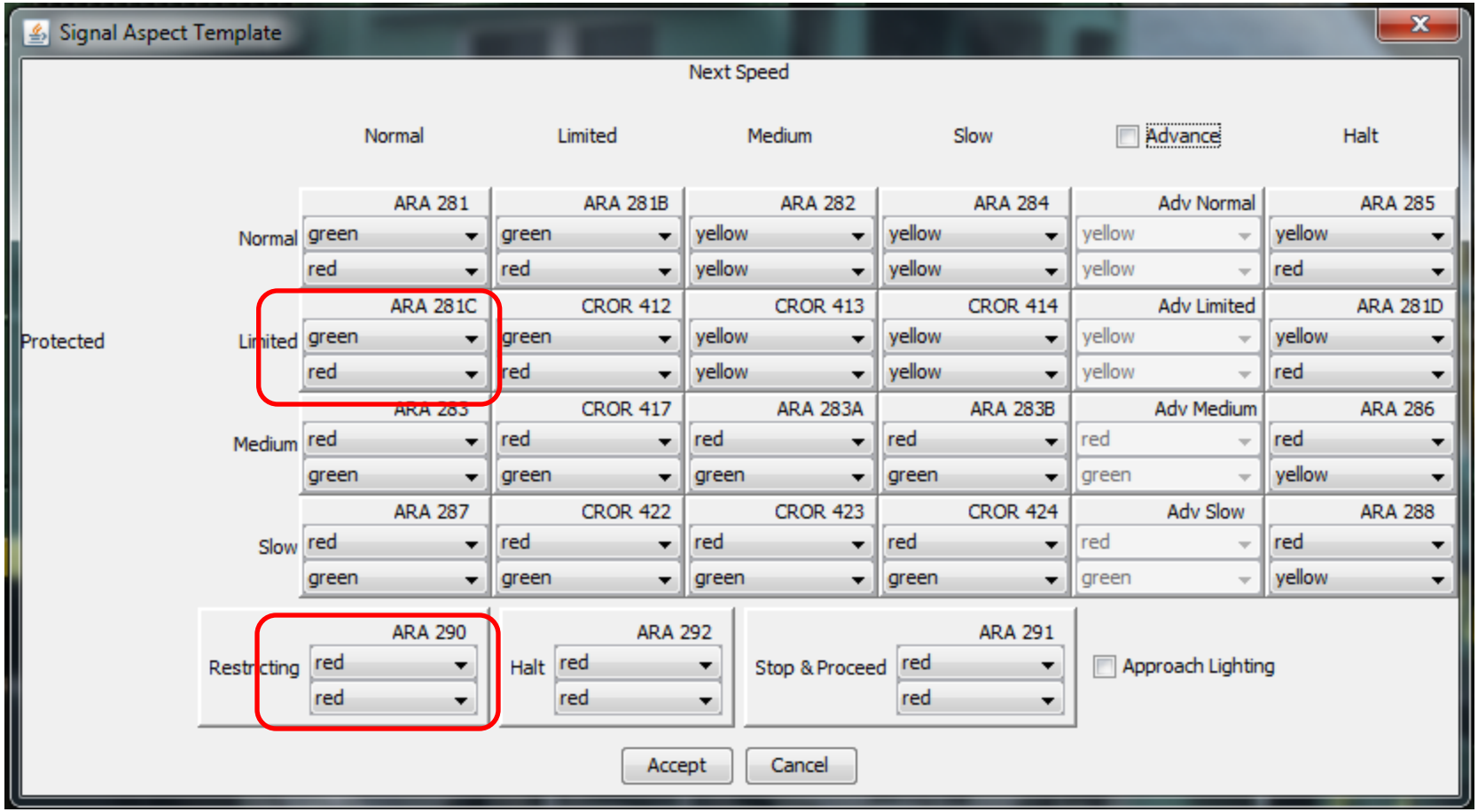
CATS

- Several outstanding features
  - Uses all the debugging tools in JMRI
  - Great benefits even without signals
  - Signaling based on 4 track speed / 2 or 3 block rules
  - “Pre-programmed” signal logic
  - CTC signals are visible whereas intermediate signals are not visible on the dispatcher panel
  - Can grant track authority
  - Can take track out of service
  - Allows train tracking by train symbol or locomotive #
  - Well written online manuals

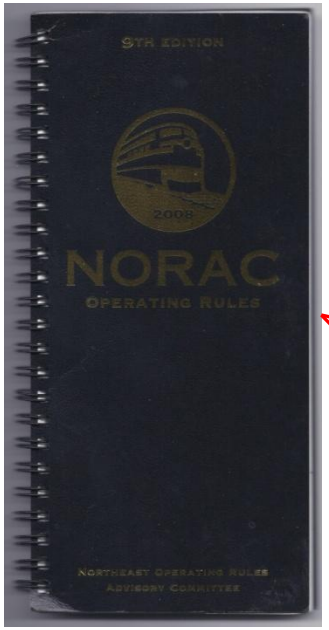
CATS Suite is 3 Programs

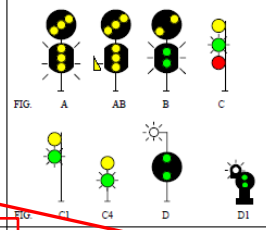
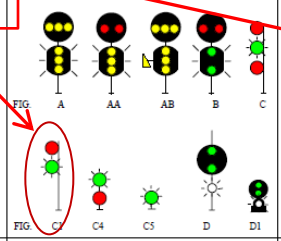
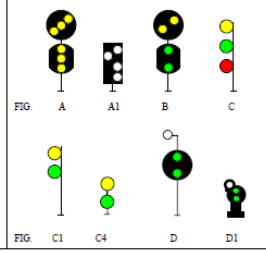
- DESIGNER
  - Used to describe the panel (e.g. track, turnouts & signals)
  - Creates a permanent stored XML file
  - Detector and signal definitions & address mapping
  - Many display options
- CATS
  - The runtime application
  - Many runtime controls and display options
- TRAINSTAT
  - Tool to allow documenting train location and time (either real time or fast clock)
  - Can be stored to file for archiving

The Signal Template Default Settings



Define Your Signal Rules



Rule	Aspect	Name	Indication
281b		APPROACH LIMITED	Proceed approaching the next signal at Limited Speed.
281c		LIMITED CLEAR	Proceed at Limited Speed until entire train clears all interlocking or spring switches, then proceed at Normal Speed. In CSS territory with fixed automatic block signals, trains not equipped with operative cab signals must approach the next signal at Limited Speed.
282		APPROACH MEDIUM	Proceed approaching the next signal at Medium Speed.

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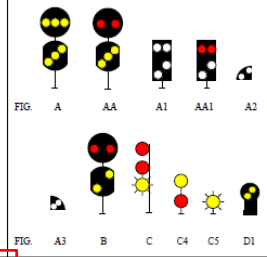
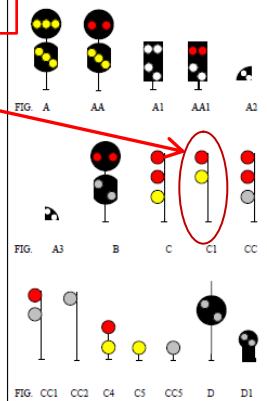
Rule	Aspect	Name	Indication
288		SLOW APPROACH	Proceed prepared to stop at next signal. Slow Speed applies until entire train clears all interlocking or spring switches, then Medium Speed applies
290		RESTRICTING	Proceed at Restricted Speed until the entire train has cleared all interlocking and spring switches (if signal is an interlocking or CP Signal) and the leading wheels have: 1. Passed a more favorable fixed signal. or 2. Entered non-signaled DCS territory. In CSS territory, trains with operative cab signals must not increase speed until the train has run one train length or 500 feet (whichever distance is greater), past a location where a more favorable cab signal was received.

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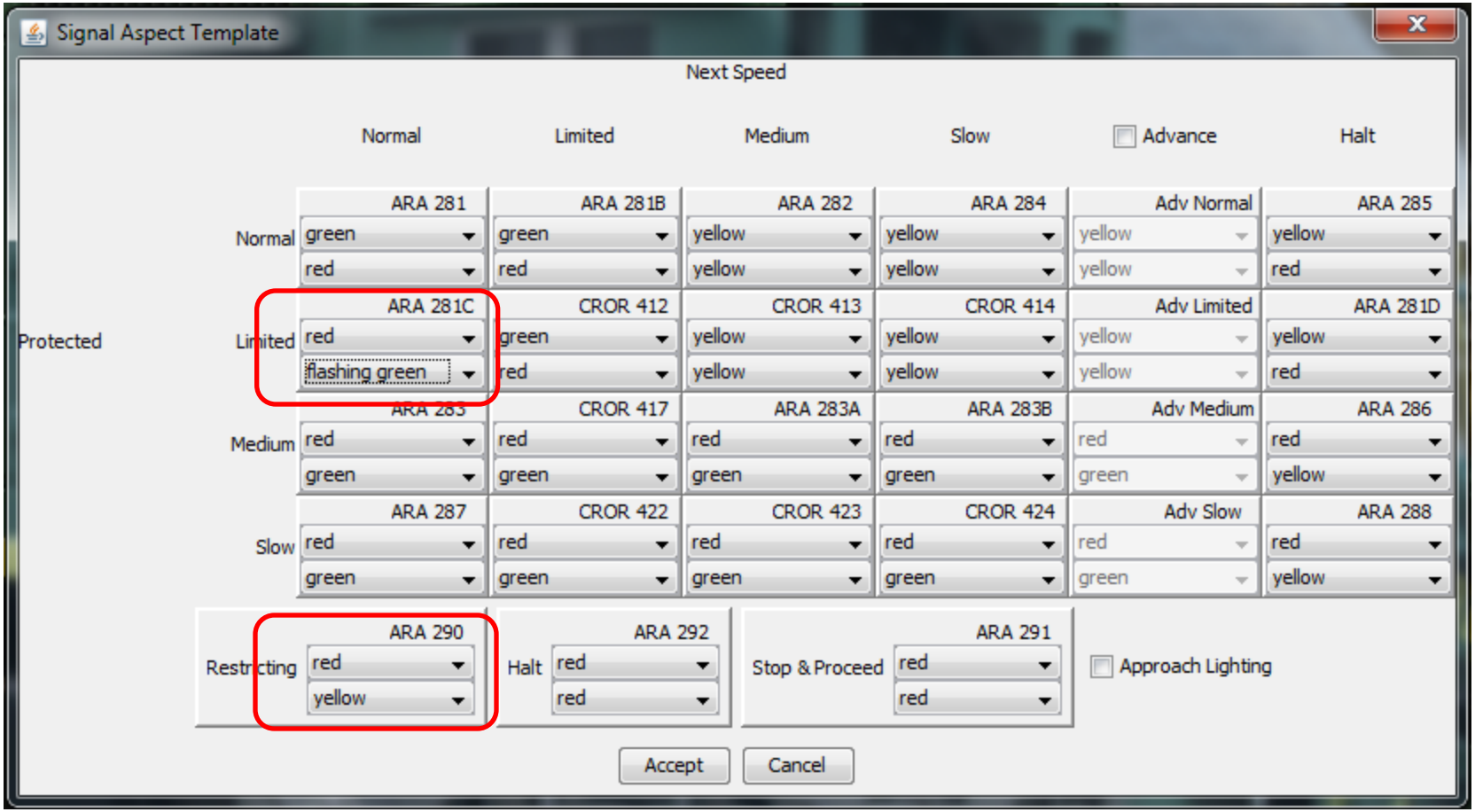
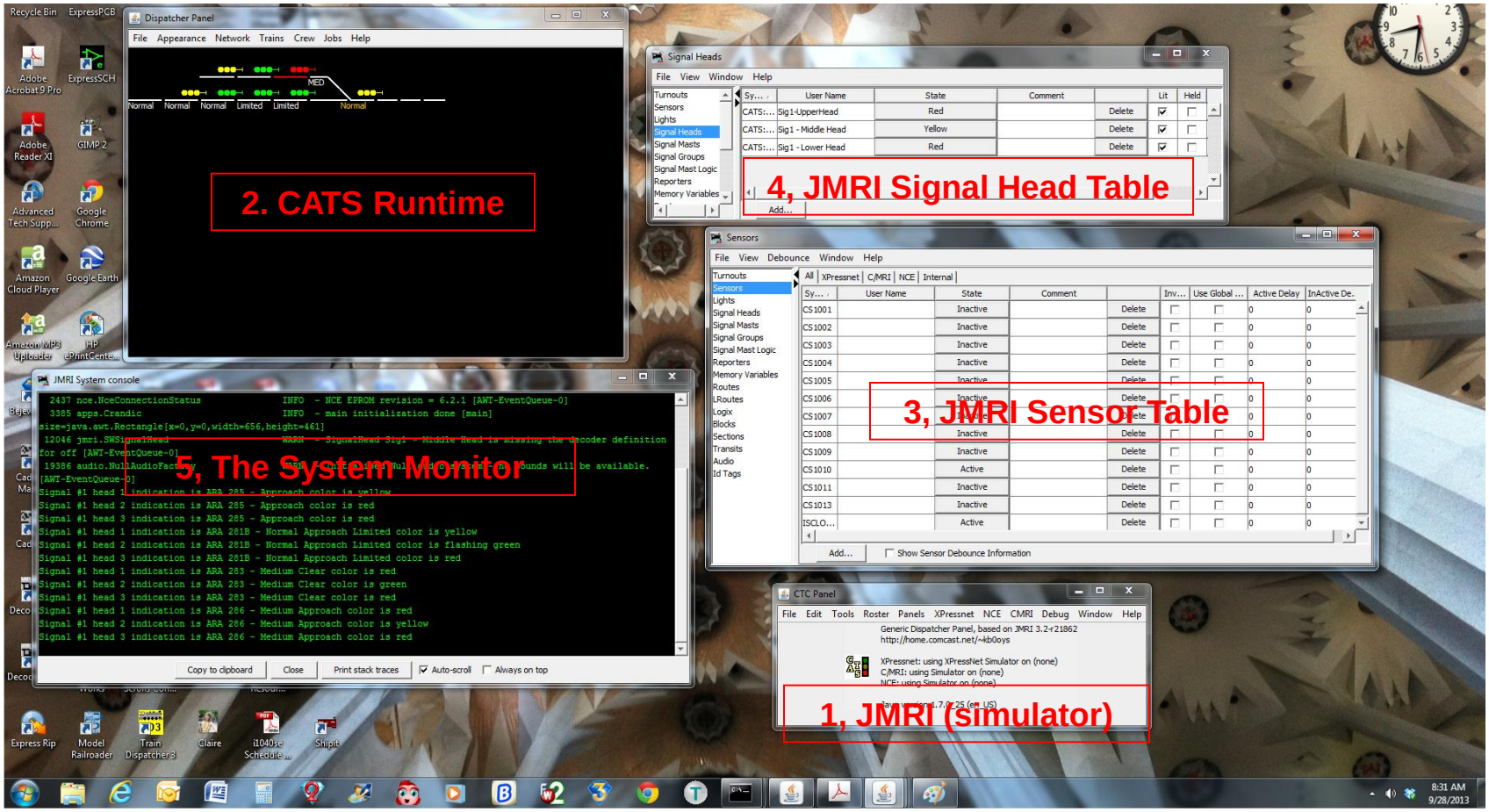
The Signal Template Edited Settings



The Testing Environment



The Difficult Requirements

- Modular specification forbids circuitry in-line with the DCC signal
- Minimal (if any) changes to existing modules if the builder choose not to add signals
- Cost
- Railroad can operate even if the signals don't
- Must be able to shuffle modules in any order at each setup and signaling must work with no wiring changes and minimal setup effort

Arbitrary Module Order

- How does one swap module order and preserve signal logic?
- The File → Import function

- File->Import reads in a saved layout (a library) without erasing any existing work. It is a way to merge multiple layouts together, add some pre-canned design elements to the existing layout, insert existing signal definitions, etc. When a file is selected, designer will grab the track plan from the file and insert the upper grid corner of the trackplan at the grid cursor location. It will expand the layout in the horizontal and vertical directions as needed. Note that the library is not inserted, but replaces existing track; thus, preserving any track not overlaid

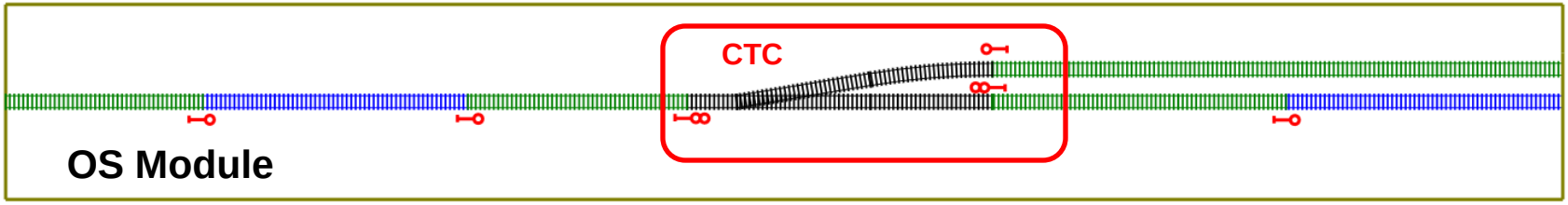
- Tracks, information associated with tracks (e.g. Block definitions), Stations, Signals, etc. will be added to the existing work. File->Import will also merge any Devices (Section 8) defined in the file, but not any Appearances (Section 14.1), Trains (Section 10), Crew (Section 12), or Jobs (Section 11). "Merging" is defined as "if something in the file does not exist in the current trackplan, it is added". This means that things in the library file will not replace things with the same name in the trackplan.

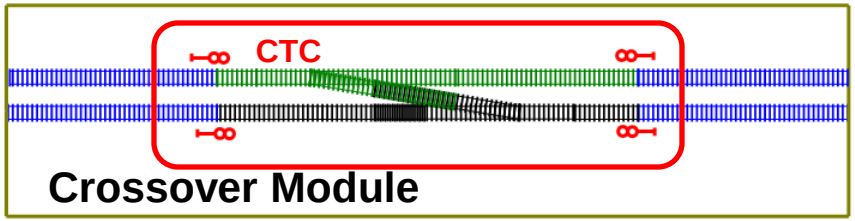
We Built 5 "*Test*" Modules

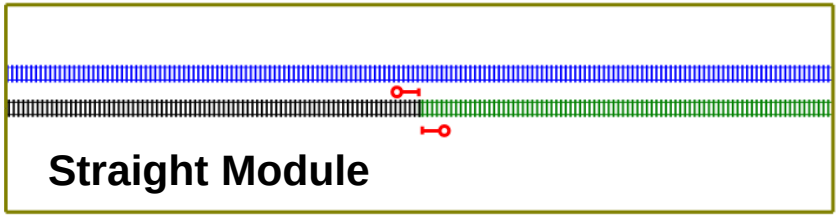
- Two were "passive" (e.g. do not have a signaling card)
  - No detection
  - No signals
  - These represented unchanged modules
- Three were "active" modules (e.g. have a signaling card)
  - These 3 modules all contained signals
  - Each module used a different type of signal
    - 1 used G-type, 1 used Searchlight, 1 used D-type
    - All wired as common anode
  - NCE AIU & DB20s used for detection, Oaktree signal boards
- Wiring strategy:
  - Inner main supplies power & detection to the left
  - Outer main supplies power & detection to the right

The Test Modules

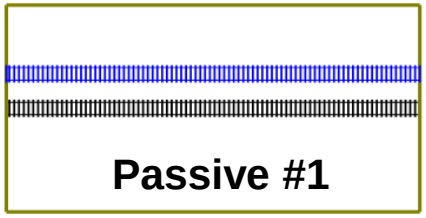
Three "Active Modules

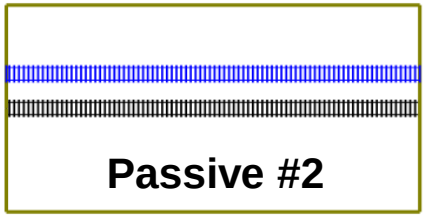




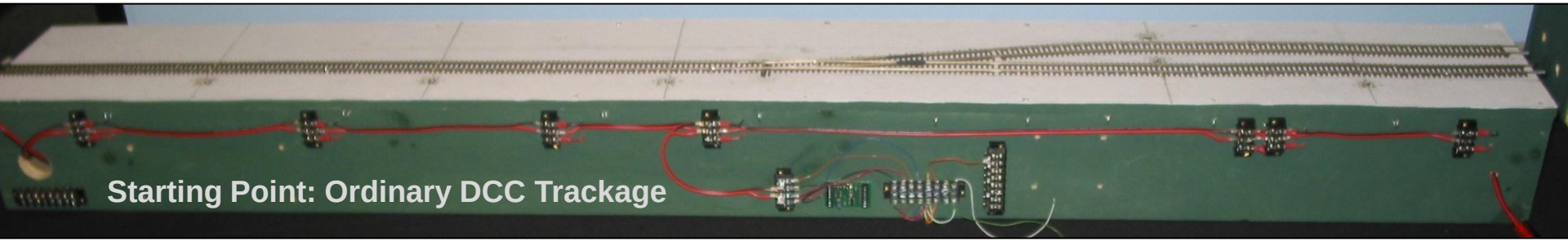


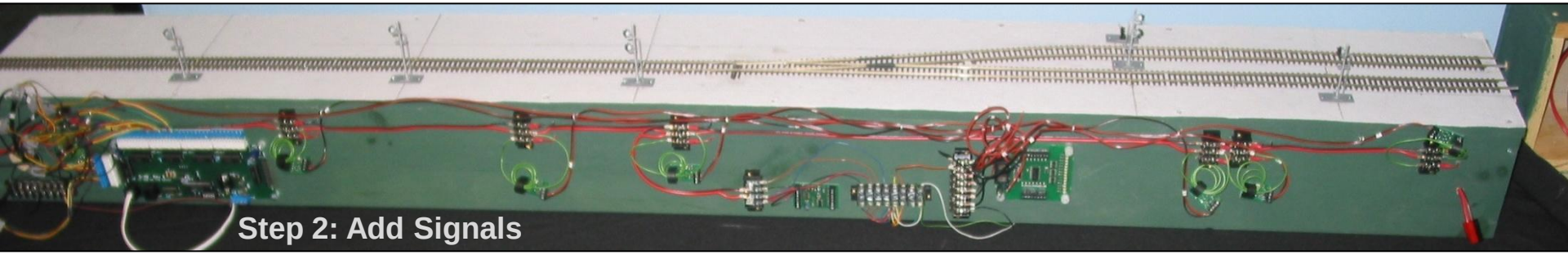
Two "Passive" Modules



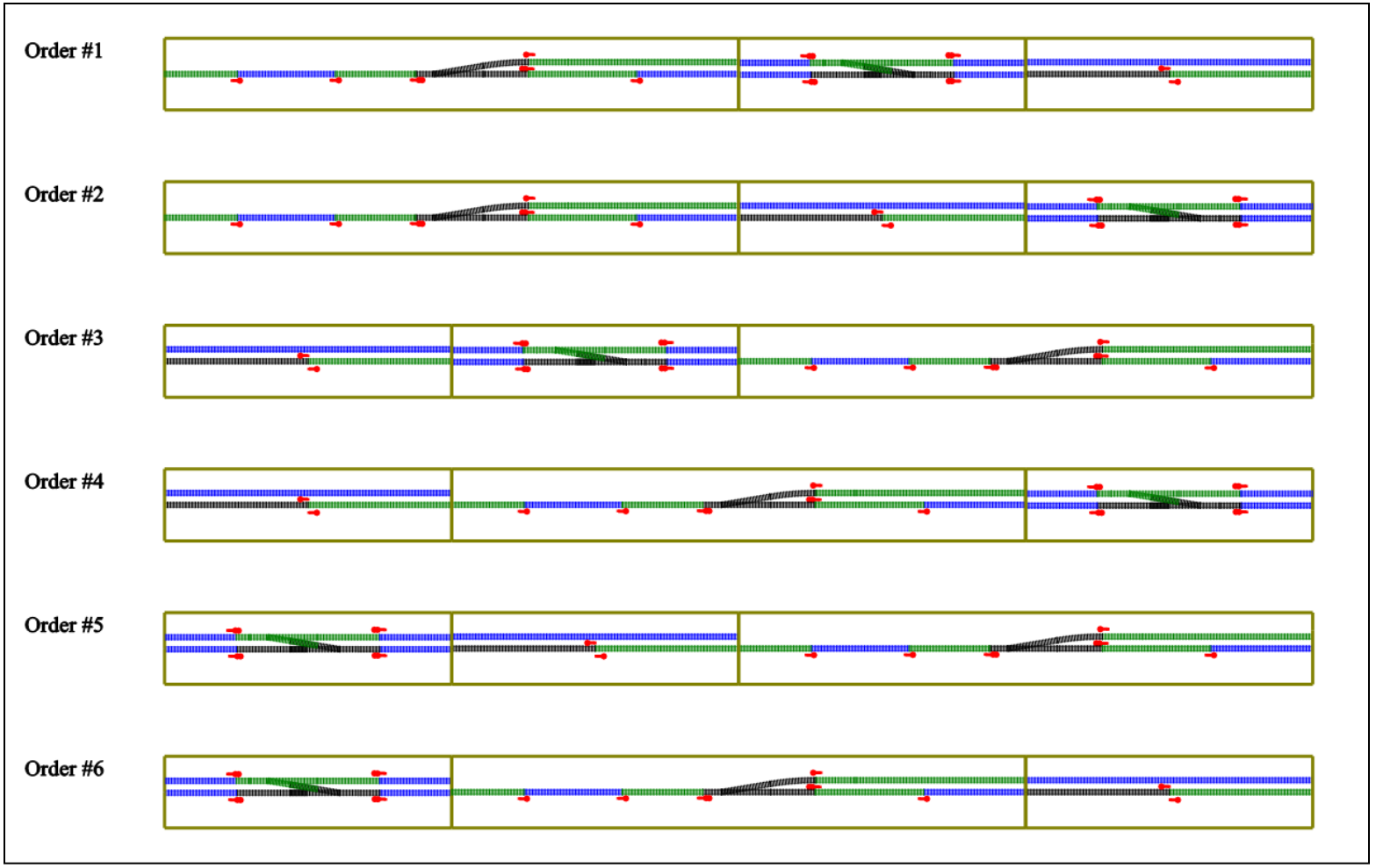


Signals in 90 Minutes

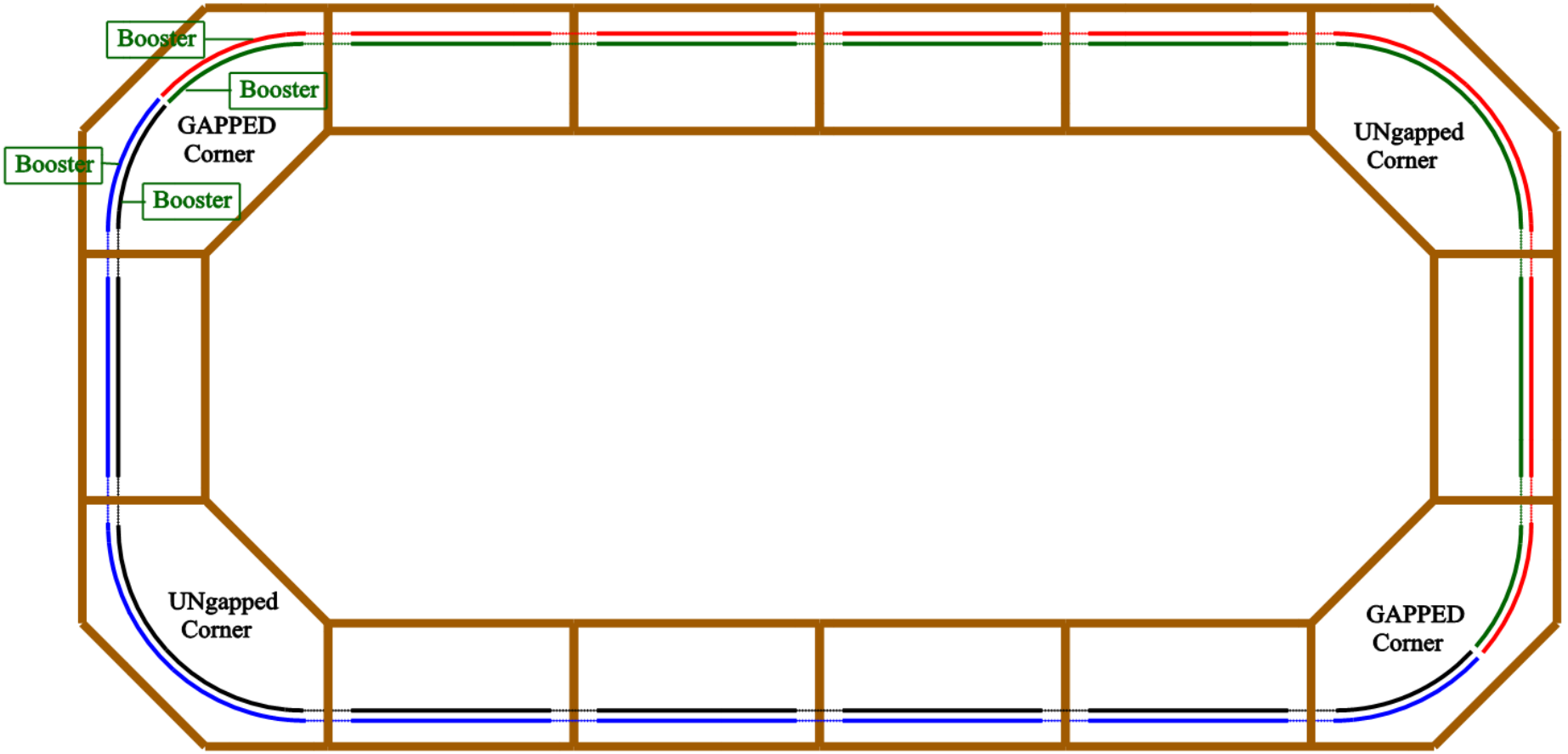




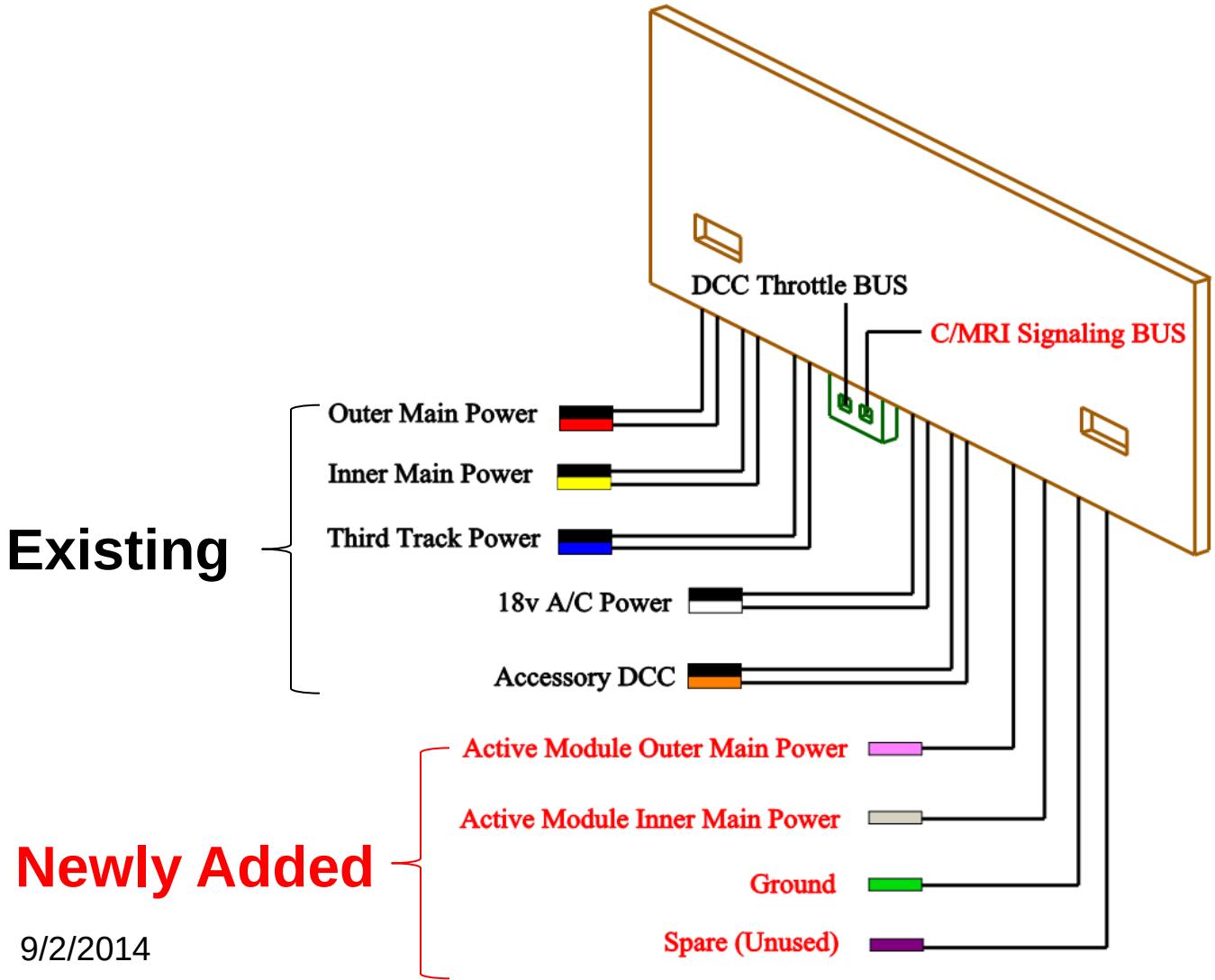
The Six Permutations



Wiring Scheme

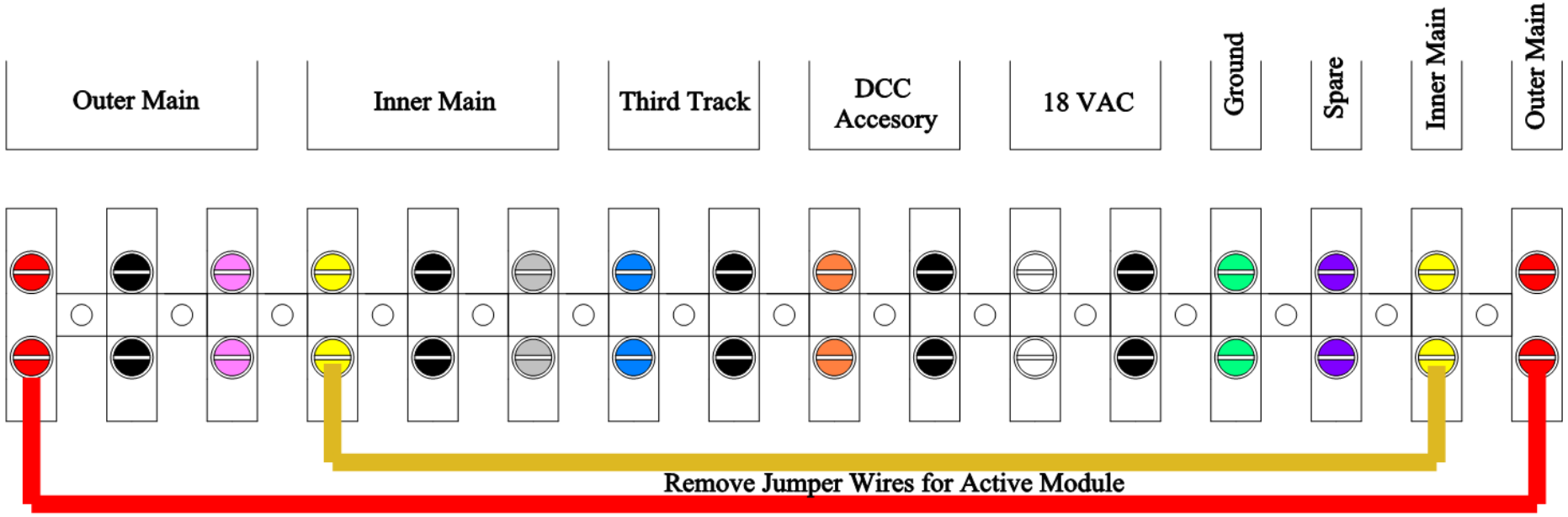


Current MU-ing



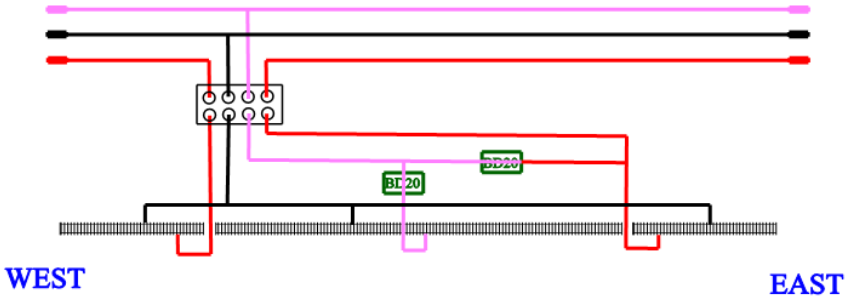
Terminal Strip Color Conventions

Wiring Harness Diagram (11-17-13)

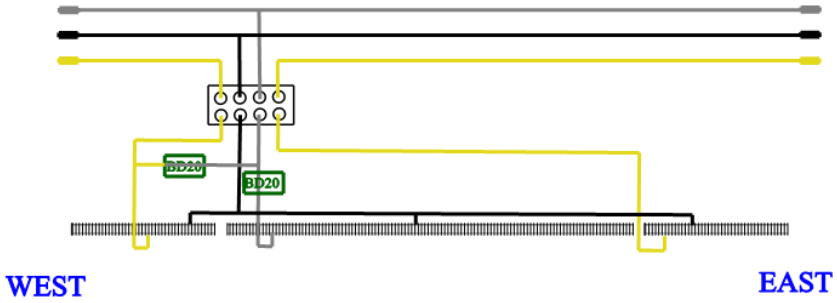


Mainline Wiring

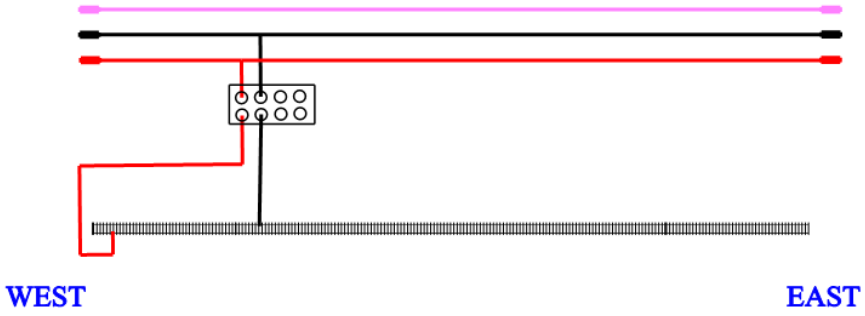
Active Module Outside Main



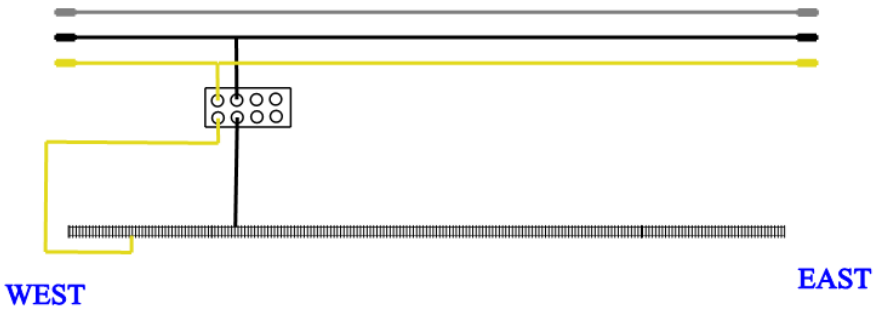
Active Module Inside Main



Passive Module Outside Main

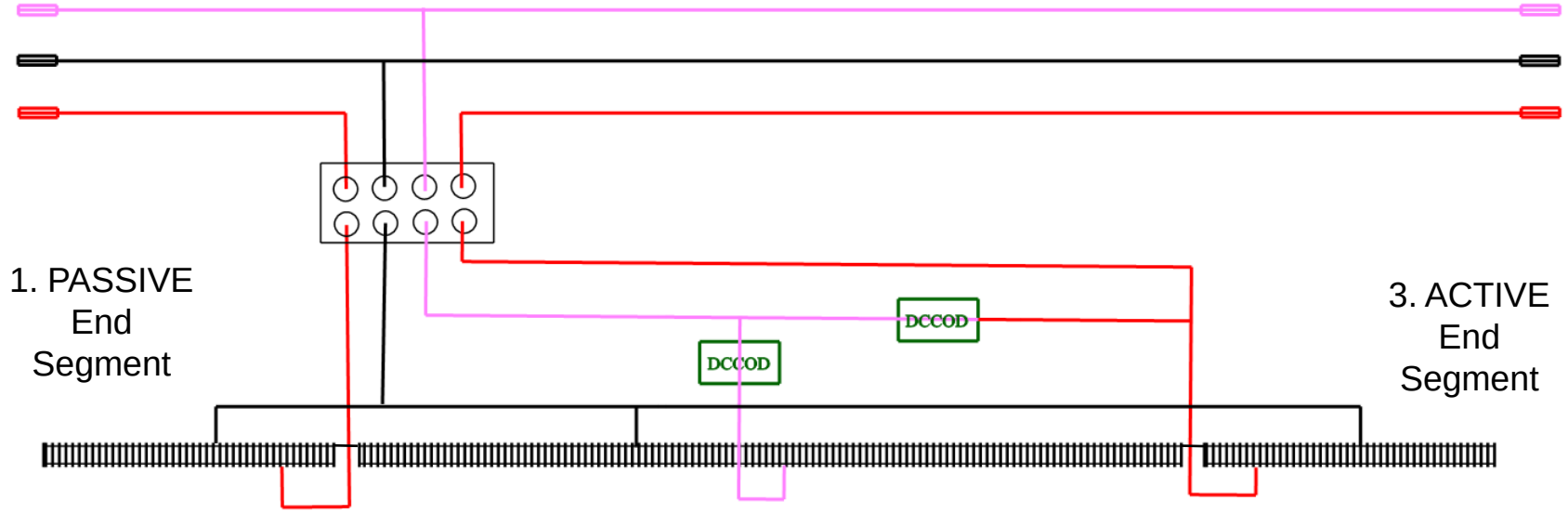


Passive Module Inside Main



Outer Main Detail

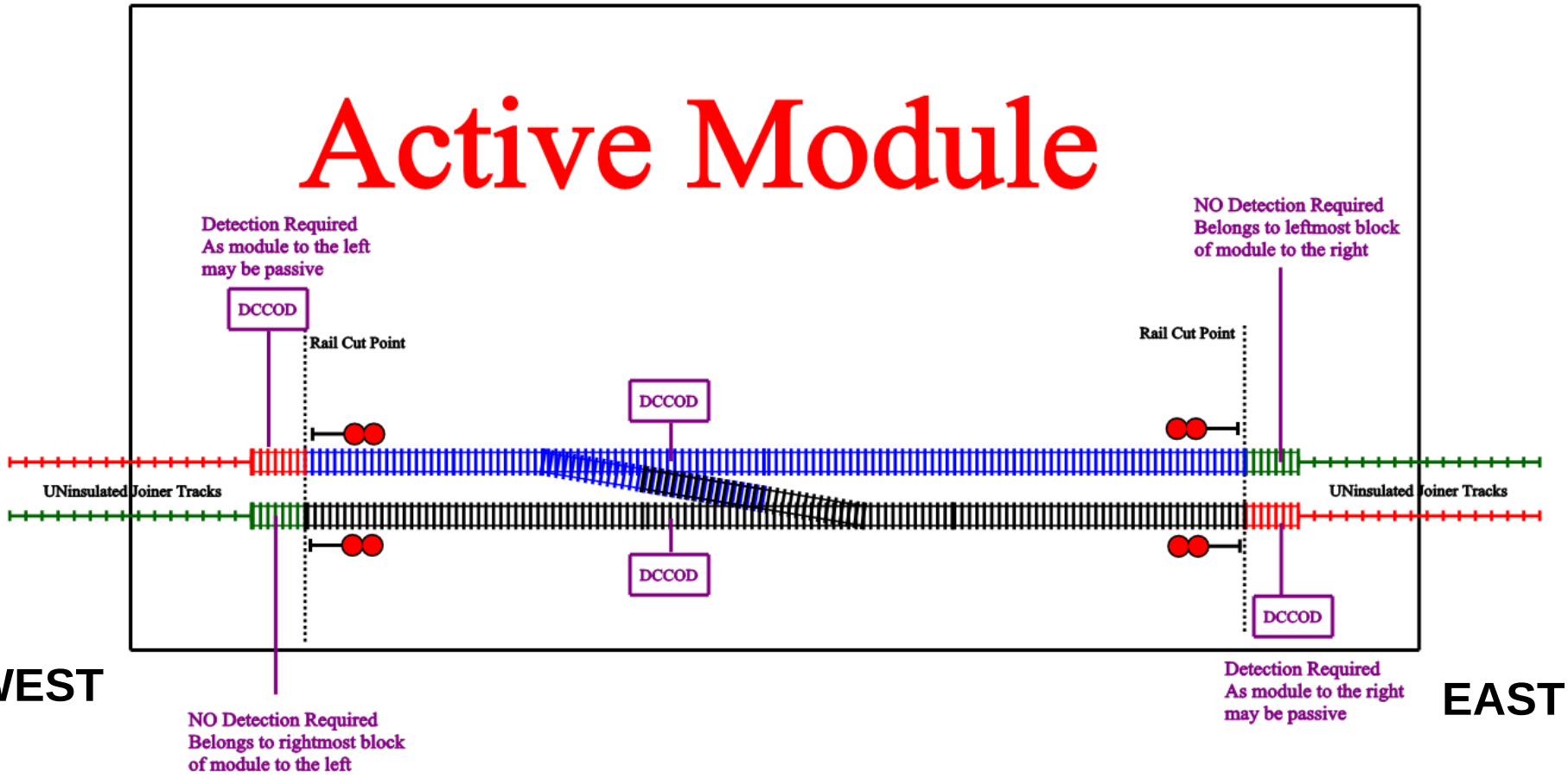
Active Module Outside Main



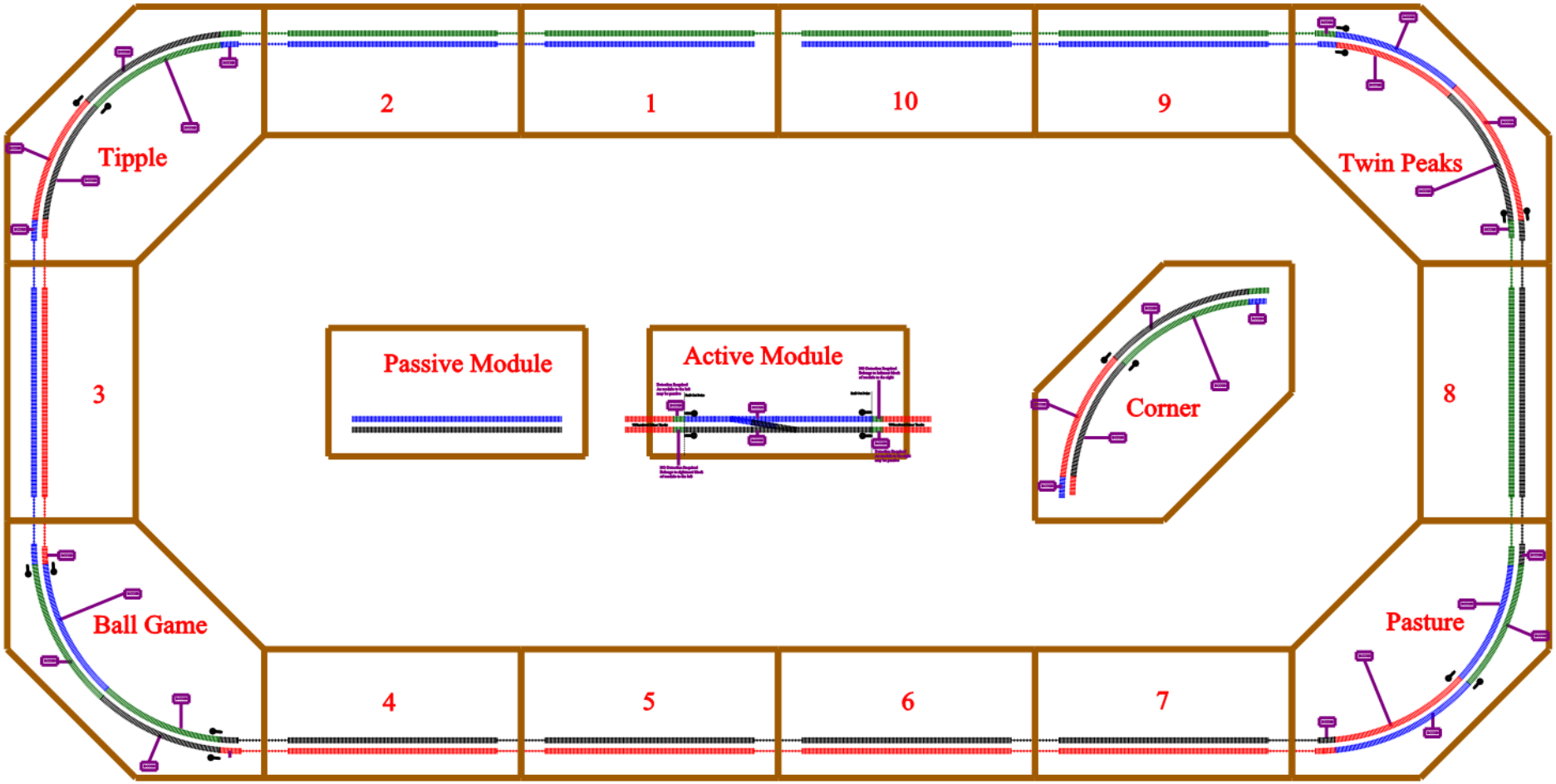
WEST

EAST

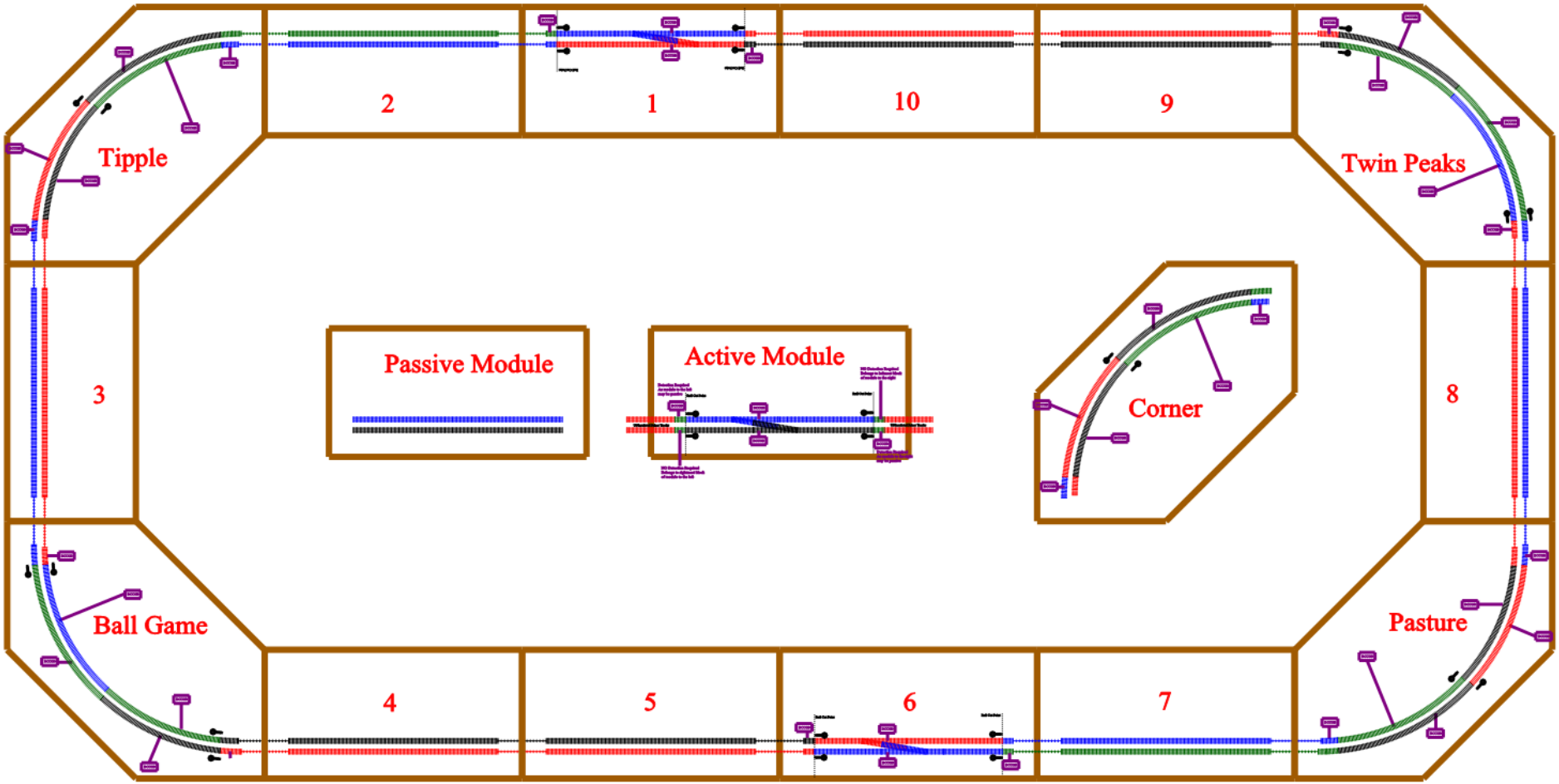
Wiring scheme



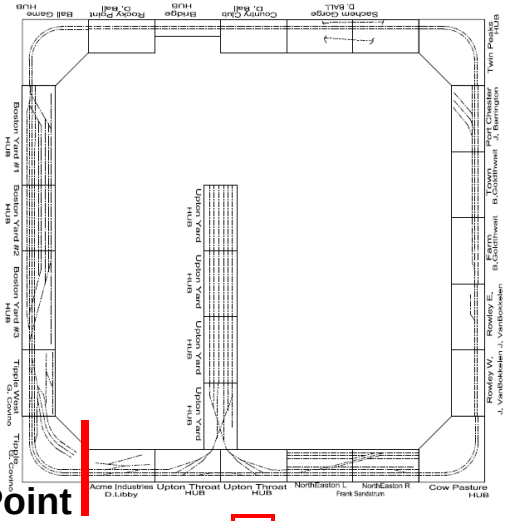
Simple Oval

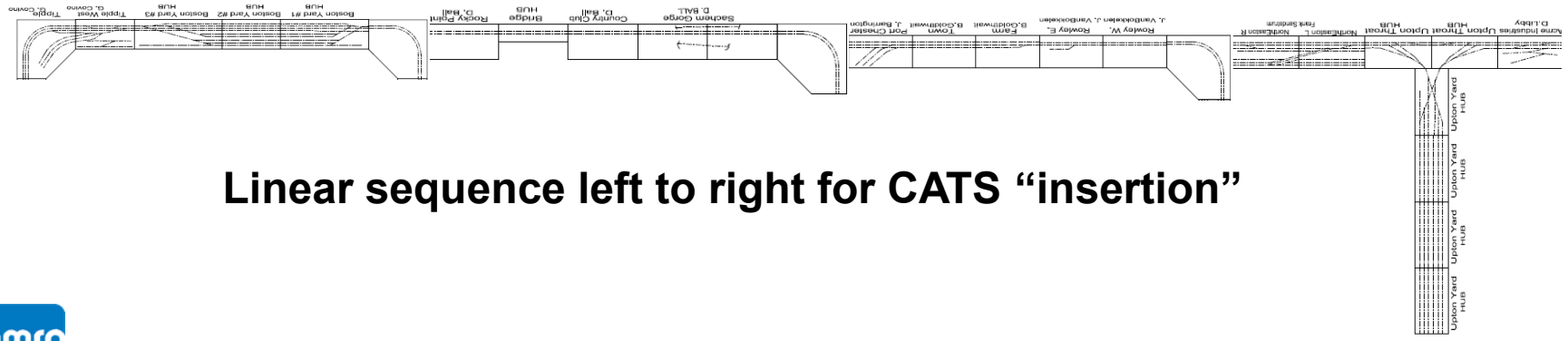

Tipple
2
1
10
9
Twin Peaks
3
Passive Module
Active Module
Corner
8
Ball Game
4
5
6
7
Pasture

“Splicing” in Active Modules



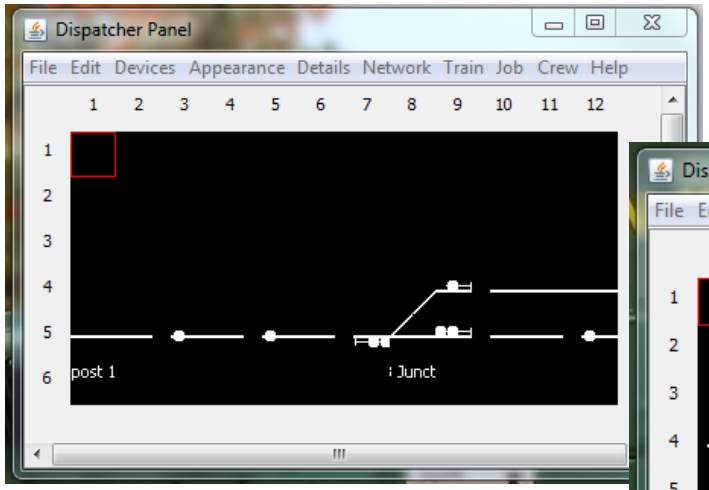
Linearize the Layout



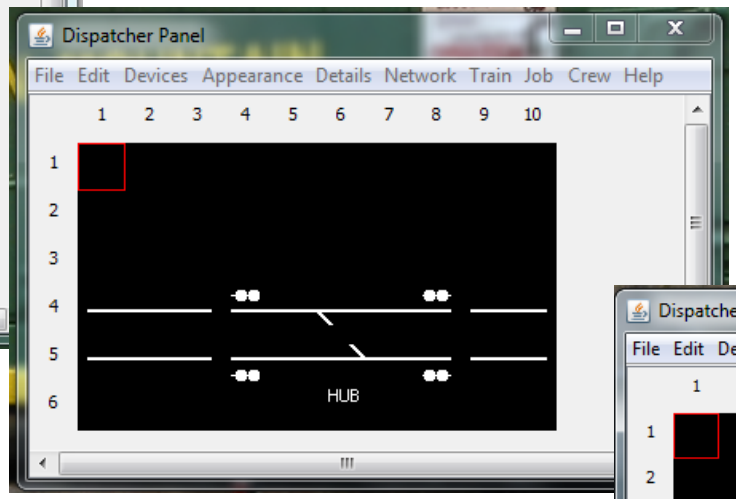


Linear sequence left to right for CATS “insertion”

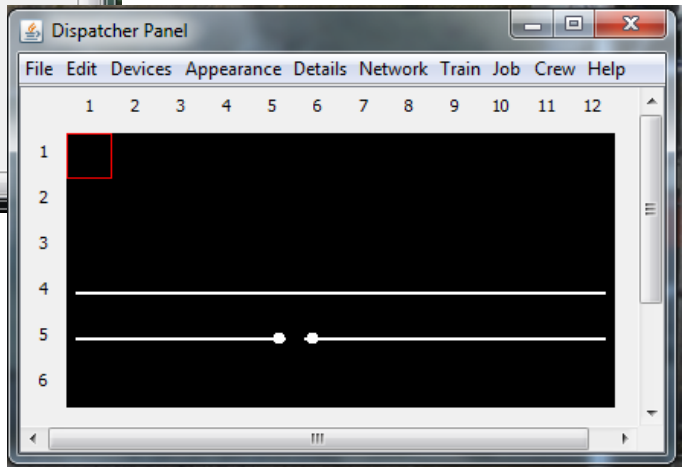
Each Module Has It's Own Designer File



OS Module

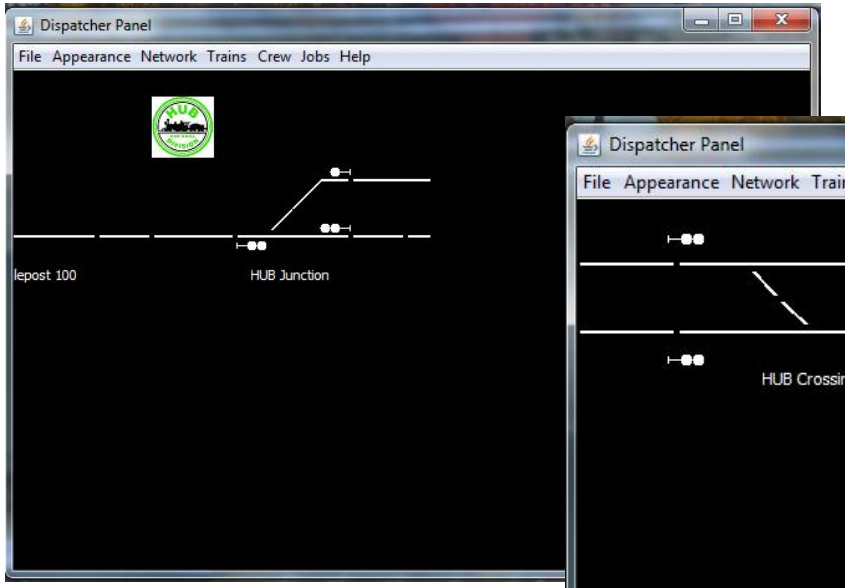


Cross-Over Module

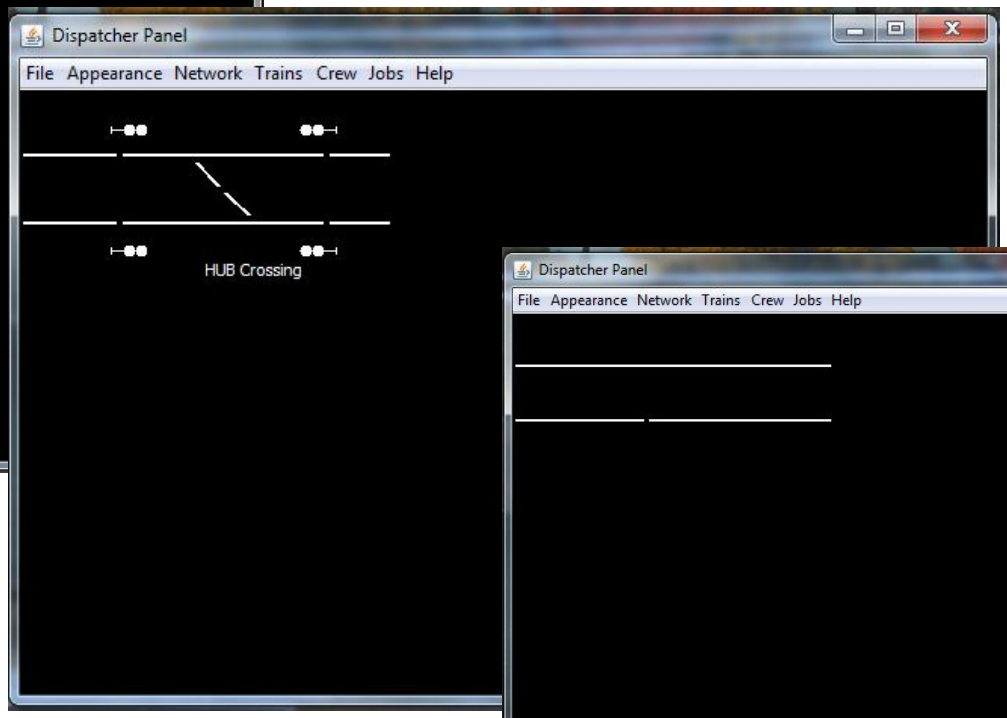


Straight Module

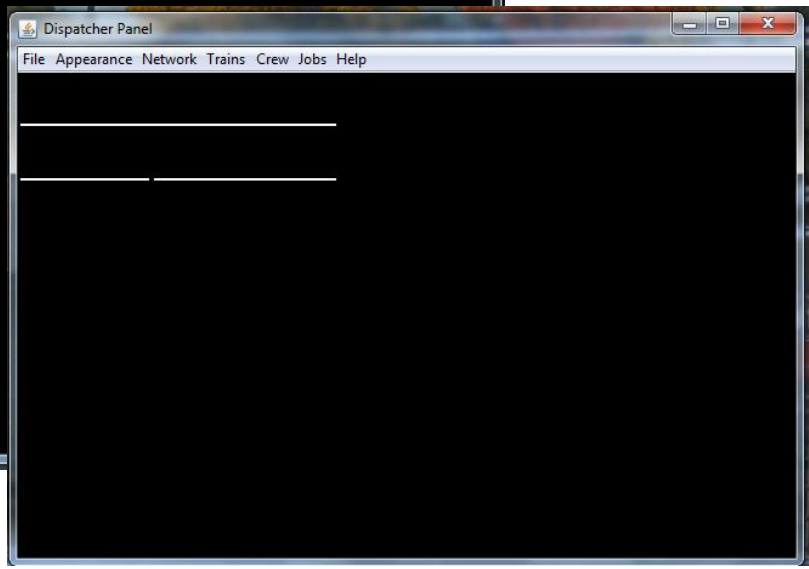
CATS Runtime



OS Module



Cross-Over Module



Straight Module

Insertion Demonstration

Runtime 3 Module Section

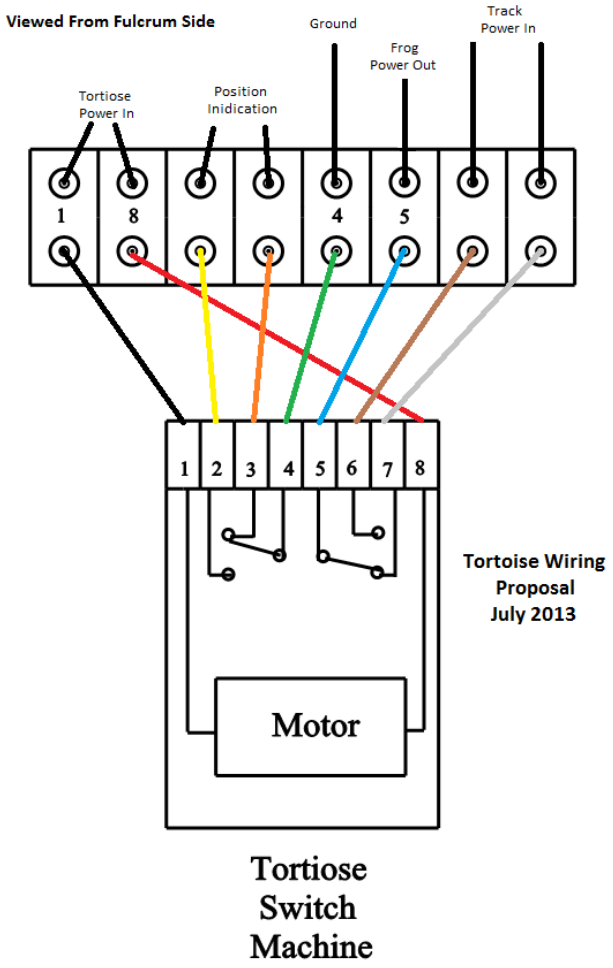
THE ROLLING MEET

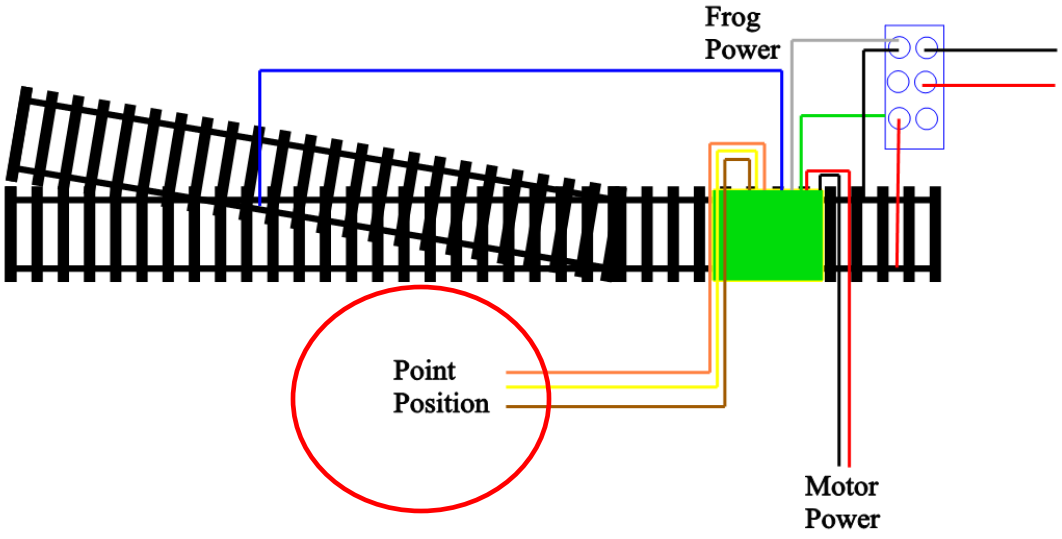
The Anxious Dispatcher

Hardware Evaluation Table

Manufacturer	Strengths	Reason for Elimination
C/MRI	**Passed all tests**	
Oaktree Systems	Reasonable price. Lots of positive testing results	Minor failure on turnout positioning. No simulator
Digitrax	Full hardware support	Signal board does not fully support all 3 color blinking aspects.
CTI Acela	Very modular, relatively low cost	Self recognizing network redefines addresses with module rearrangement. No simulator
ProTrack Grapevine	Very Modular	Possible issues with detection method. No simulator
Custom Signals	Manufactures signals as well as boards. Source for the Atlas system	Does not support JMRI. Fails a major requirement
Signals by Spreadsheet	Very clever combination of hardware and software for signaling	Does not support JMRI. Fails a major requirement
Integrated Signal Systems	Long time Manufacturer of high end signals	Does not support JMRI. Fails a major requirement

Turnout Wiring





DCC Turnouts Welcome!

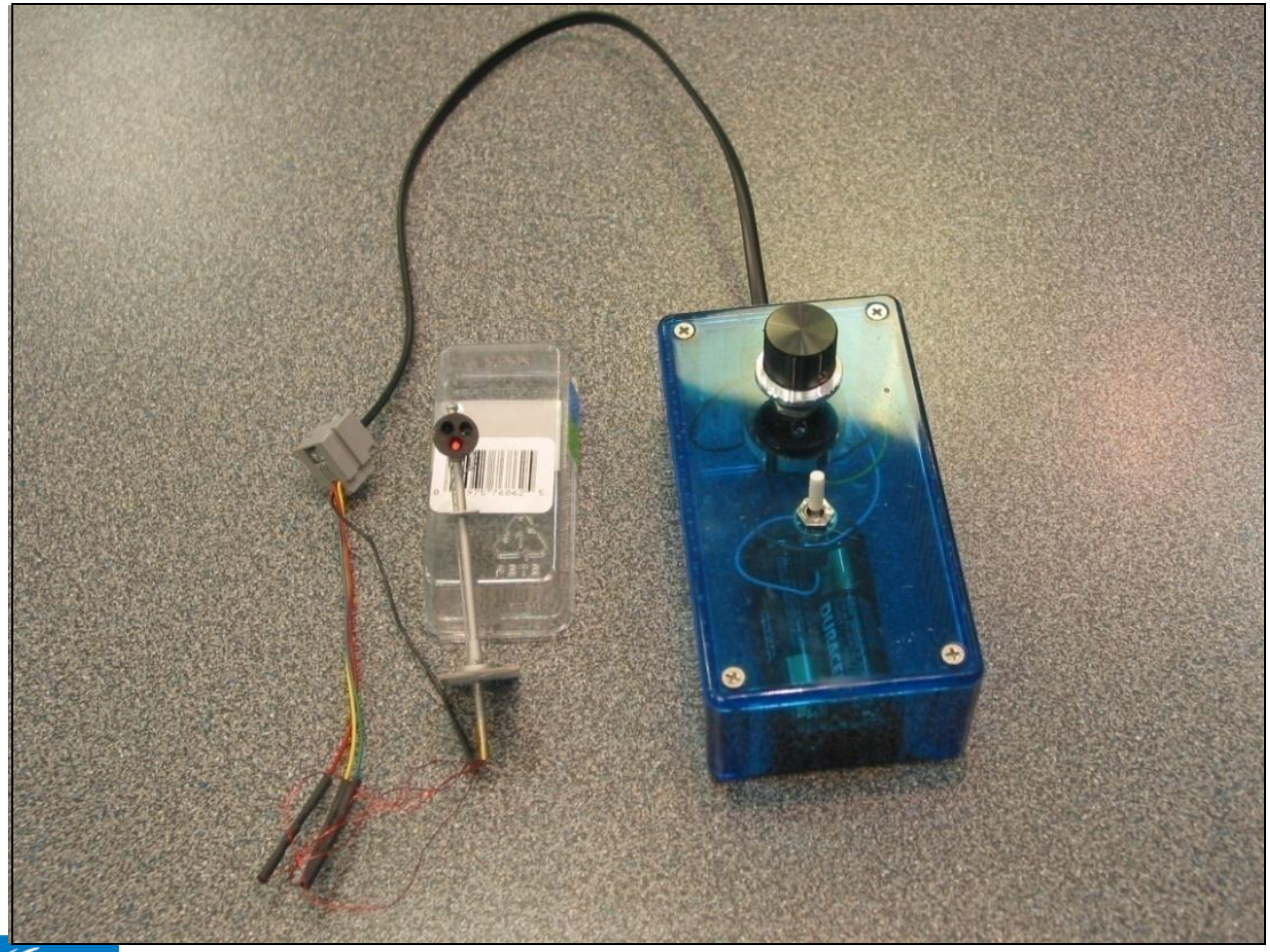
- We could use more crossovers on the mainlines
- All/Most mainline turnouts should be DCC controllable
- 3 ways to throw: throttle, pushbutton, CATS – must agree
- All accessory decoders are fine
- Costs:

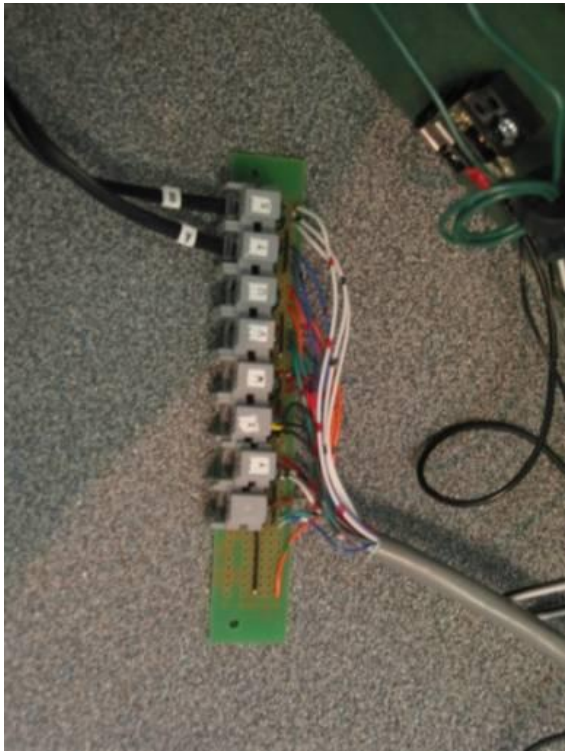
	List	# TOs	Cost/TO	On-line$	Cost/TO
NCE (SW-8)	$ 59.95	8	$ 7.49	$ 49.95	$ 6.24
Digitrax (NF)	$ 39.99	4	$ 10.00	$ 31.95	$ 7.99
NCE (SW-IT)	$ 19.95	2	$ 9.98	$ 16.95	$ 8.48
CVP	$ 35.00	4	$ 8.75	$ 35.00	$ 8.75
Team Digital	$ 99.95	8	$ 12.49	$ 84.95	$ 10.62
Digitrax	$ 59.95	4	$ 14.99	$ 49.95	$ 12.49
MRC	$ 69.98	4	$ 17.50	$ 49.99	$ 12.50
Wabbit	$ 31.95	2	$ 15.98	$ 27.95	$ 13.98
Lenz	$ 74.87	4	$ 18.72	$ 59.95	$ 14.99
RR-Cirkits†	$ 32.25	8	$ 4.03	$ 27.95	$ 3.49
† Not a DCC stationary decoder					

Signal types

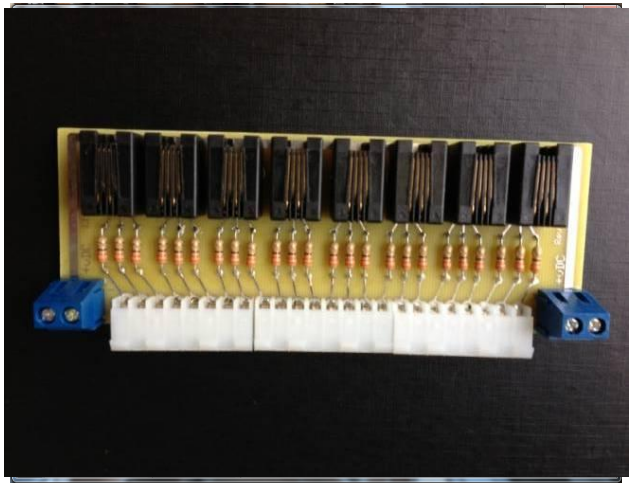
- The module group standard will be the three triangular light G-Type signal with any number of heads. Green on the right.
- However, based upon modeler preference, any physical signal type is acceptable.
- Electrically, we will only support **common anode**, lighting one LED or bulb per output. Common anode B&O or PRR signals are fine. Common cathode signals can be made to work but with considerable effort that will come only from the module owner.
- We are considering and working on approaches to removable plugs. Currently nothing formal to report

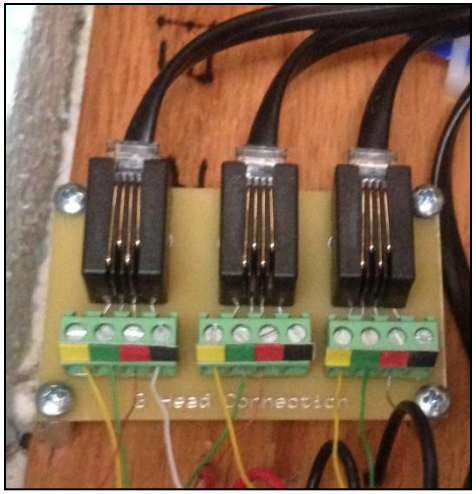
Signal Connections
Work in progress

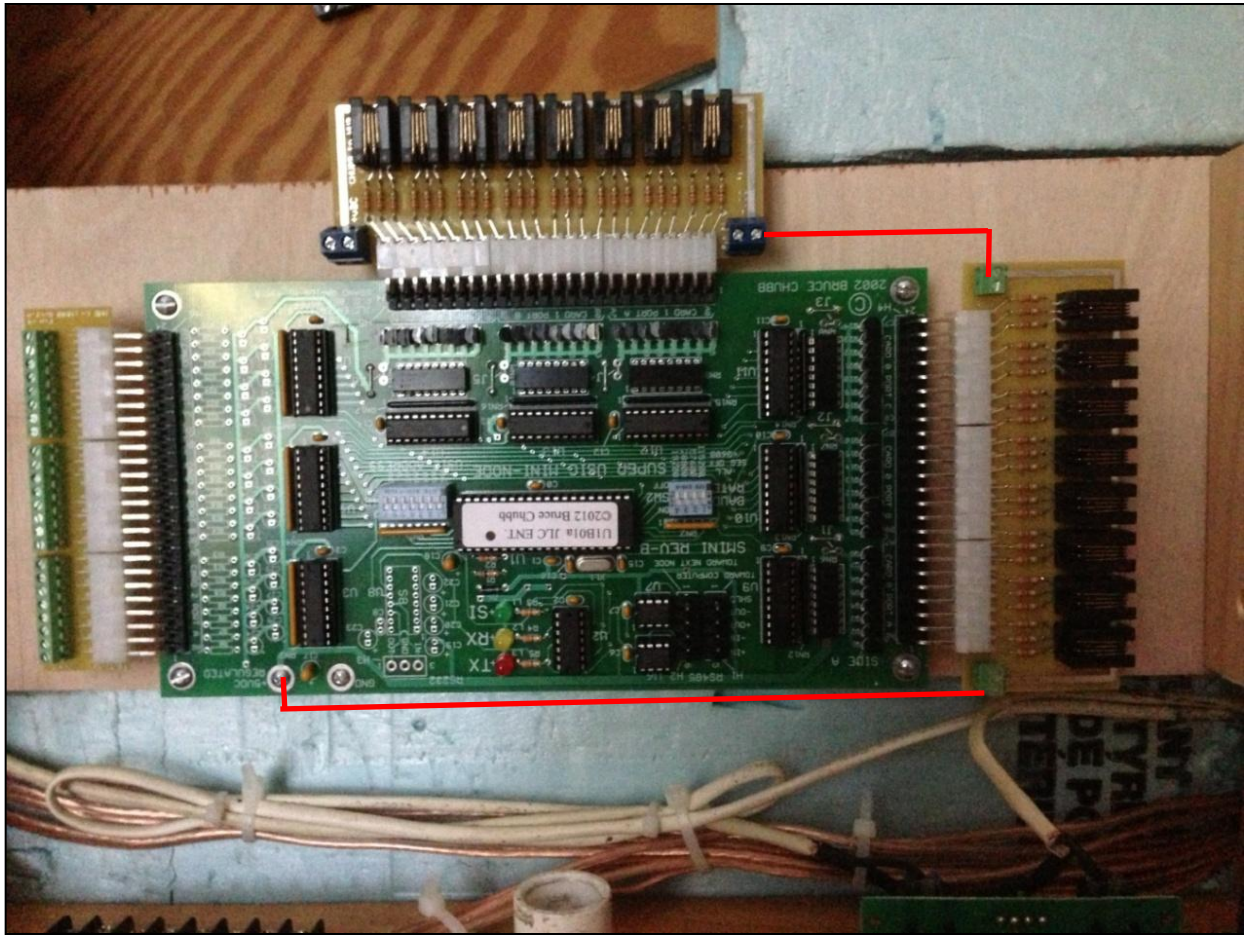




CHUBB to HUB

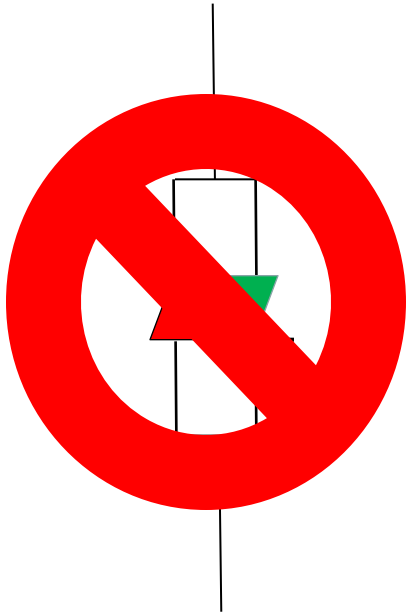




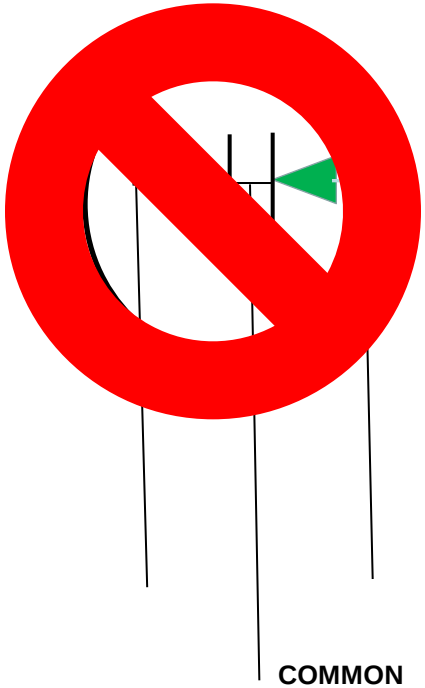


3 Choices for Searchlights

2 lead bipolor LED



3 lead Common Cathode LED



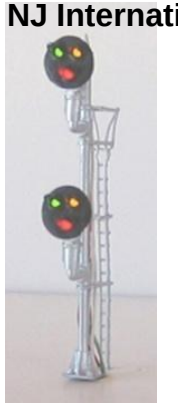
COMMON CATHODE

4 lead Common Anode LED

Commercial Signals

NJ International

#1053
$32.99



#1054
$34.99

#1056
$36.99

Tomar

#H-855
$26.30

#H-865
$49.70

Oregon Rail Supply (KITS)

#116
$11.95

#538
$19.95

Custom Signal Systems

G-Double
$30.00

South Bend

SB-G
$20.00

Custom Signal (Atlas)

Common Cathode

#235
$34.95

#238
$44.95

#239
$44.95

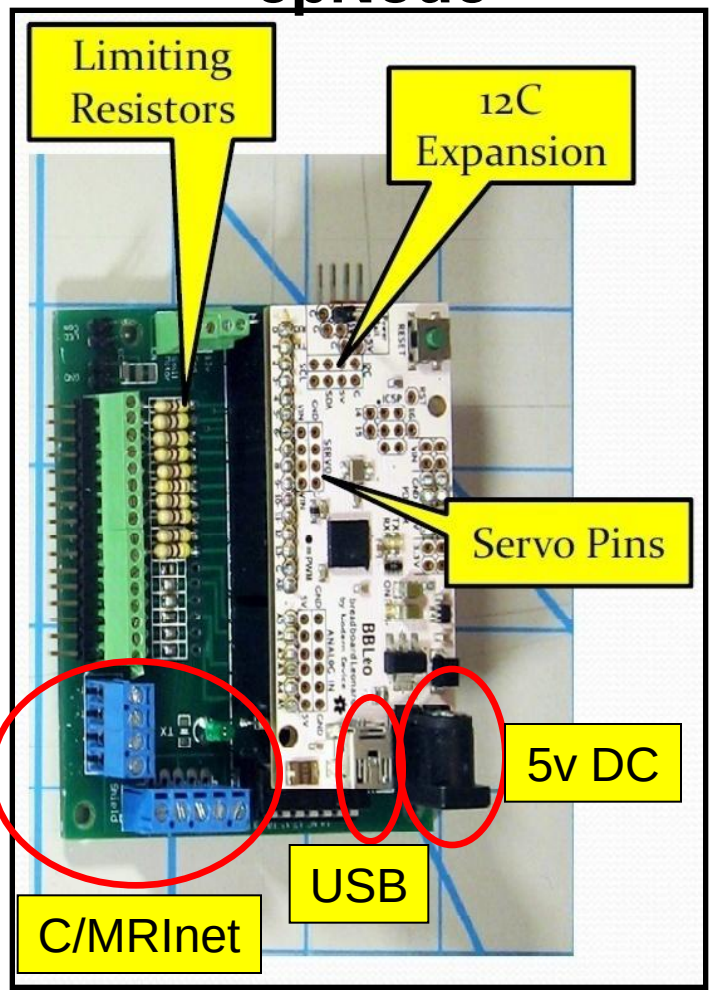
Integrated Signal Systems

Detection – Chubb DCCOD

- How is it powered? 12v unregulated DC
- Does it use transformer coupling? YES
- Is the sensitivity adjustable? YES
- Built-in de-bounce (3.5 sec off, 250 ms on)
- How much resistance in cars? 4700 Ohms
- Fraction of cars with resistors? 100% - 1 Axle
- Low cost source of resisted wheelsets
- C/MRI DCCODs as kits (around $10)

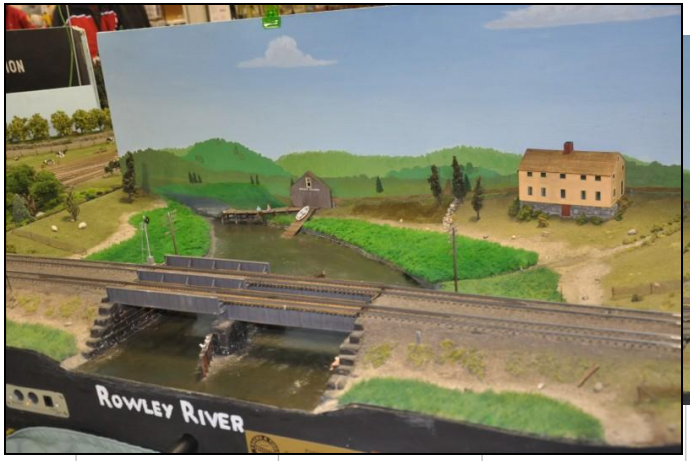
New Kids on the Block

cpNode



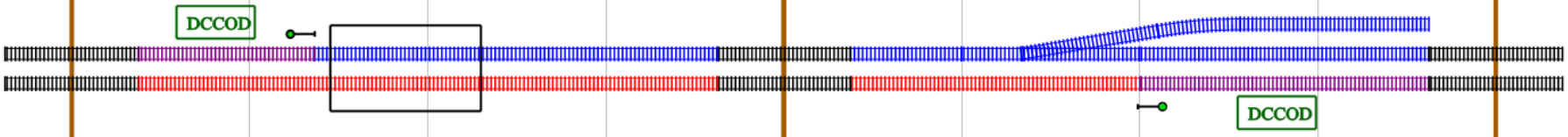
- Arduino based
- 16 Configurable ports
- Configurable node address
- Configurable baud rate
- Behaves like an SMINI
- Small: 3 x 2 ½ inches
- Low cost
- Built-in Turnout control
- Expandable

Straightforward Modules



Requirements: 3 Sensors
6 Outputs

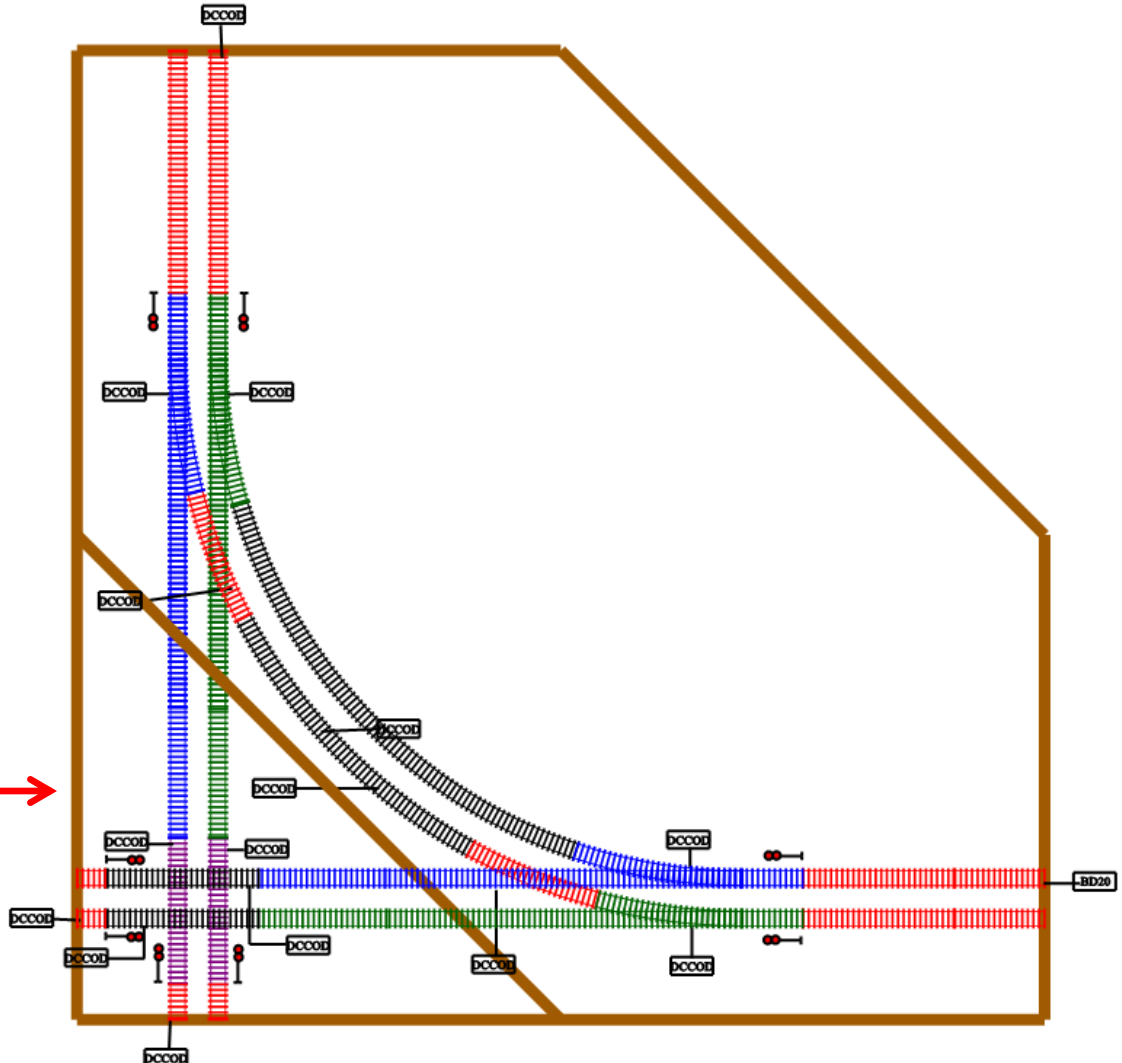
cpNode: 10 outputs, 6 inputs
SMINI: 48 outputs, 24 inputs



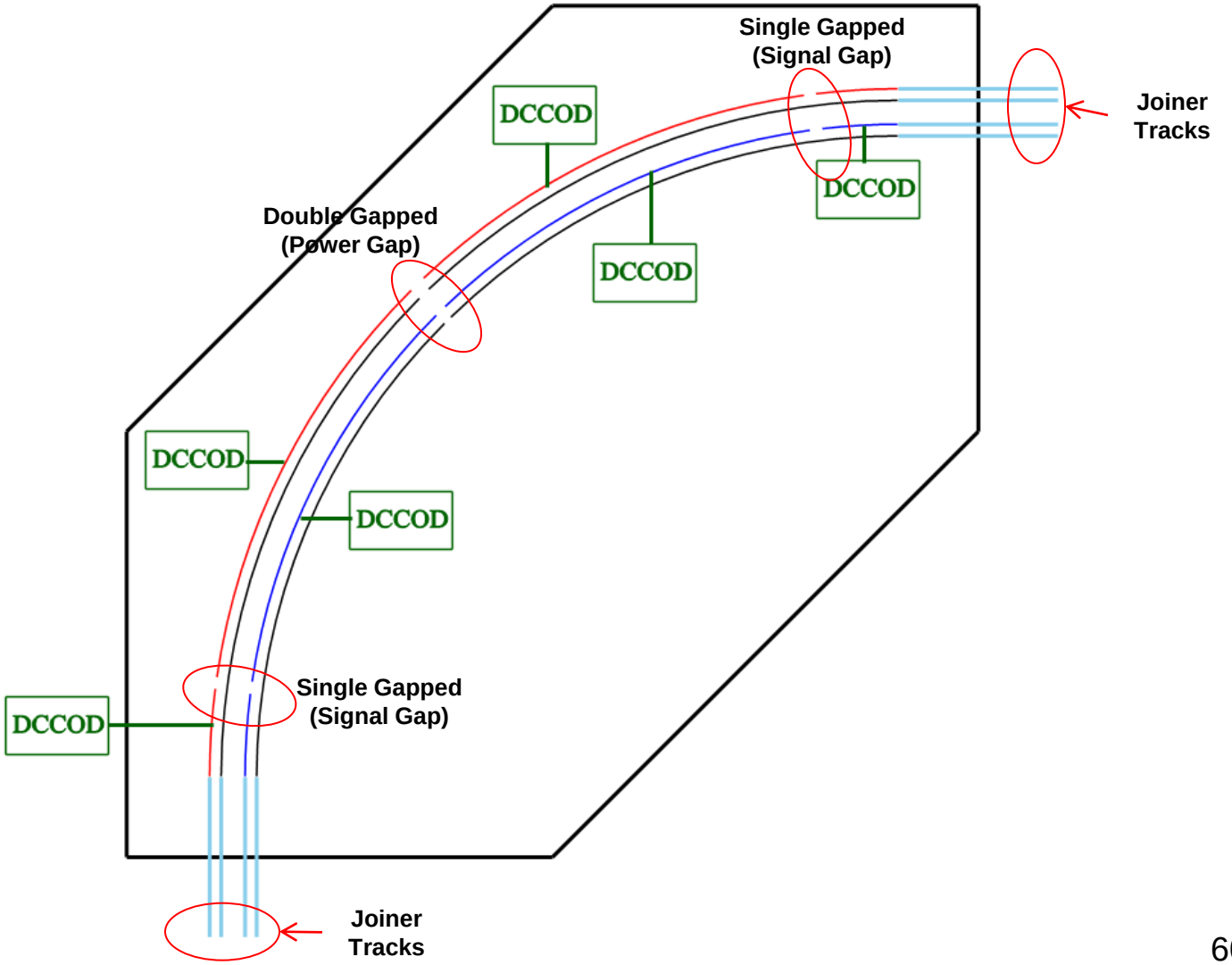
If I Only Had a Few More Pins

cpNode with an IOX16
•6 Sensors (inputs)
•26 Turnouts (outputs)

Requirements:
4 two headed G-type Signals: 24 LEDS
6 DDCODs

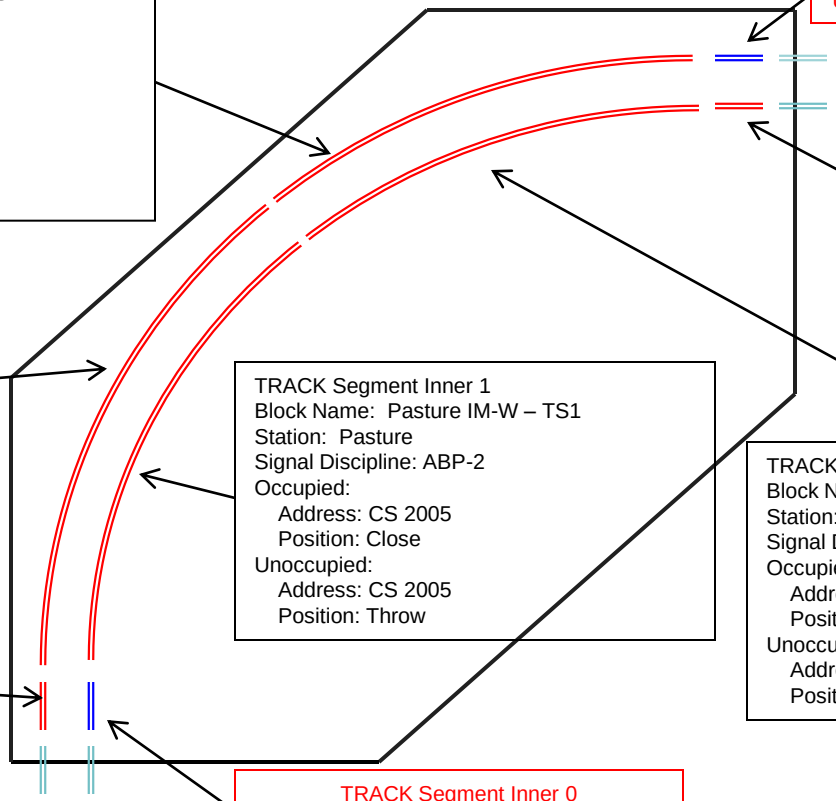


Corner Modules



Pasture (documentation)

Chubb Board Address = 2



TRACK Segment Outer 1
Block Name: Pasture OM-E – TS1
Station: Pasture
Signal Discipline: APB-2
Occupied:
Address: CS 2002
Position: Close
Unoccupied:
Address: CS 2002
Position: Throw

TRACK Segment Outer 0
Undefined Outer Main End Track Segment

TRACK Segment Inner 3 (active East ditzel)
Block Name: Pasture IM-W – TS3
Station: Pasture
Signal Discipline: APB-2
Occupied:
Address: CS 2001
Position: Close
Unoccupied:
Address: CS 2001
Position: Throw

TRACK Segment Outer 2
Block Name: Pasture OM-E – TS2
Station: Pasture
Signal Discipline: APB-2
Occupied:
Address: CS 2004
Position: Close
Unoccupied:
Address: CS 2004
Position: Throw

TRACK Segment Inner 1
Block Name: Pasture IM-W – TS1
Station: Pasture
Signal Discipline: ABP-2
Occupied:
Address: CS 2005
Position: Close
Unoccupied:
Address: CS 2005
Position: Throw

TRACK Segment Inner 2
Block Name: Pasture IM-W – TS2
Station: Pasture
Signal Discipline: APB-2
Occupied:
Address: CS 2003
Position: Close
Unoccupied:
Address: CS 2003
Position: Throw

TRACK Segment Outer 3 (active West ditzel)
Block Name: Pasture OM-E – TS3
Station: Pasture
Signal Discipline: APB-2
Occupied:
Address: CS 2006
Position: Close
Unoccupied:
Address: CS 2006
Position: Throw

TRACK Segment Inner 0
Undefined Inner Main End Track Segment

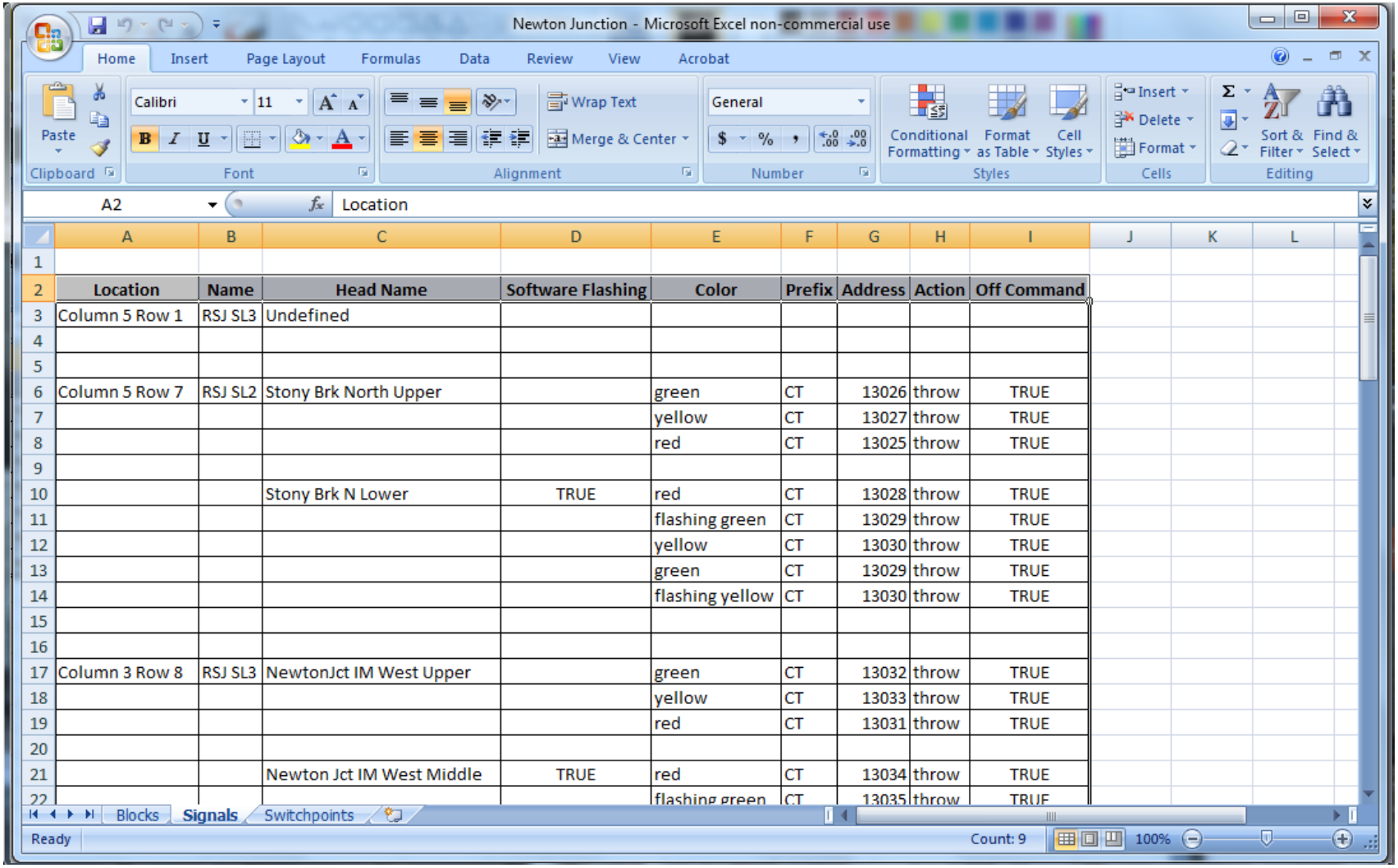
Manual Documentation

HUB CATS File Development Documentation

Upton Yard Signal
Program file
East Module
Signal Block Definitions

Block Definition			Actual Signal Location on Module	Define Signal		Details/Signal Head Definitions				
				Panel Placement						
Block Name	Signal Discipline	Address "CS"		In Tile	Facing	Actual Head	Details	Aspect	Address "CT"	
Upton Yard OME TS2	CTC	7004	Outer Main	Upleft	Left	Top	Head0	Red	7001	
								Yellow	7002	
								Green	7003	Software Flashing
						Middle	Head1	Red	7004	
								Yellow	7005	
								Green	7006	
						Bottom	Head2	Red	7007	
								Yellow	7008	
								Green	7009	
Upton Yard IMW TS1	CTC	7001	Inner Main	Upleft	Left	Top	Head0	Red	7011	
								Yellow	7012	
								Green	7013	Software Flashing
						Middle	Head1	Red	7014	
								Yellow	7015	
								Green	7016	
						Bottom	Head2	Red	7017	
								Yellow	7018	
								Green	7019	
Upton Yard LE TS1	CTC	7011	Local	Upleft	Left	Top	Head0	Red	7021	
								Yellow	7022	
								Green	7023	Software Flashing
						Middle	Head1	Red	7024	
								Yellow	7025	
								Green	7026	
Upton Yard EYL TS3a	CTC	7010	Yard Exit	Rightlow	Bottom	Top	Head0	Red	7027	
								Yellow	7028	
								Green	7029	Software Flashing
						Middle	Head1	Red	7030	
								Yellow	7031	
								Green	7032	
						Bottom	Head2	Red	7033	
								Yellow	7034	
								Green	7035	

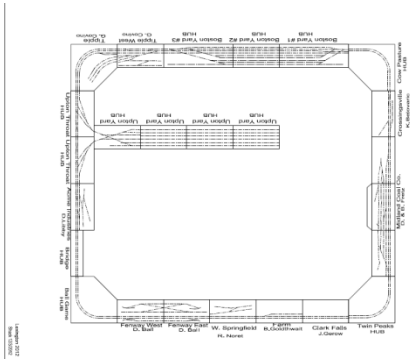
CatNip

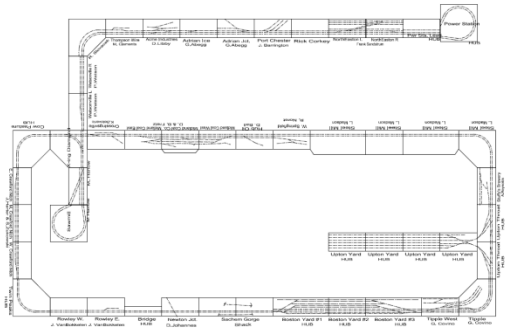


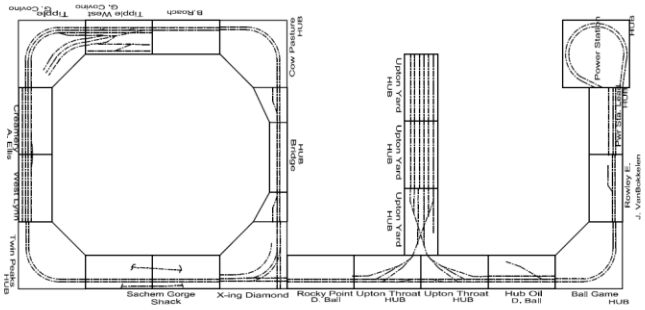
	A	B	C	D	E	F	G	H	I
1									
2	Location	Name	Head Name	Software Flashing	Color	Prefix	Address	Action	Off Command
3	Column 5 Row 1	RSJ SL3	Undefined						
4									
5									
6	Column 5 Row 7	RSJ SL2	Stony Brk North Upper		green	CT	13026	throw	TRUE
7					yellow	CT	13027	throw	TRUE
8					red	CT	13025	throw	TRUE
9									
10			Stony Brk N Lower	TRUE	red	CT	13028	throw	TRUE
11					flashing green	CT	13029	throw	TRUE
12					yellow	CT	13030	throw	TRUE
13					green	CT	13029	throw	TRUE
14					flashing yellow	CT	13030	throw	TRUE
15									
16									
17	Column 3 Row 8	RSJ SL3	NewtonJct IM West Upper		green	CT	13032	throw	TRUE
18					yellow	CT	13033	throw	TRUE
19					red	CT	13031	throw	TRUE
20									
21			Newton Jct IM West Middle	TRUE	red	CT	13034	throw	TRUE
22					flashing green	CT	13035	throw	TRUE

New Challenges

- Detection sensitivity
- Compatibility with other modular groups
- Approaches to removable signals
- Track complexity
  - Wiring track power
  - The bridge module has become the “draw bridge” module
  - Linearize the signal bus

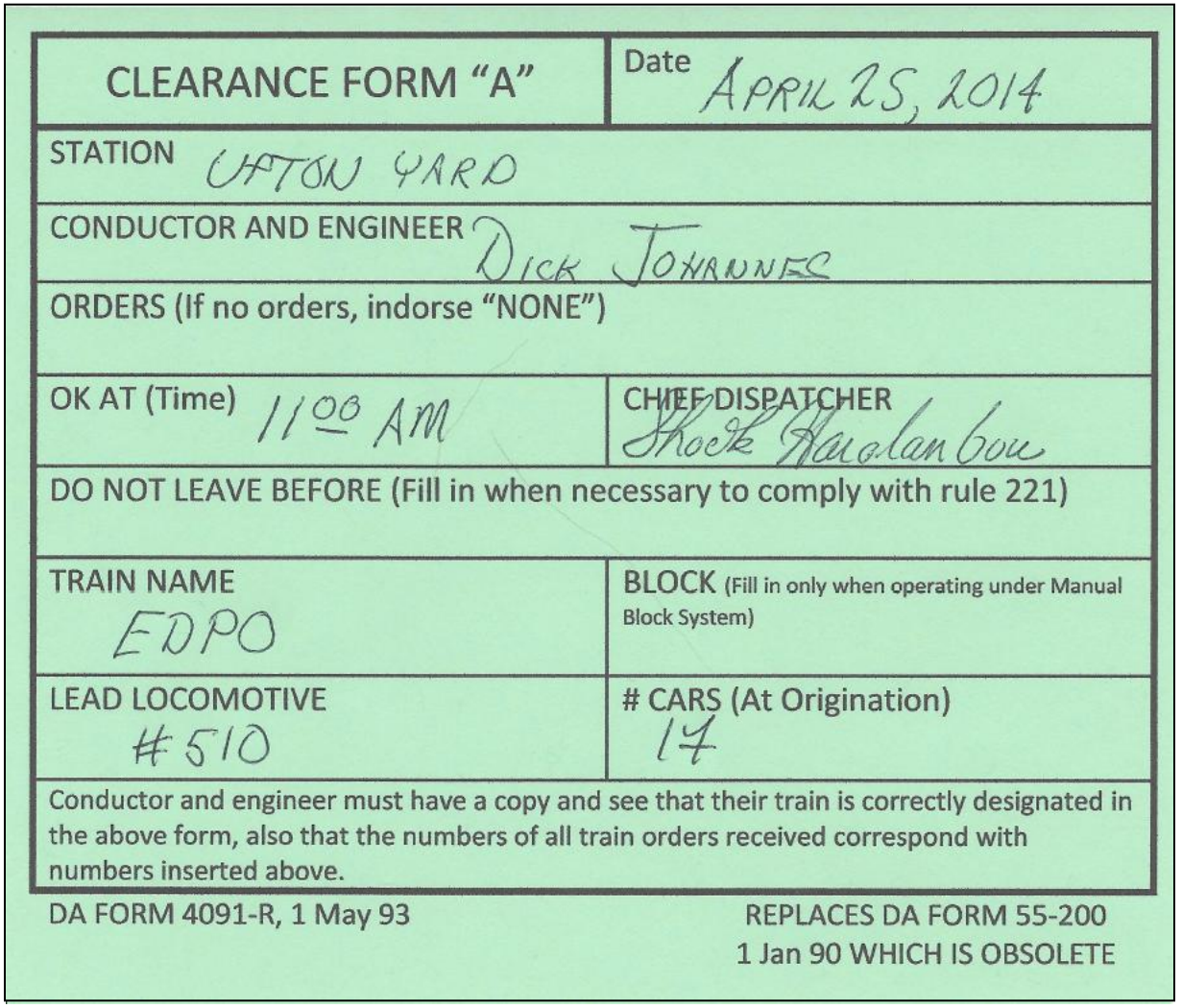






Clearance Form "A"

- **This is the form that makes a train a train**
- **We use it to fill in the needed info for train tracking**



CLEARANCE FORM "A"	Date APRIL 25, 2014
STATION UFTON YARD	
CONDUCTOR AND ENGINEER DICK JOHANNES	
ORDERS (If no orders, indorse "NONE")	
OK AT (Time) 1100 AM	CHIEF DISPATCHER Rock Haralambou
DO NOT LEAVE BEFORE (Fill in when necessary to comply with rule 221)	
TRAIN NAME EDPO	BLOCK (Fill in only when operating under Manual Block System)
LEAD LOCOMOTIVE #510	# CARS (At Origination) 17
Conductor and engineer must have a copy and see that their train is correctly designated in the above form, also that the numbers of all train orders received correspond with numbers inserted above.	

DA FORM 4091-R, 1 May 93

REPLACES DA FORM 55-200
1 Jan 90 WHICH IS OBSOLETE

Architecture

WiThrottle and Engine Commander

JMRI & CATS

WIFI

WIFI

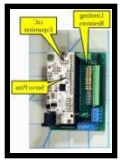
Lenz LAN/USB

XpressNet

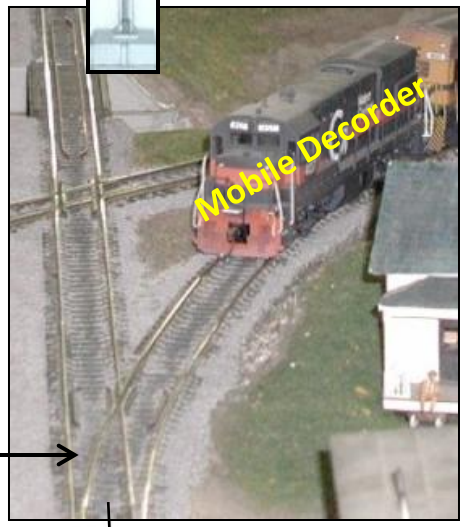
RS 485 Cable

C/MRI Outputs

Command Station



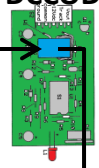
C/MRI Net



Mobile Decorder

Booster 1

DCCOD



Occupancy Feedback

DCC Track Power

Booster 2

DCC Accessory Power

Stationary Decoder

Point Feedback

Turnout Motor

Summary

- Signaling a modular layouts can be done without constraining either the sequence of modules or limiting the function of the signaling system
- Can run with or without a dispatcher
- Pre-setup: Create linear list of modules “importing” the layout plan for that particular setup into CATS
- Setup = 1) Link the physical modules 2) Load the CATS equivalent 3) Run
- HUB modular railroad uses:
  1. Lenz DCC with a LAN-USB connection
  2. C/MRI SMINI boards + (cpNodes & SMicros)
  3. C/MRI DCCOD occupancy detectors
  4. JMRI & CATS software

References (Books)

- *Railroad Signaling*. Brian Soloman, MBI Publishing 2003.
- *How to operate your model railroad*. Bruce A Chubb, 2nd Edition, Kalmbach, 1977.
- *Realistic Model Railroad Operation*. Tony Koester. Kalmbach 2003.
- *The Model Railroaders Guide to Junctions*. Jeff Wilson. Kalmbach 2006.
- Railroader's C/MRI Applications Handbook V3.0 (Volumes 1,2,&3 Especially Vol 2). Bruce Chubb. Available through JLC Enterprises.
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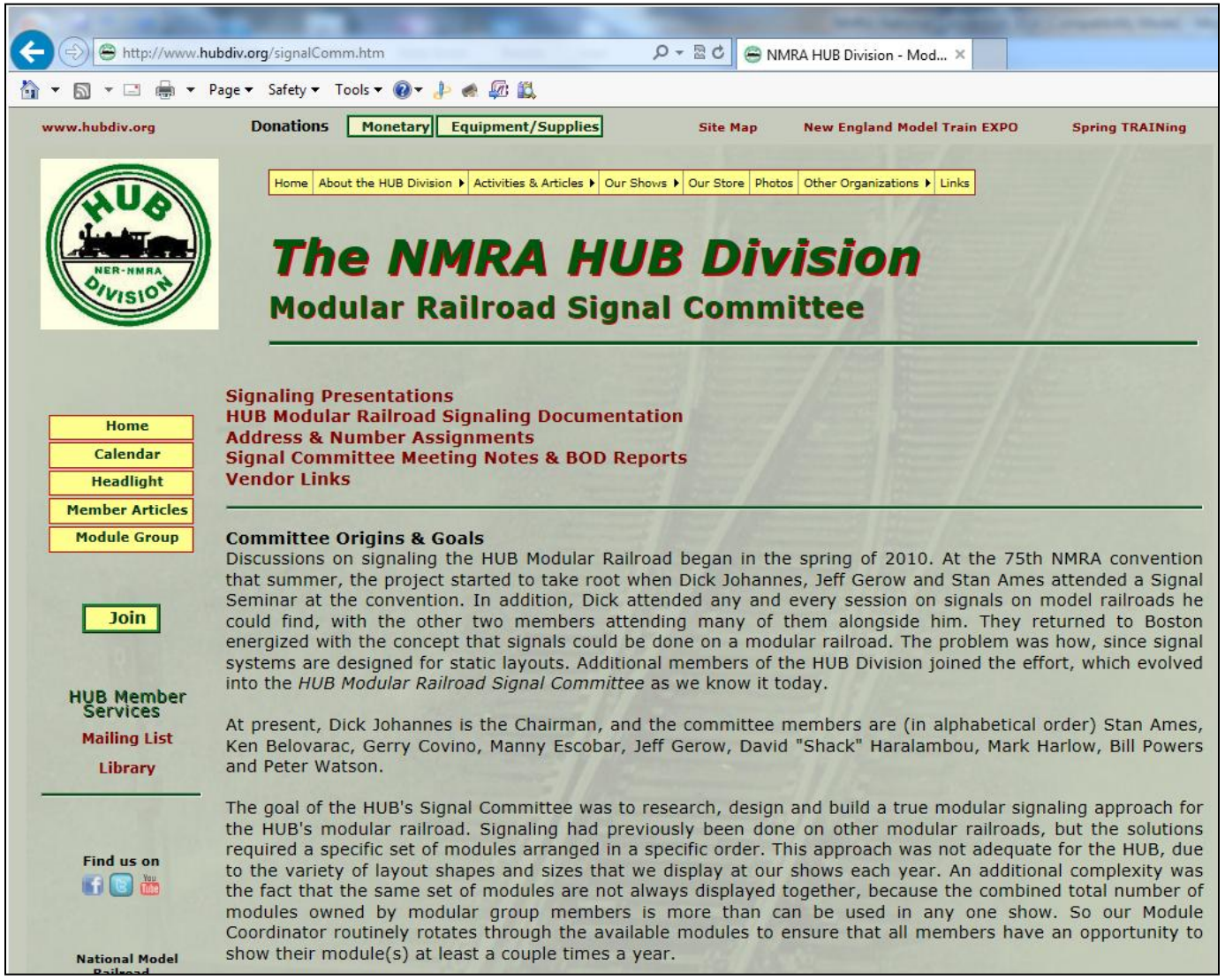

THANK YOU!

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