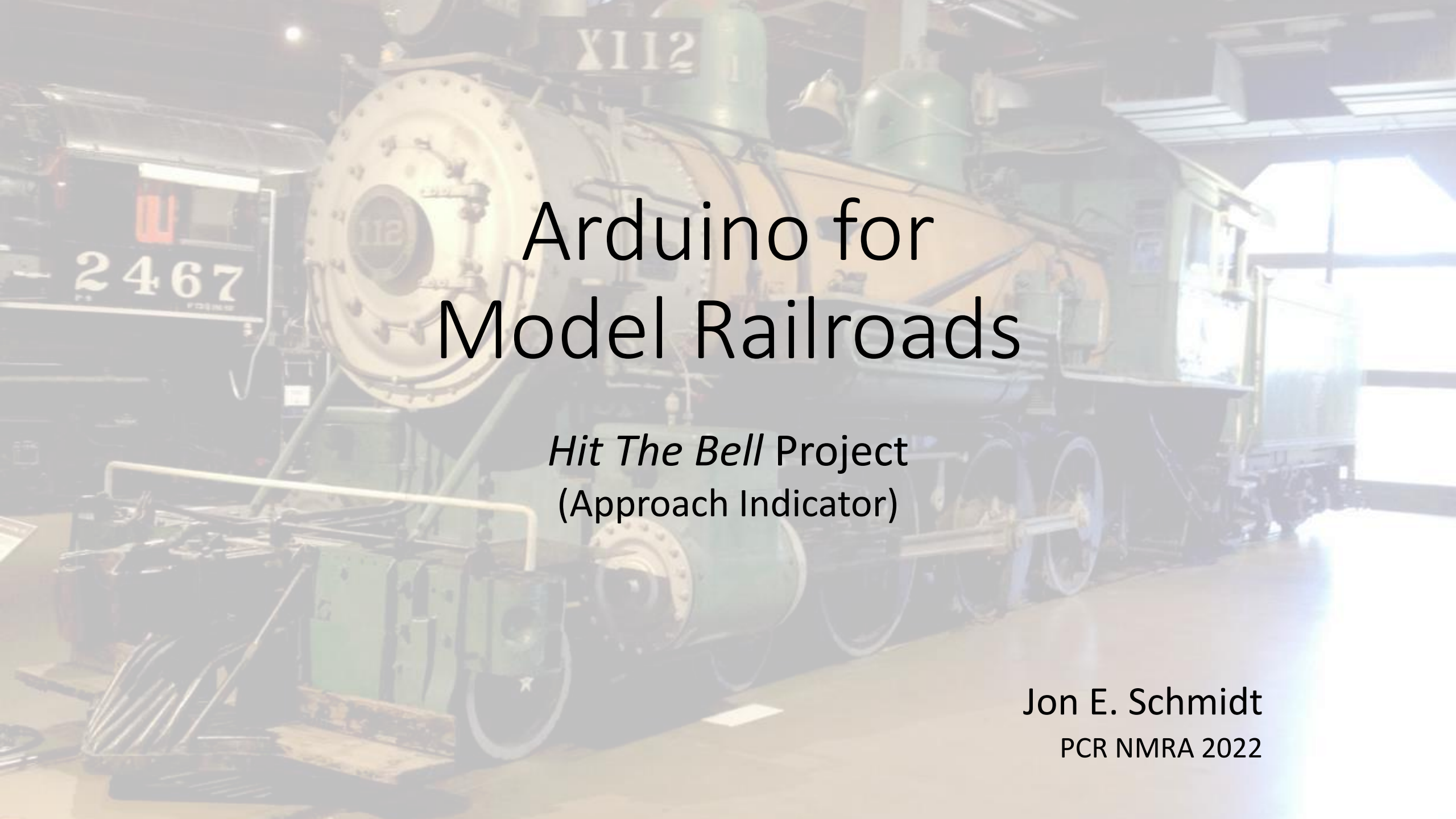


Arduino for Model Railroads

Hit The Bell Project
(Approach Indicator)

Jon E. Schmidt
PCR NMRA 2022

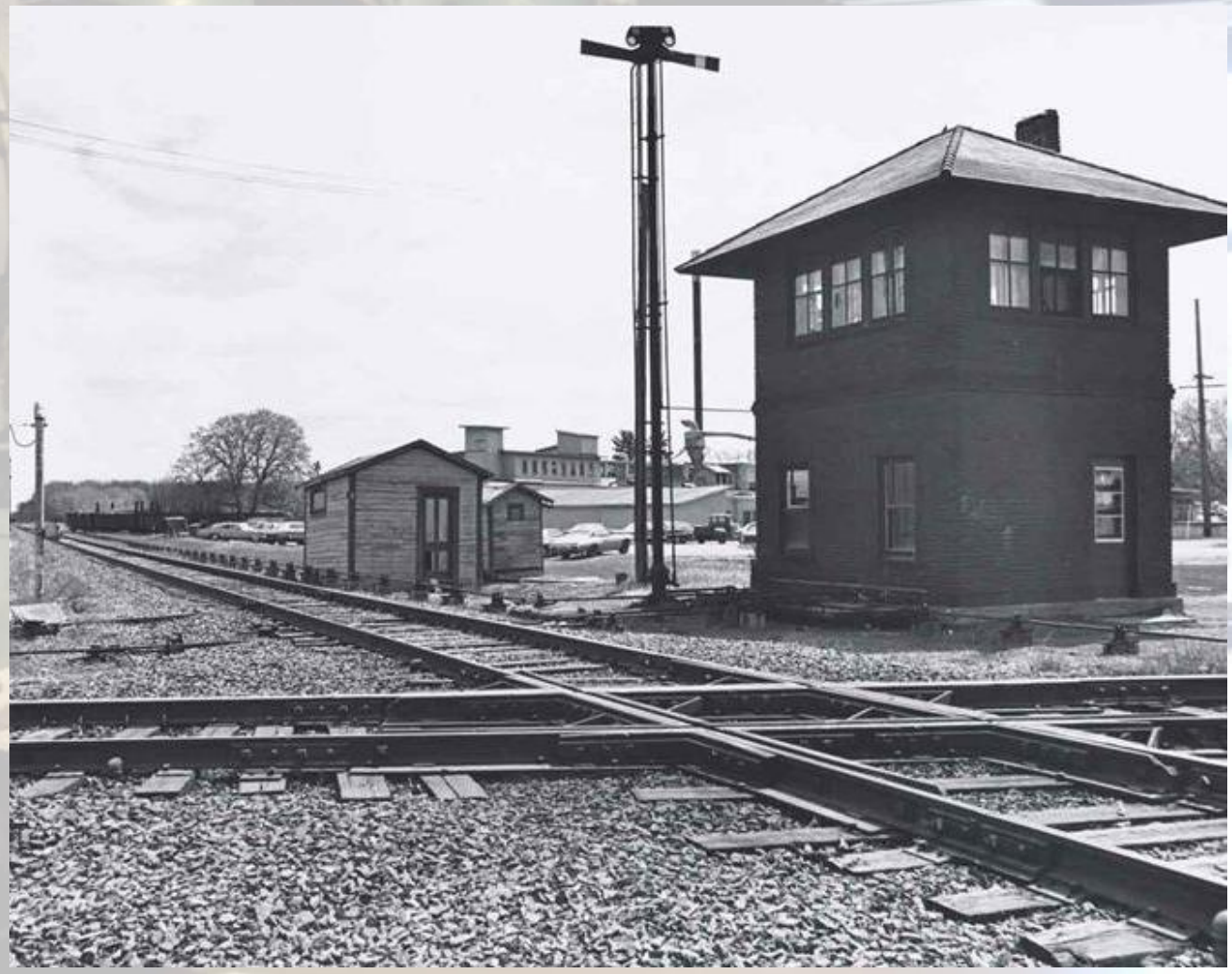
Hit The Bell

Railroad towers were control centers for a crossing or complex trackwork.

The operators were responsible for talking with the dispatcher, delivering orders to trains, setting signals, and setting routes.

The tower controls had a way to alert the operator that a train was approaching, i.e. a bell.

A train would actuate a track circuit which would ring a bell in the tower: Hence “hit the bell.”

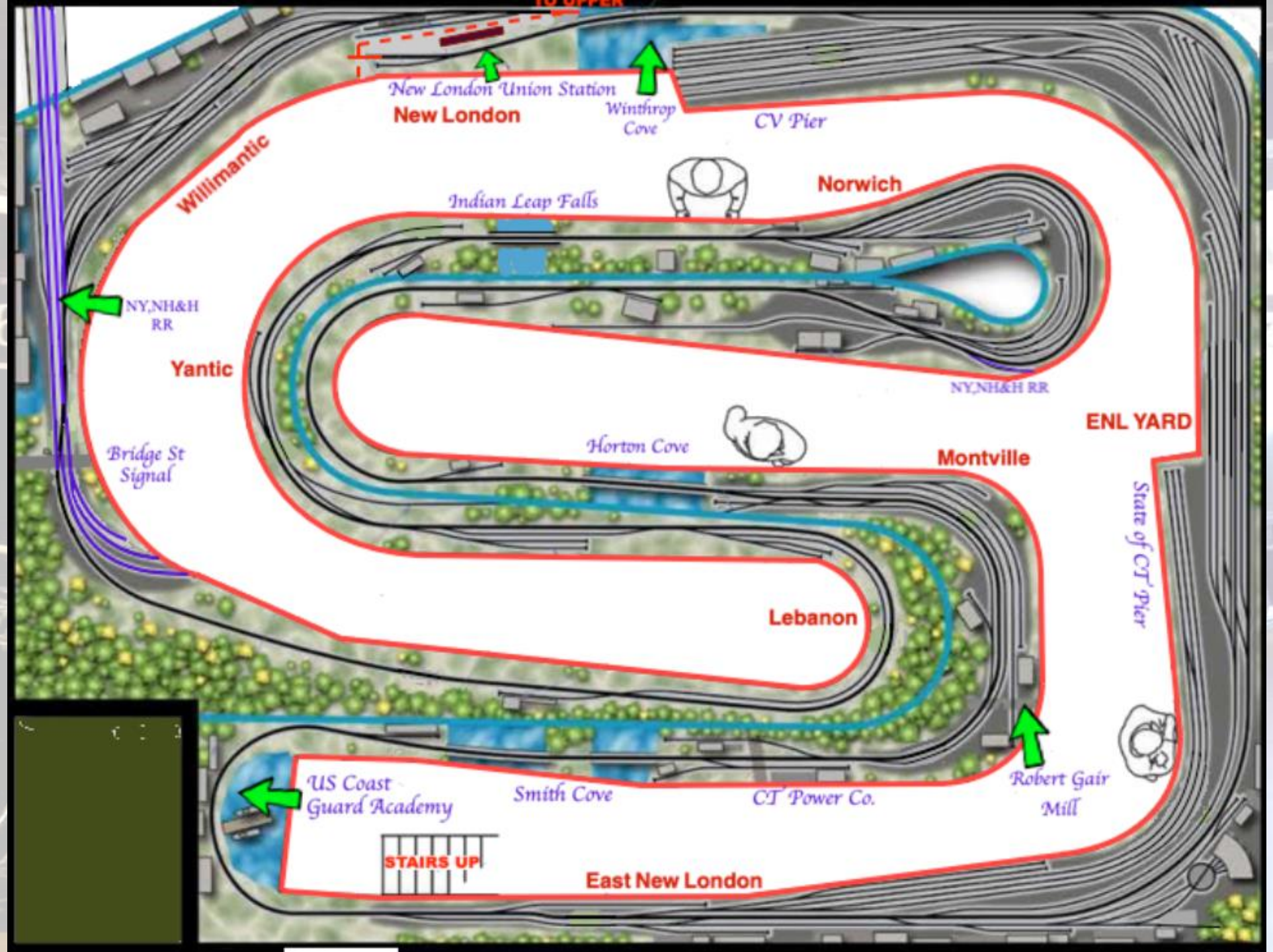


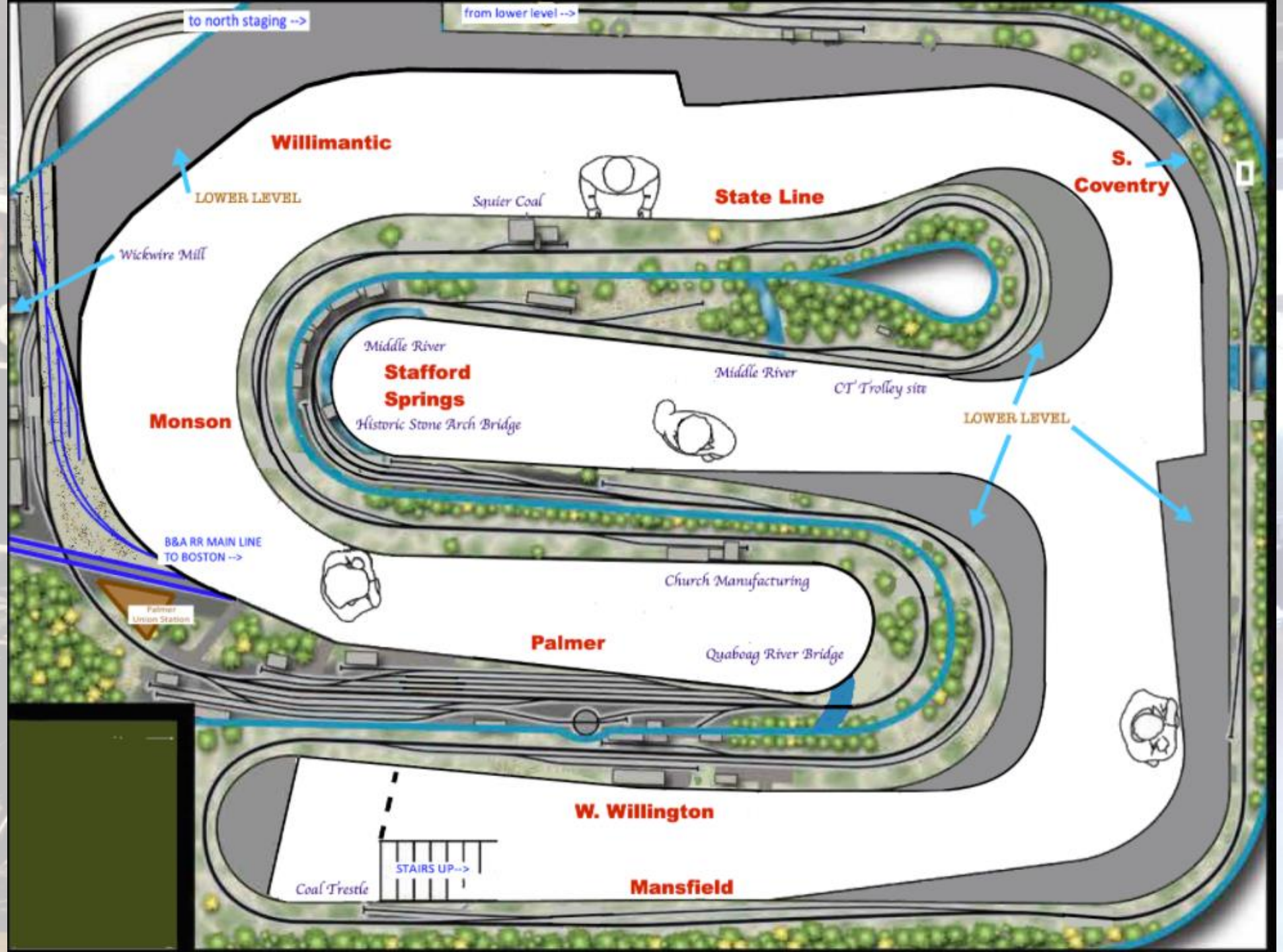
The Central Vermont in NorCal

- Time warp: 1956
- Modeling 1956 when railroad still had towers and steam and diesel.
- CV is a large HO model in a 30’ by 40’ building.
- Model represents the CV from New London, CT to Brattleboro, VT
- Dispatching was by timetable and train order. (TT&TO).
- Requires agent-operators to copy and deliver train orders.
- Dispatcher is remotely located.
- There are two agent offices underneath the railroad. One covers the south towns, the other north towns.

Central Vermont Railway (the real one)

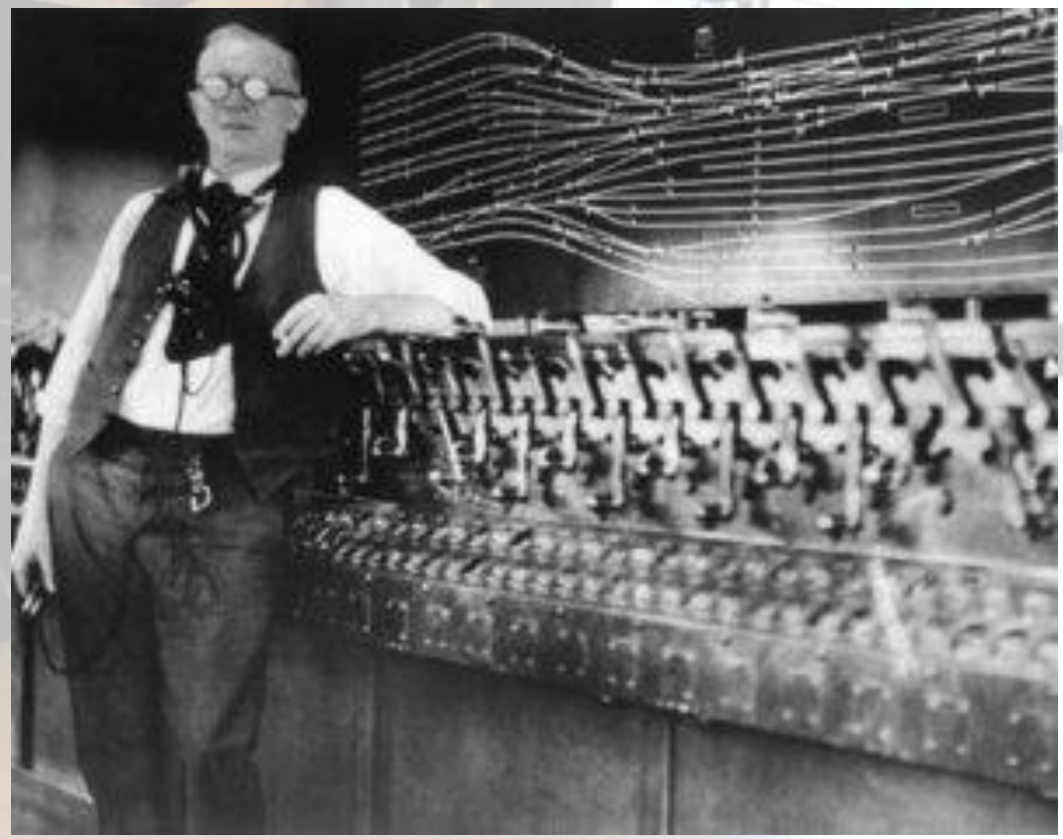
- Train order towns with agent-operators:
  - East New London
  - Montville
  - Norwich
  - Yantic
  - Lebanon
  - Willimantic
  - Mansfield
  - Stafford Springs
  - Palmer

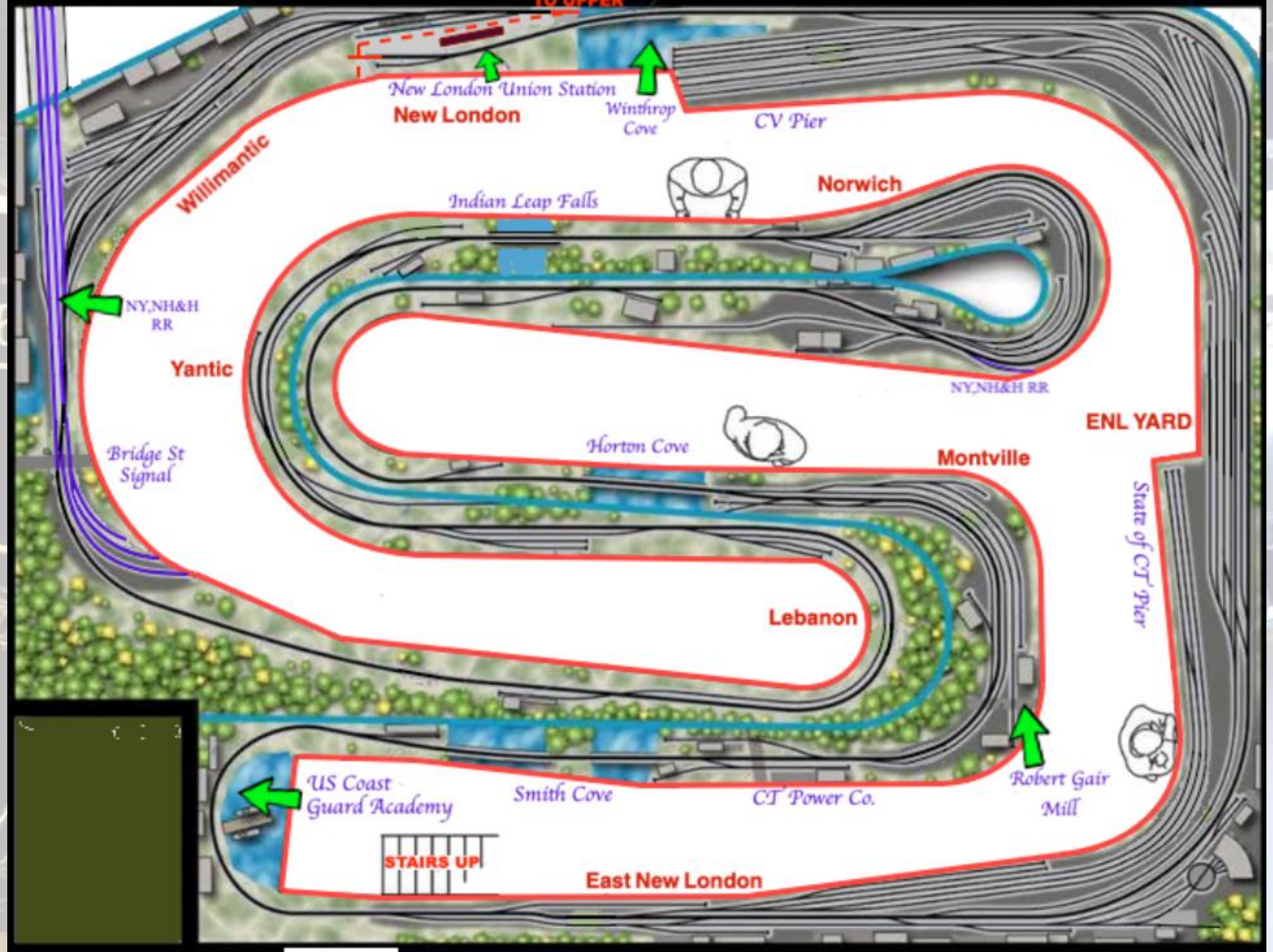

New London Union Station
New London
Winthrop Cove
CV Pier
Willimantic
Indian Leap Falls
Norwich
NY,NH&H RR
Yantic
NY,NH&H RR
ENL YARD
Horton Cove
Bridge St Signal
Montville
State of CT Pier
Lebanon
US Coast Guard Academy
Smith Cove
CT Power Co.
Robert Gair Mill
STAIRS UP
East New London


to north staging -->
from lower level -->
Willimantic
LOWER LEVEL
Squier Coal
State Line
S. Coventry
Wickwire Mill
Middle River
Stafford Springs
Middle River
CT Trolley site
Monson
Historic Stone Arch Bridge
LOWER LEVEL
B&A RR MAIN LINE TO BOSTON -->
Church Manufacturing
Palmer Union Station
Palmer
Quaboag River Bridge
W. Willington
STAIRS UP-->
Coal Trestle
Mansfield

Agent Offices

- Underneath the railroad at Montville and Yantic
- No direct view of the trackage
  - Closed-circuit TV
- Open to train level for passing orders
- Phones to communicate to
  - Dispatcher
  - Crews




New London Union Station
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Horton Cove
Bridge St Signal
Montville
State of CT Pier
Lebanon
US Coast Guard Academy
Smith Cove
CT Power Co.
Robert Gair Mill
STAIRS UP
East New London

Agent Offices: Palmer - Montville

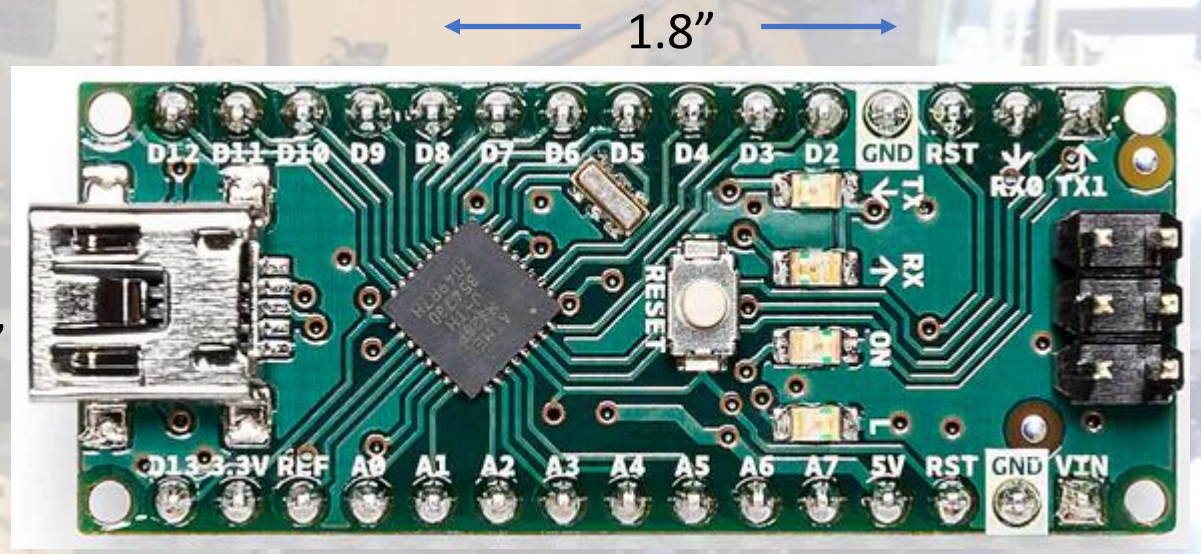
Hit The Bell

- We needed a way to detect and announce the approach of a train
  - Ignore when a train leaves the area
- Directional approach detection requires two sensors – distant and home – at both north and south approaches
- Decided on a software-based approach – I'm not a hardware guy
- Arduino seemed ideal – but I knew nothing about it
  - I taught myself Arduino

1974

Arduino Nano

- Computer on a board
- Fully programmable – C++
- 8 Analog ports
  - For light-sensitive resistors
- 11 Digital ports
  - For detection such as infrared
  - For output to ring the bell
- Small: 0.7x1.8 inches
- 5 Volt DC required
- Generally available for $10



Arduino

"Open-source" hardware

Many versions of the hardware

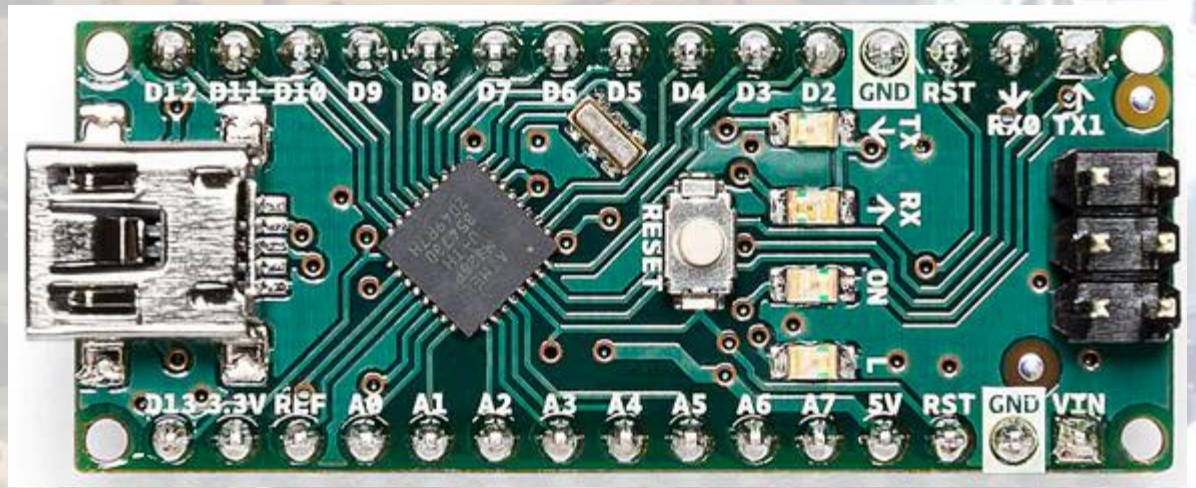
Speed, memory size, number and types of analog/digital ports

"Shields" – boards to complement the Arduino with special function

Wifi – Ethernet – other

Arduino IDE – Integrated Development Environment – on your computer

"Sketch" = program

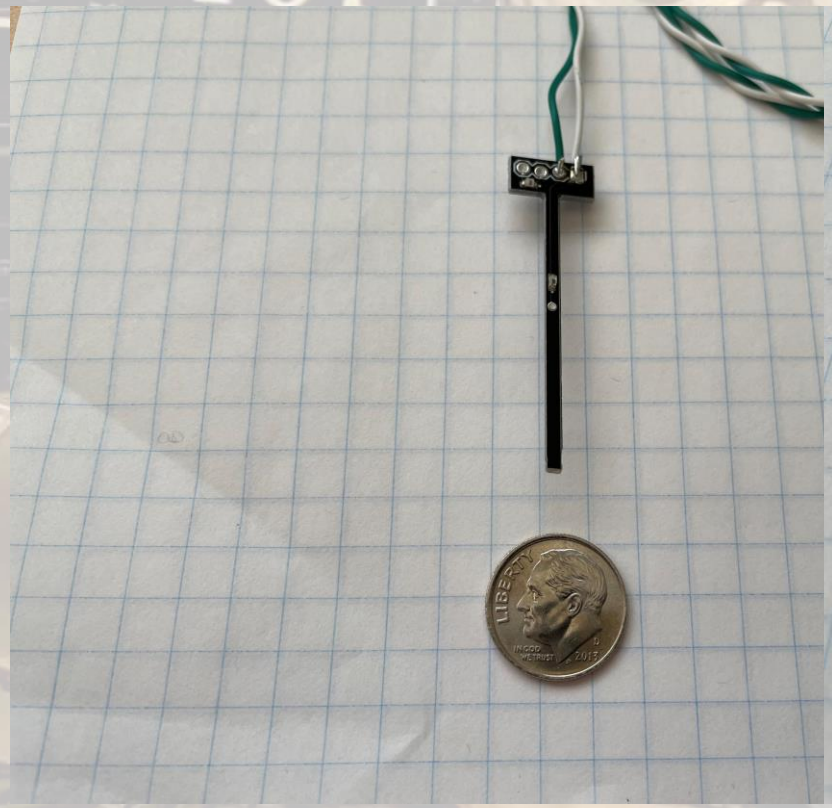


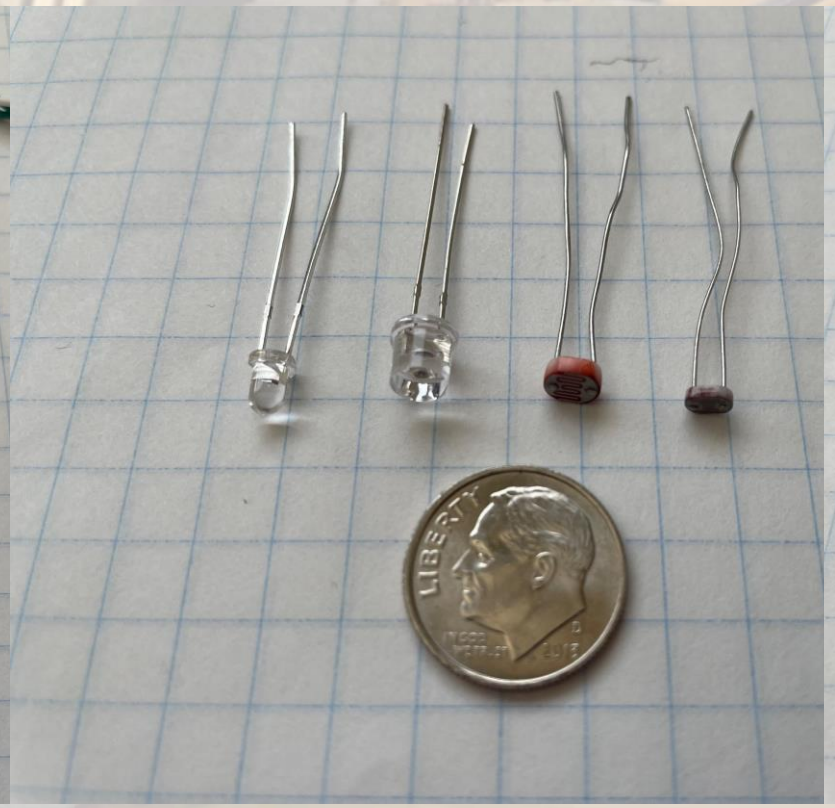
Hit the Bell Design Criteria

- Create something useful for the *community*
- Allow *either* optical sensors or digital sensors, or both
  - Mix and match
  - Photo resistor/photo diode/photo transistor
- Lighting levels change – sunbeams move
  - Auto-calibration of the optical sensors
    - Eliminate need for pot tweaking or 2nd reference sensors
    - Automatic readjust for change in room lighting
- Easy installation & configuration
  - Standard flexible design
  - *Easy* software configuration

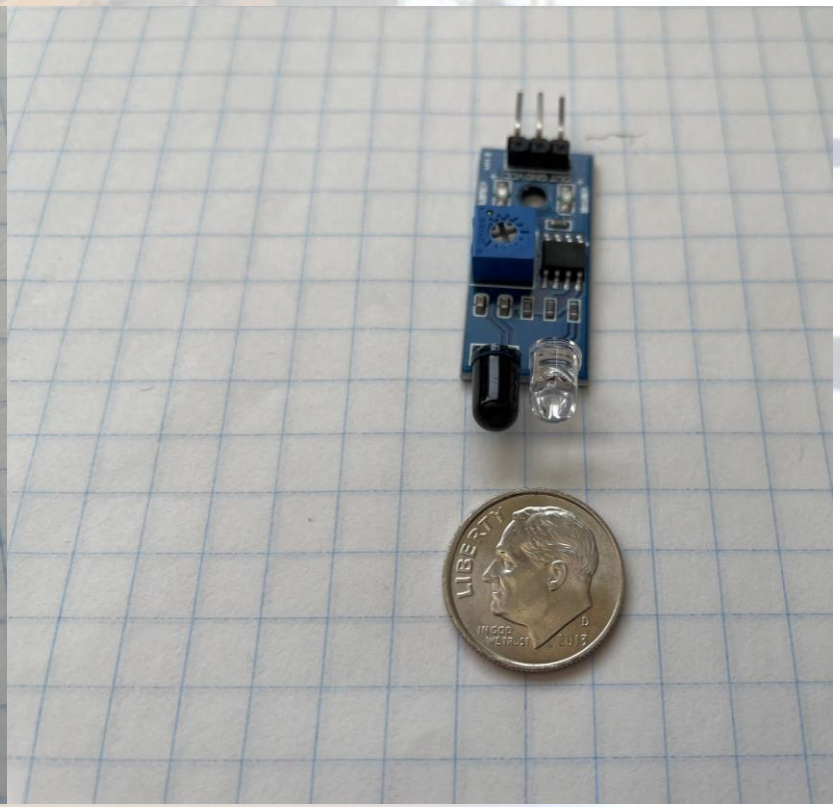
Hit the Bell - Sensors

Optical Analog (Photo[Diode/Resistor])





Digital (Infrared)



Learning Arduino

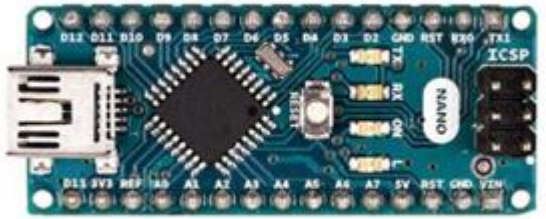
- Picked up a starter kit – Arduino Uno
- Started working my way through the tutorials
- Breadboarded many projects – got a feel for how things played and worked together
- Used my laptop & Arduino IDE to program
  - I have a programming background – C++ for Arduino very familiar
- Started to breadboard my project
- It worked!

Working with Arduino

- Breadboarding was fun – got to try ideas and test
- Also got to test out a *full* configuration of four stations
  - Analog + digital sensors
- Tested multiple types of analog sensors
  - Confirmed that my auto-calibrate code worked with all types
- Designed a Nano-based board

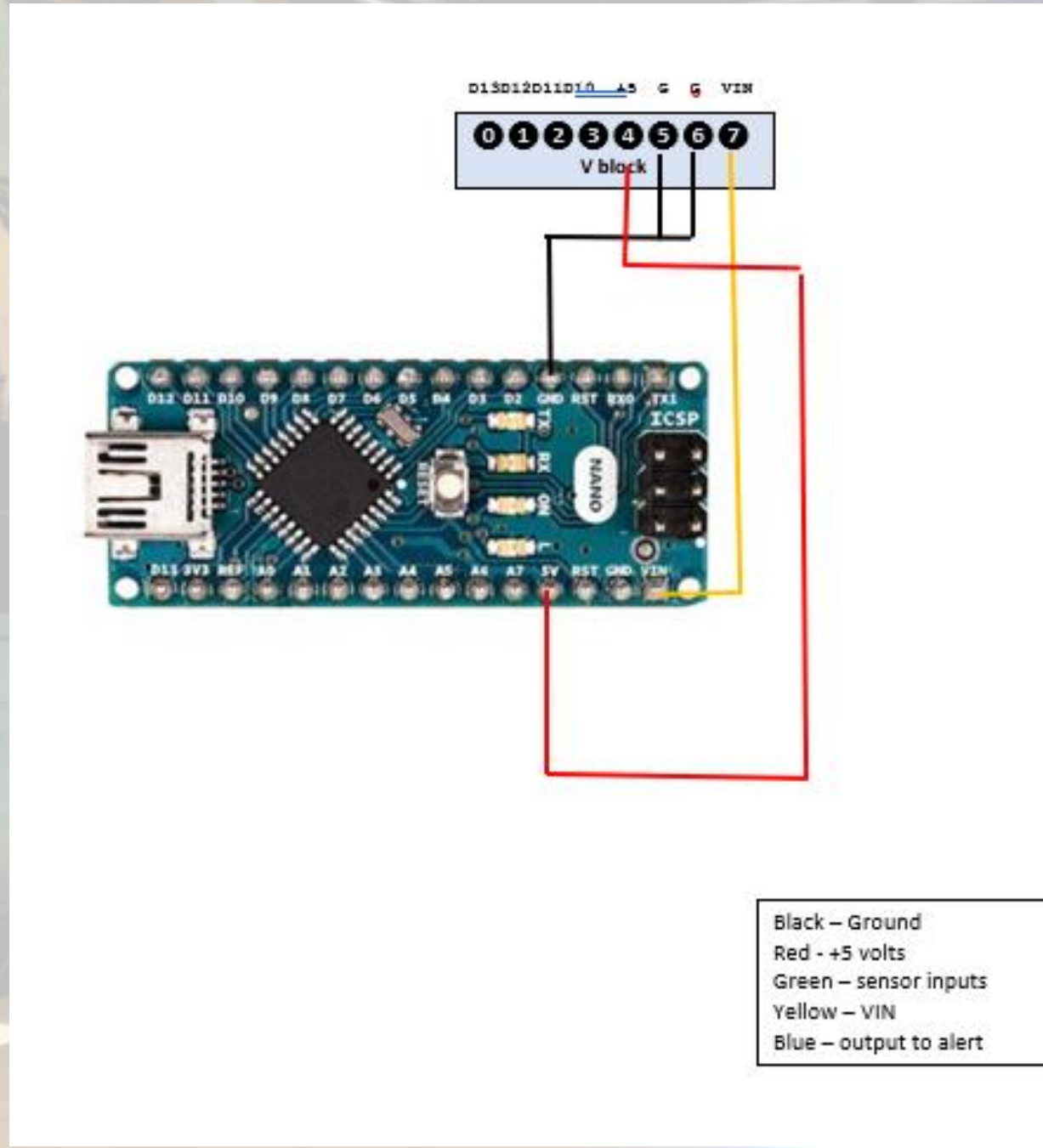
Nano Circuit Diagram

Bare Nano



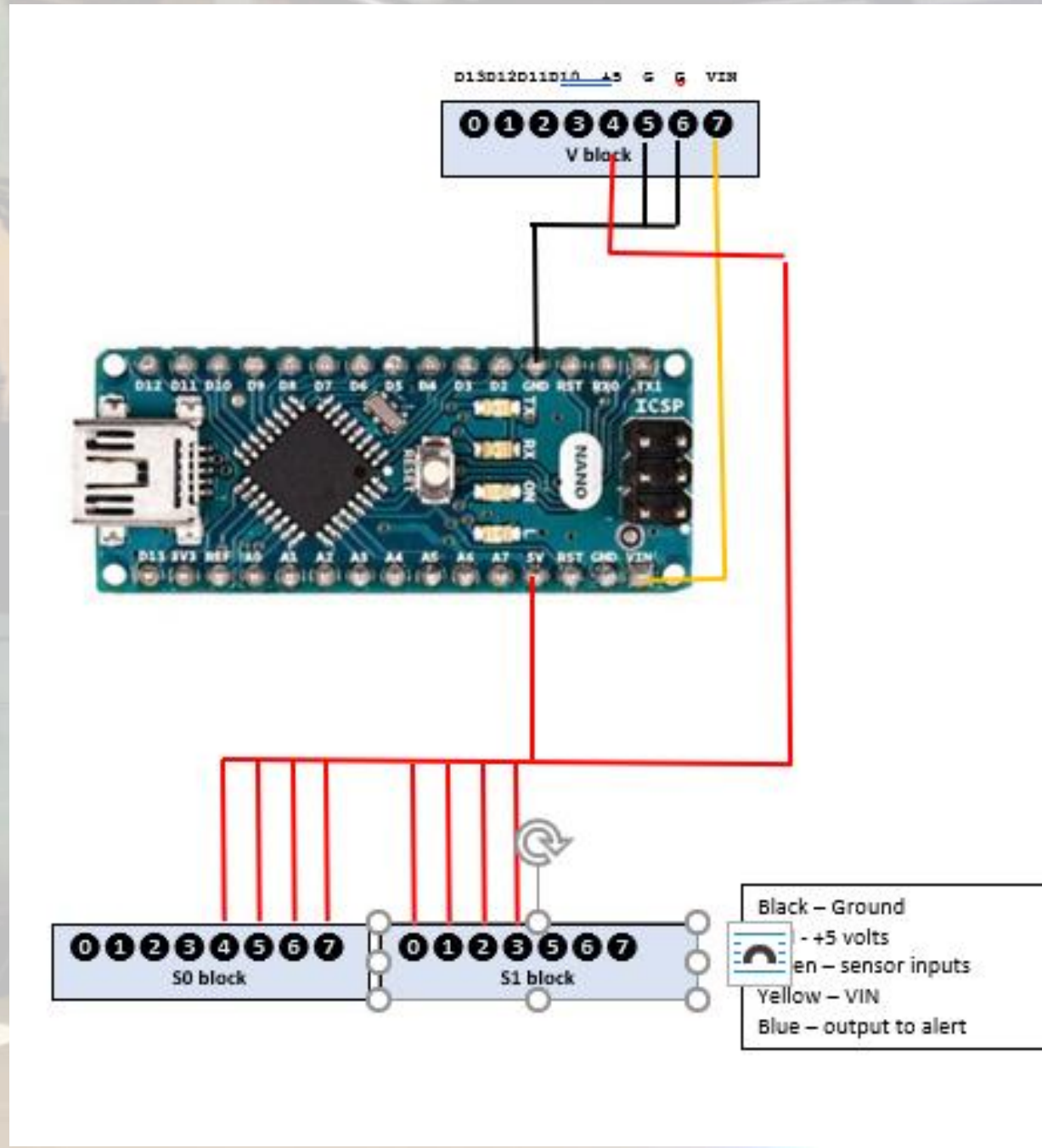
Nano Circuit Diagram

Add power



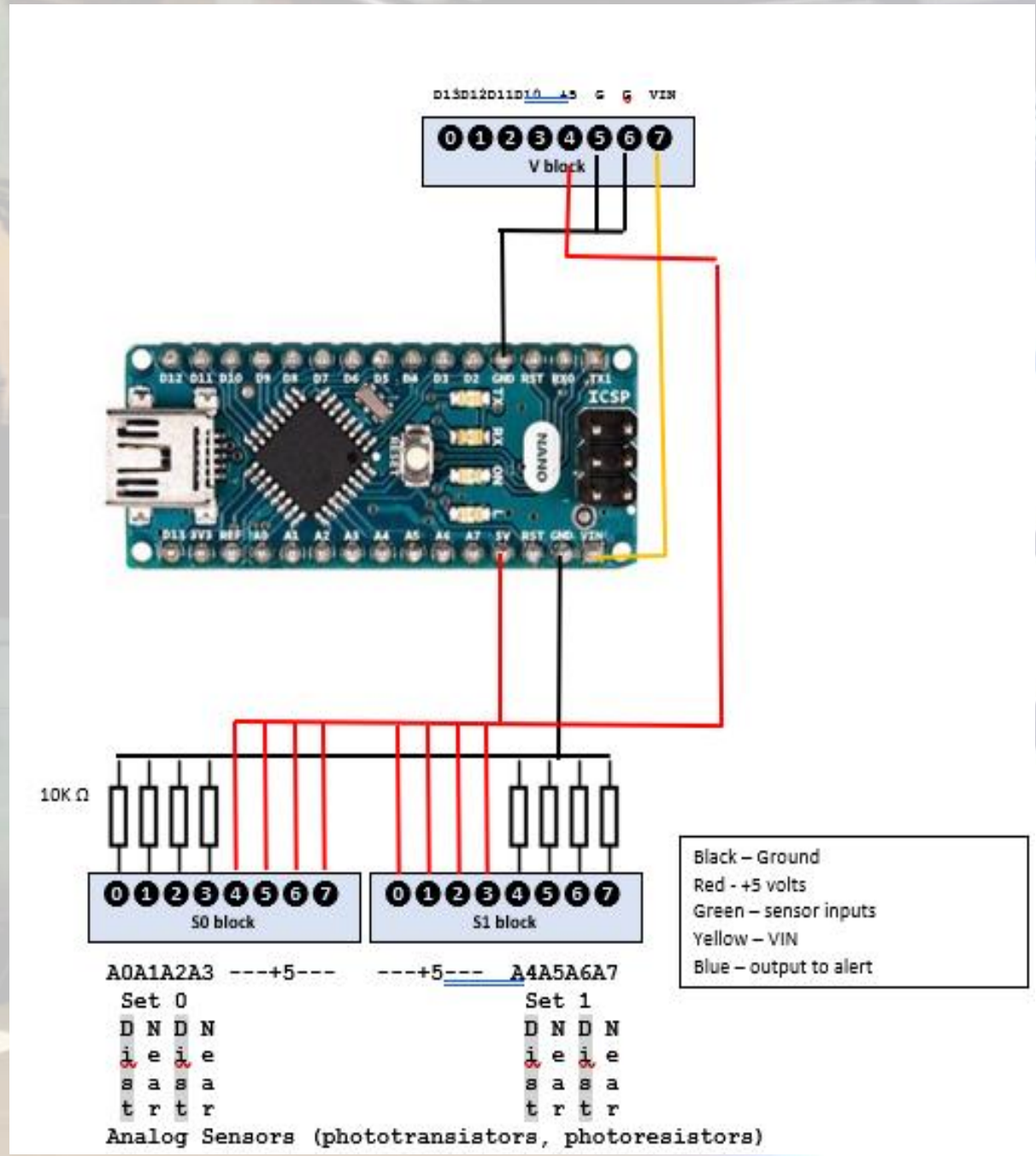
Nano Circuit Diagram

Send power to analog sensor terminals



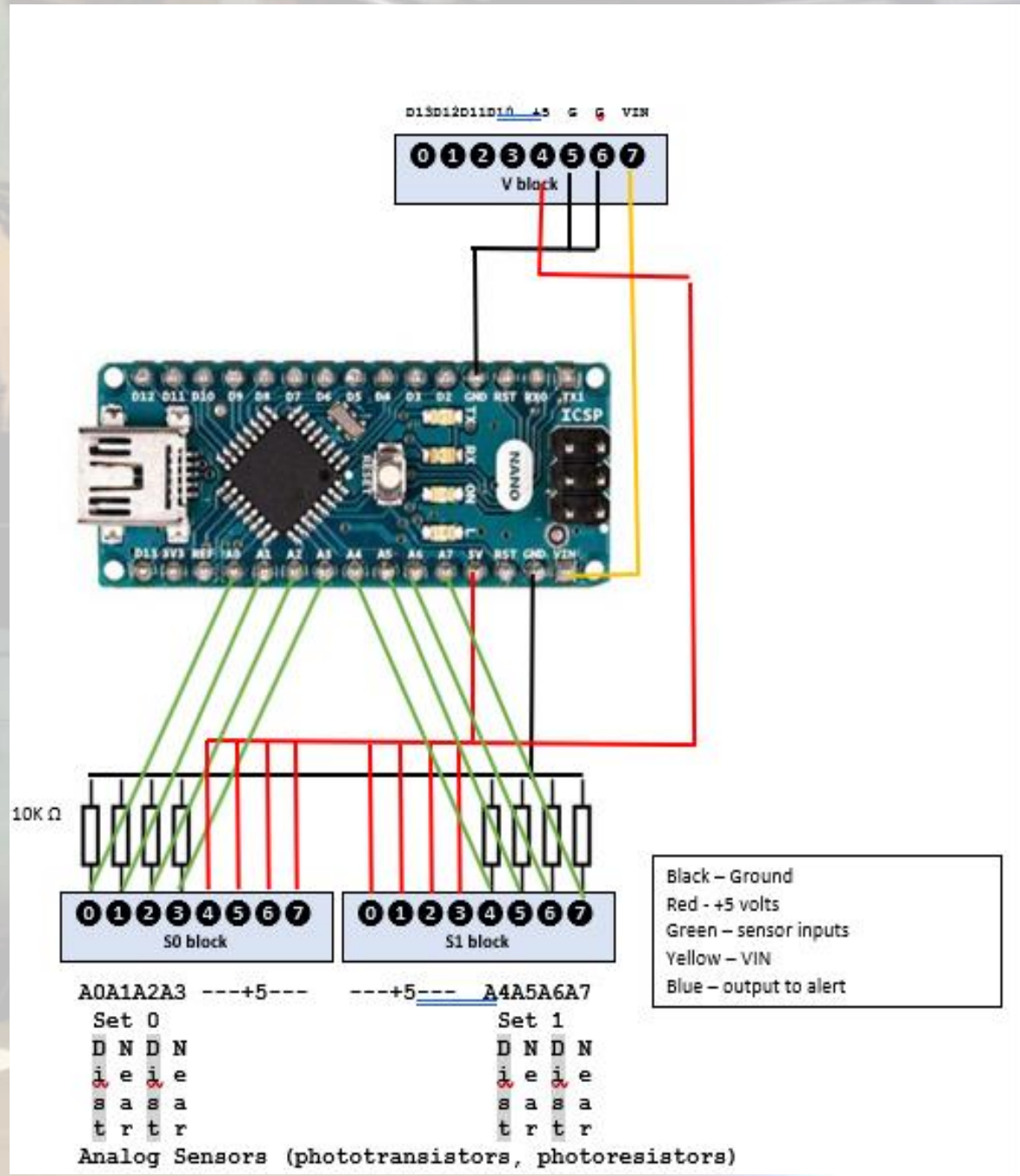
Nano Circuit Diagram

Add pull-down resistors to analog sensor terminals



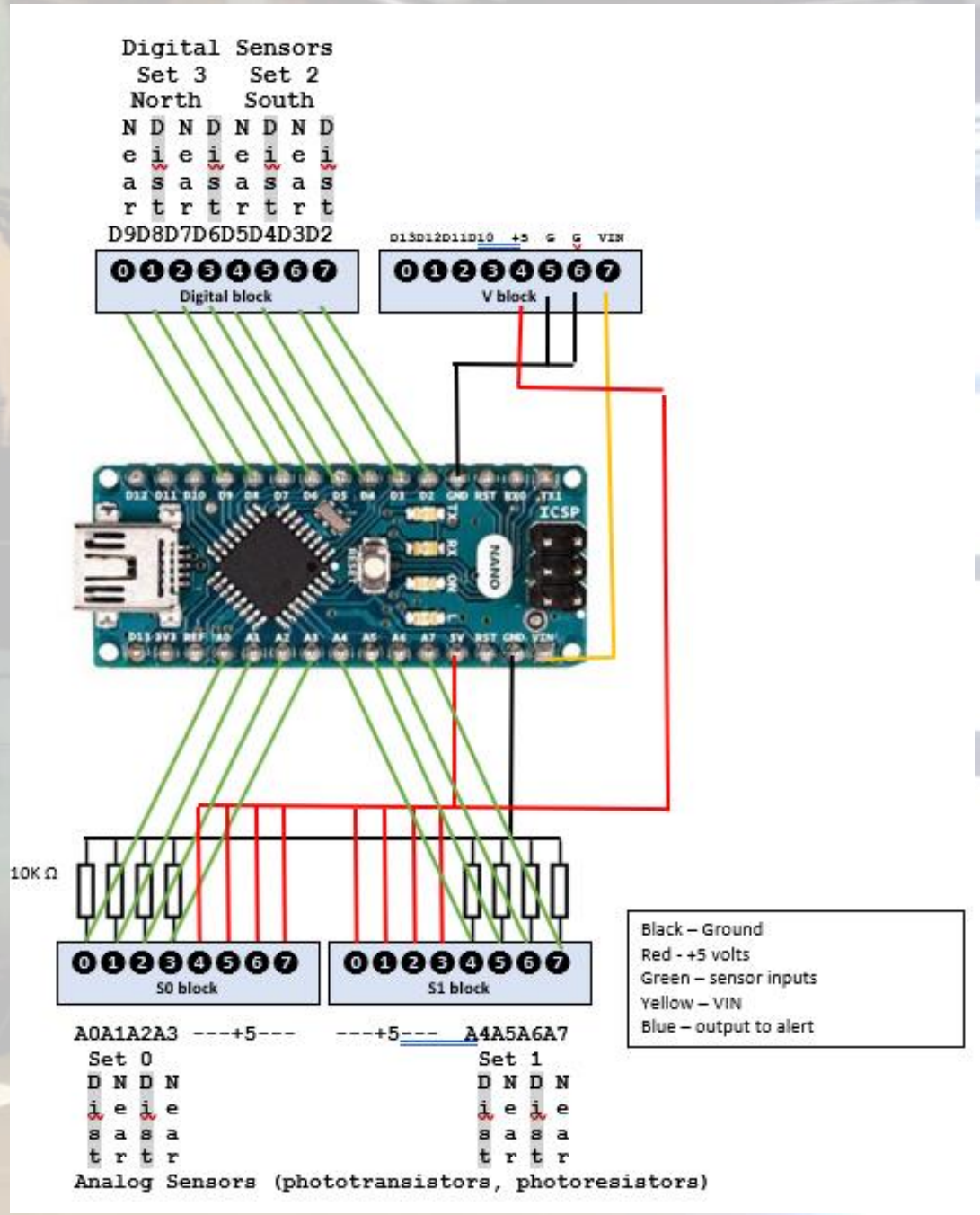
Nano Circuit Diagram

Tie the analog sensor terminals to the Nano



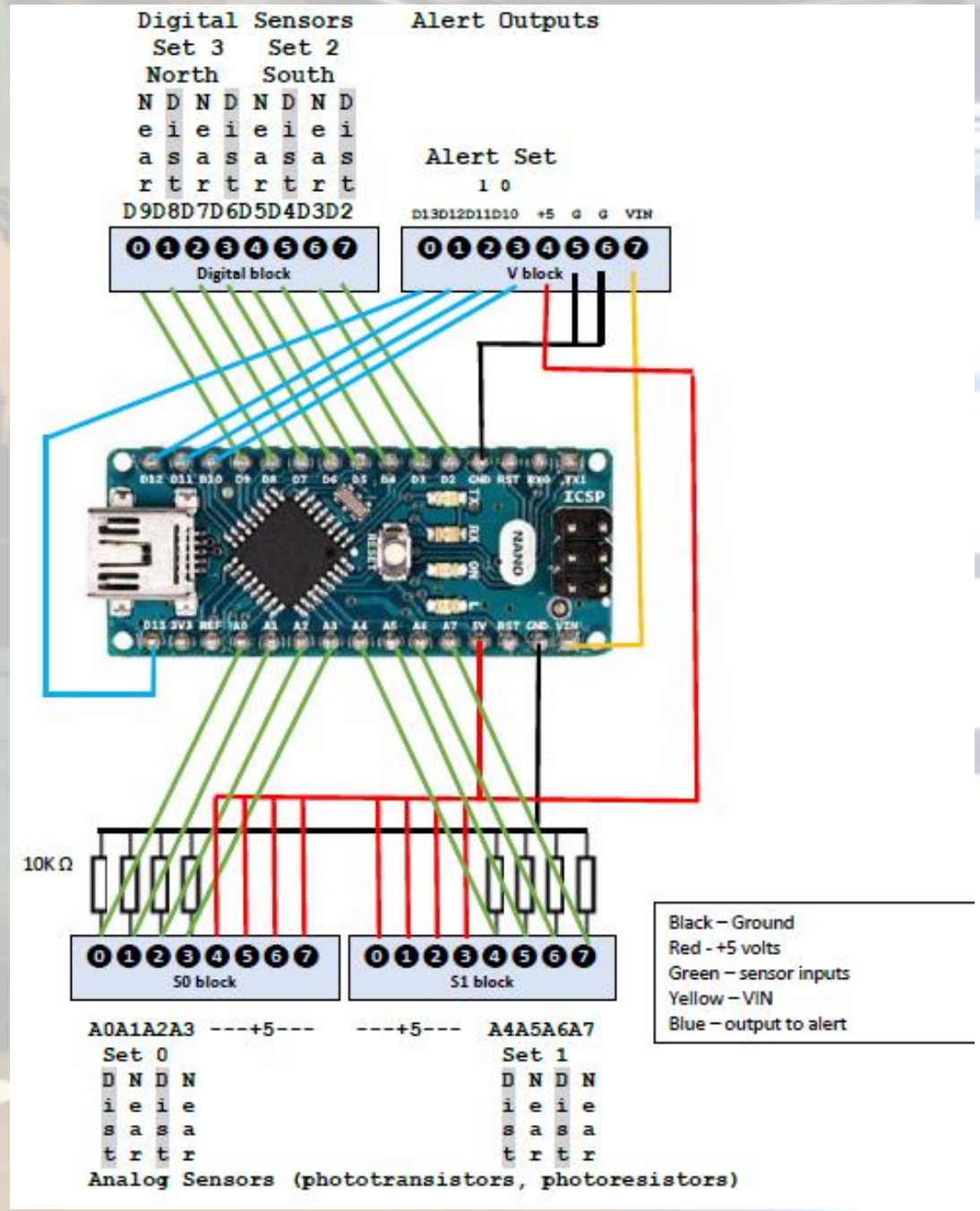
Nano Circuit Diagram

Add the digital sensor lines to the terminal block



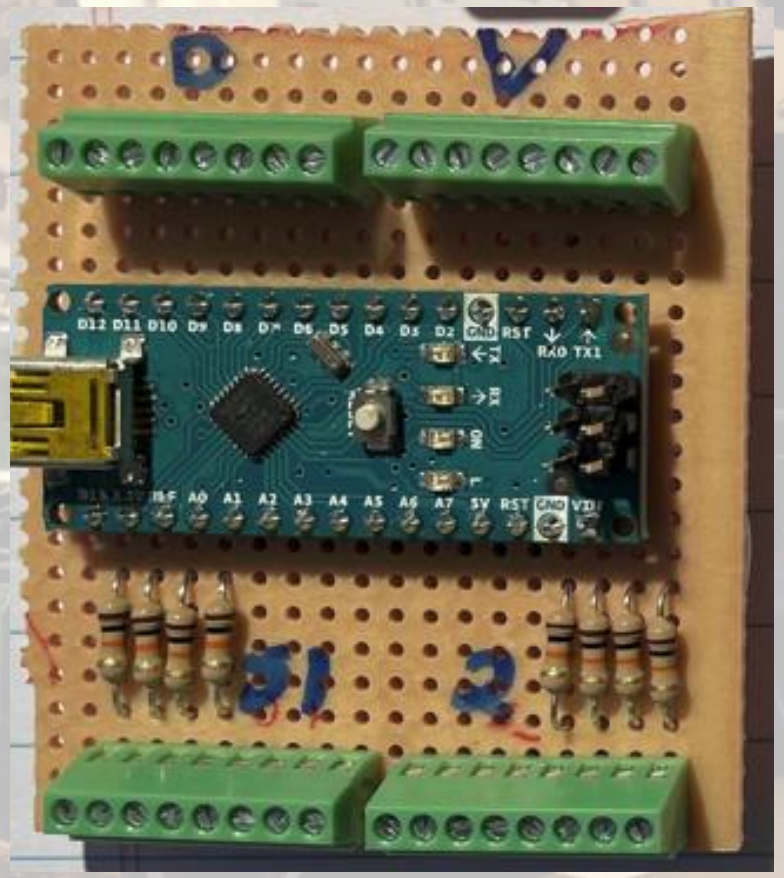
Nano Circuit Diagram

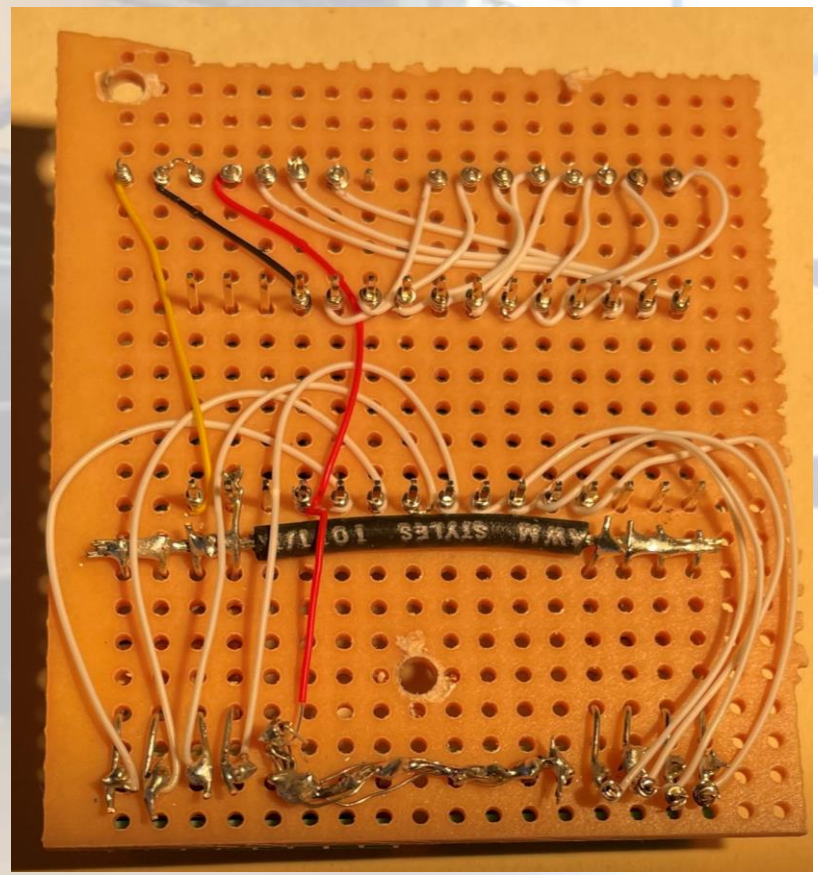
Add the digital output lines to the output/power block



Nano Circuit Diagram

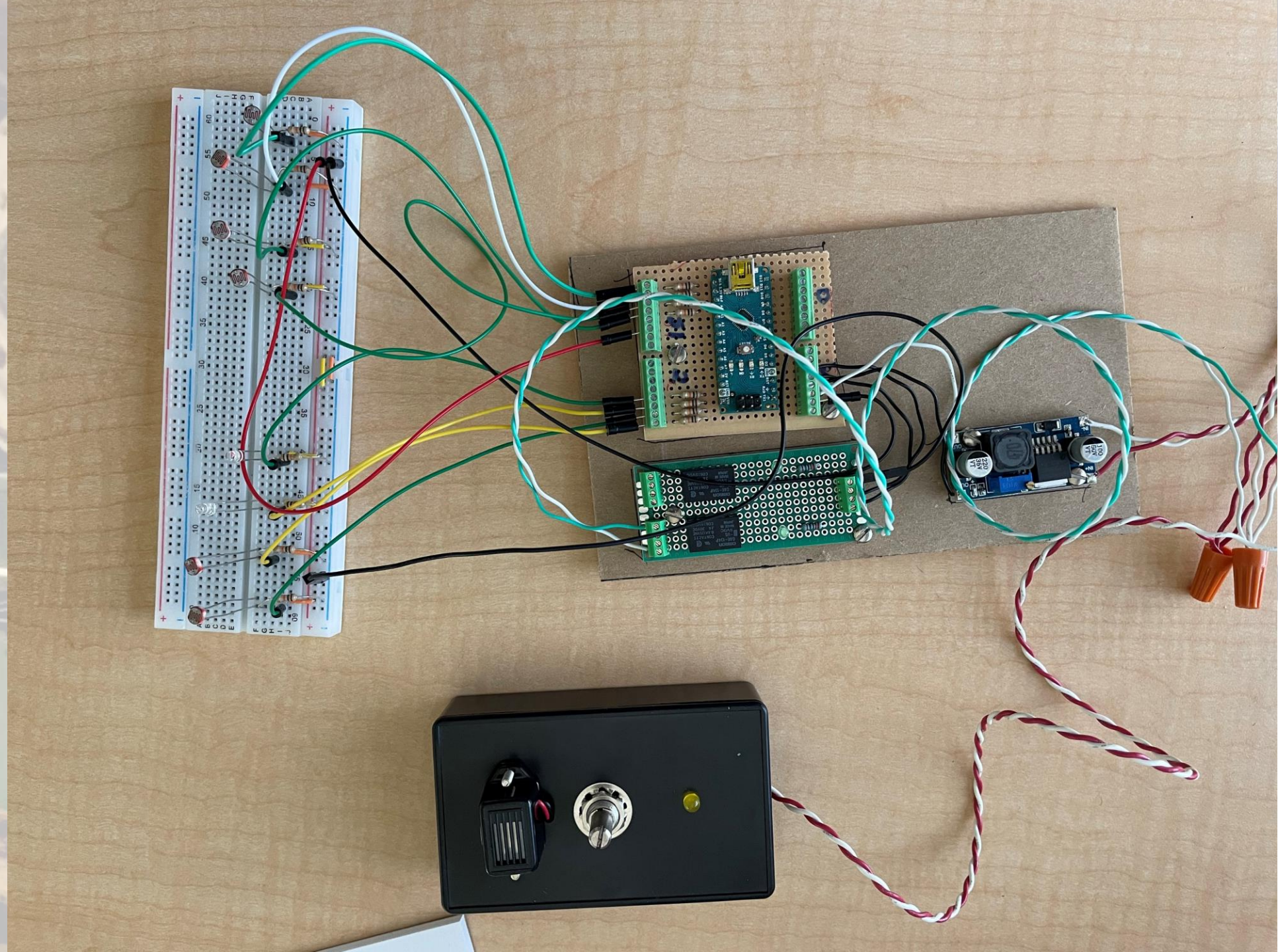
- And built one





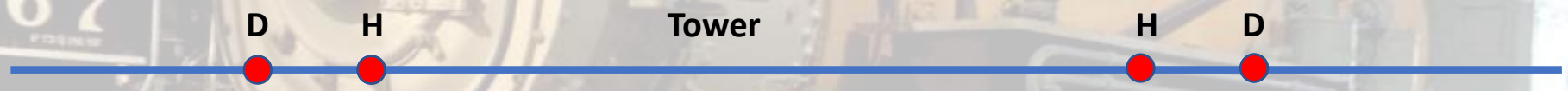
Breadboard

- And tied it to a breadboard
- Mixed diode & Resistor sensors
- Black box is the “bell.” Buzzer + LED + relay board



Sketch outline

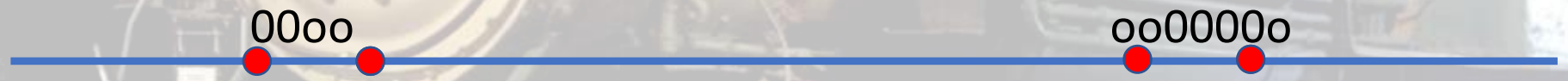
- Each “approach” needs a *distant* and a *home* sensor



- The sketch maintains a high/low value for each analog sensor
  - And looks for a drop indicating occupancy
  - High/low reset every *RecalibrateMts* minutes (5)
- Initial wakeup: Sensor readings were all over the map
  - LED lighting was responsible – Seth advised integrating the values
  - Ran a 34 ms average – values stabilized

Sketch outline

- Approach is triggered when distant sensor is covered before home sensor
- Design such that both sensors must be covered to trigger approach
  - Implications for sensor spacing – small locomotives



- Then I ran a log train with skeleton cars
  - Lots of alerts – sensors went wild
  - Had to fix
- Added in two timers
  - *HoldOccMs* will keep the sensor occupied (1000 ms) if it drops
    - (i.e. between cars)
  - *DontRepeatSecs* will ignore a following alert if too soon (30 secs)

Sketch Definitions

Define the active stations

```
// Define the active stations: 0-1 Analog detection, 2-3 digital detection
// A "station" is a set of two approaches, four sensors:
//                      East DISTANT/HOME and West DISTANT/HOME
//                      Station 0   Station 1     Station 2   Station 3
//                      East  West  East  West    East   West   East   West
const boolean WorkApproach [8] =
                     {true, true, false,false, false,false,  false, false};
```

Define which bell for each station and duration of sound

```
// digital output pins for alert relays for each approach
//                   Station 0   Station 1     Station 2   Station 3
//                   East  West  East  West    East   West   East   West
const int AlrtPins[8] =
                     {10,   10,   11,   11,    12,    12,    13,    13};
// duration of alert in seconds - how long to ring the bell
const int AlertLenSecs[8] =
                     { 5,    5,    5,    5,     5,     5,     5,     5};
```

Sketch Definitions

Other defines

```
// Analog sensor pins
// NOTE a sensor entry of 0 in the *pins arrays will be skipped
//                    Station 0        Station 1
//                    East    West     East    West
//                    D  H    D  H     D  H    D  H
const int Apins[8] = {A0,A1,  A2,A3,   A4,A5,  A6,A7};// analog sensors - Nano

// Digital sensor pins
//                    Station 2   Station 3
//                    East  West  East  West
//                    D  H  D  H  D  H  D  H
const int Dpins[8] = {2, 3, 4, 5, 6, 7, 8, 9};// digital sensors
//
// invert flag for digital sensor if HIGH sensor means clear
boolean   InvertDig = true;
```

Installation help

- Not obvious if a sensor is installed improperly
- First level of help – light LED 13 if any sensor is active
  - Better, but needs a 2nd pair of eyes
- HelpInstallAI sketch
  - Rings the bell with a signal if a sensor is covered
  - Bell reports Station number and sensor number
- “Hit the Bell” is now called “Approach Indicator” project

The Bell

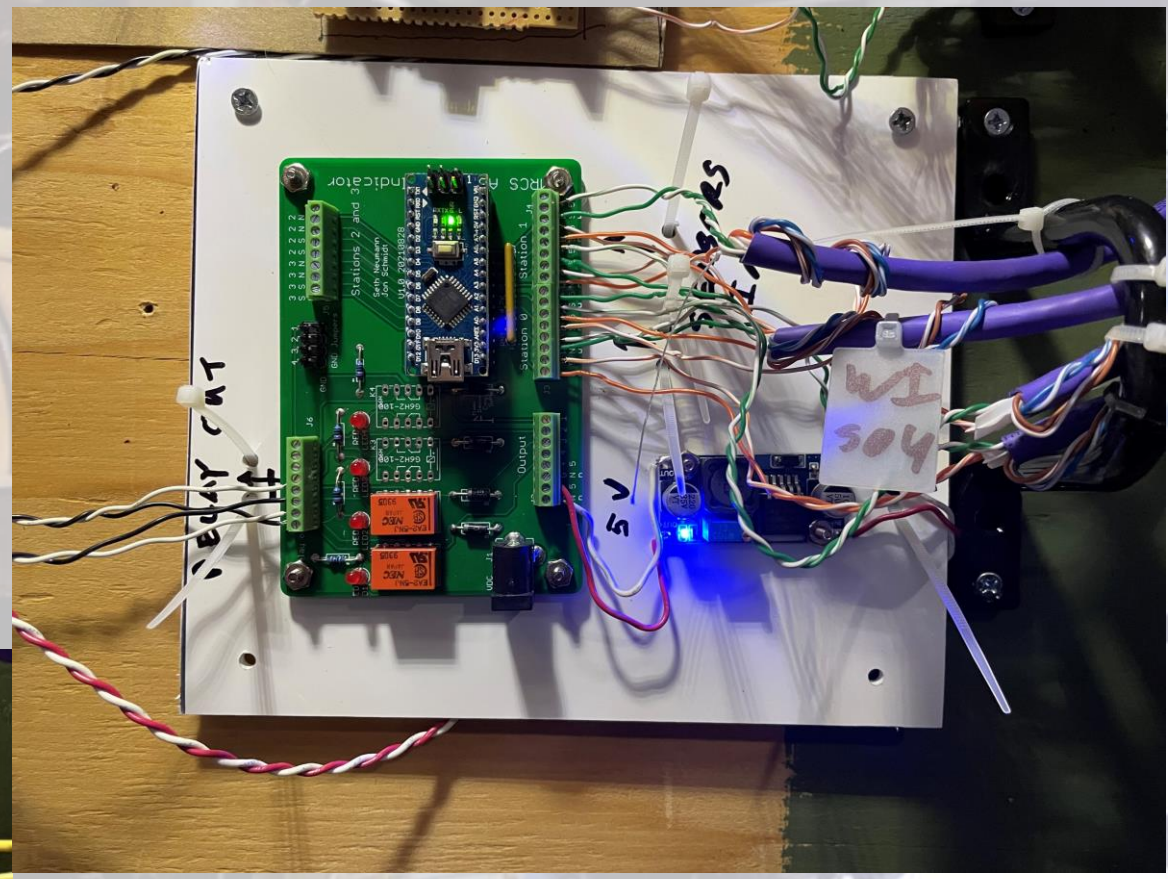
- Any device will work – Arduino drives relay
- Usually one bell per station
  - Configurable to bell per approach
- Initially we used a 12V buzzer with LED driven by a relay
- Used the duration of the bell to indicate direction of the train
- Overkill – wanted a bell
  - Refused to use doorbell – too electrically noisy (and loud)

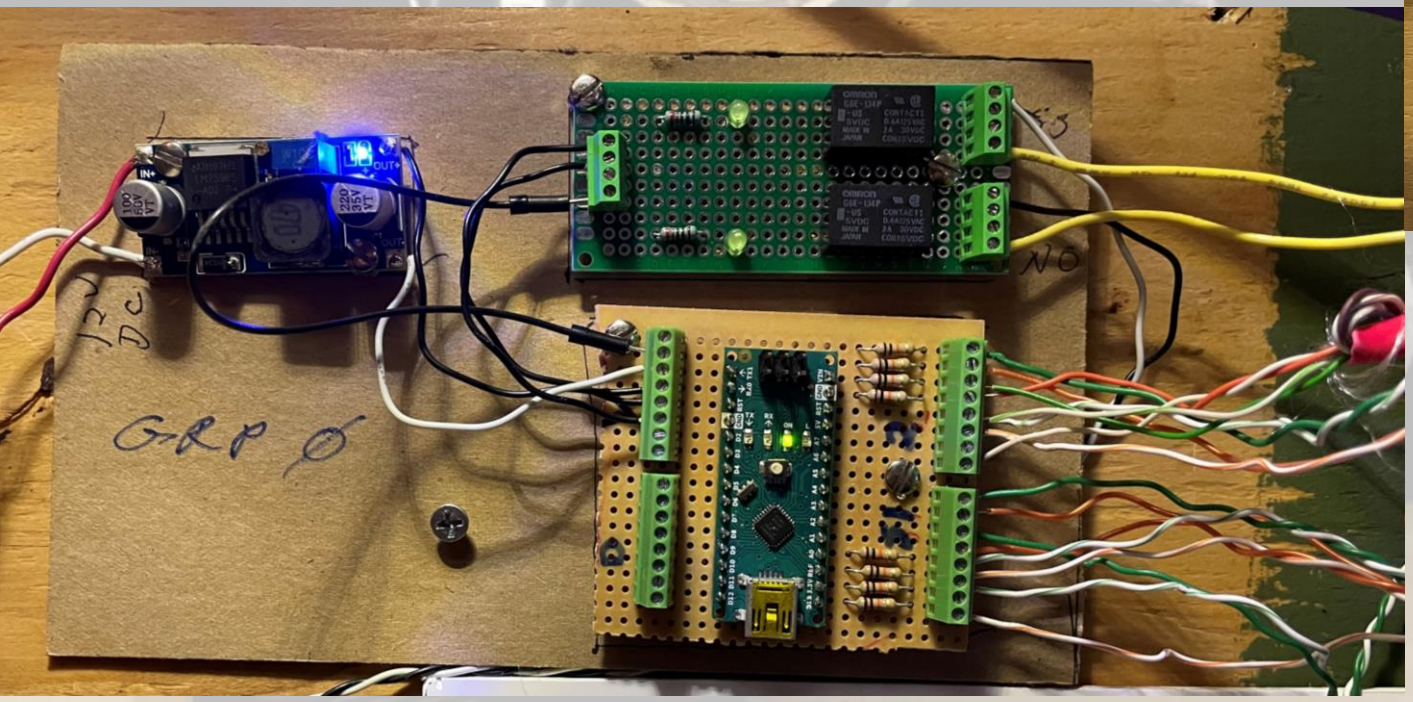
The Bell

- Approached Iowa Scaled Engineering – we were using their grade crossing bell
- Did they have a bell such as one for a CTC panel?
  - No, but if we had the sound they could maybe make one
  - Seth had the sound from a real CTC panel
  - They made 4 bell units for us
    - Now installed and active

Installed on the CV in NorCal

- Four stations, eight approaches
- with distant/near analog sensors each

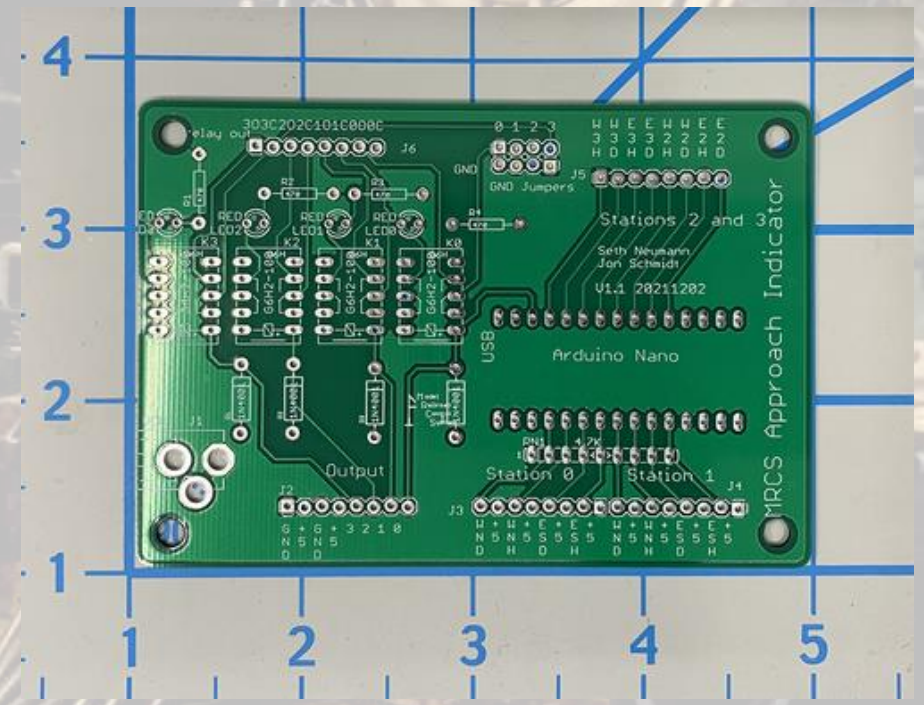


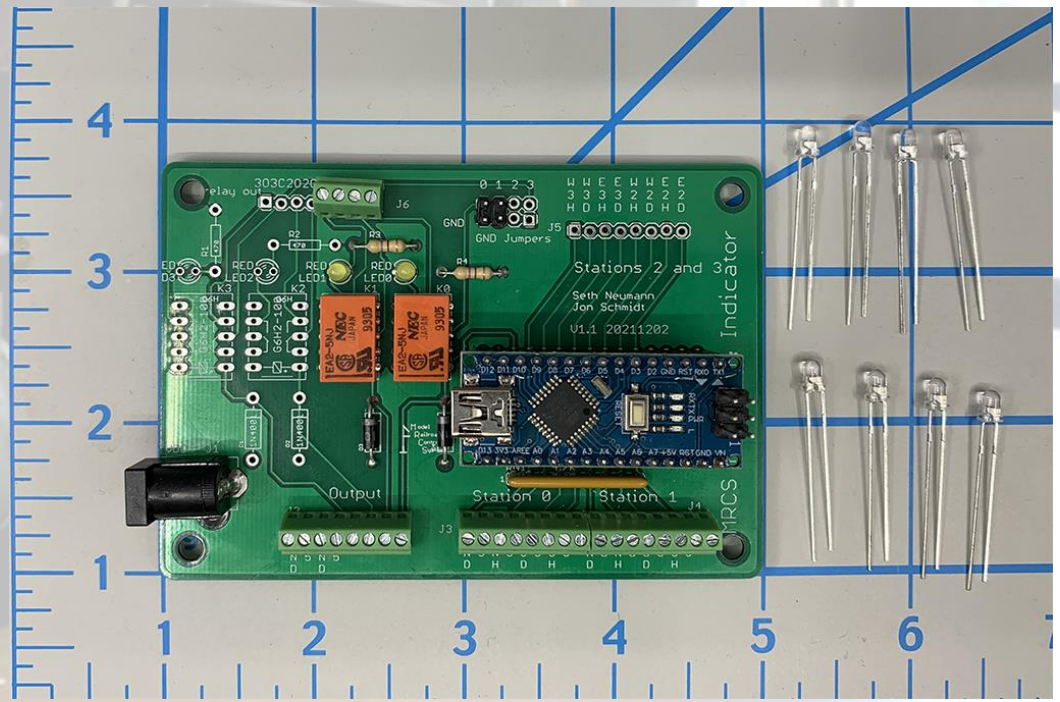


Notes:

- Hit the Bell (Approach Indicator) great first project
  - Simple – stand-alone Arduino
- Follow-on projects
  - Grade Crossing Controller – Handles multiple track configurations
  - Effects Controller – Randomized control of special effects/sounds on a model
  - MRCS Semaphore Control
  - Resist Test – Tests and reports on optical sensor sensitivity

Model Railroad Control Systems made printed circuit boards
for the Approach Indicator
Printed circuit board only or loaded board
Sketch is on github





Notes:

- Next?
  - Investigate Arduino to cpNodes – CMRI
  - Arduino to DCC
  - Arduino to Wifi
  - …

Reference

https://www.arduino.cc/ Home for all things Arduino

Getting Started with Arduino (Banzi/Shiloh, Maker Media)
https://www.makershed.com/search?q=arduino

https://store-usa.arduino.cc/products/arduino-starter-kit-multi-language Starter kit

https://groups.io/g/arduini Arduino for model railroading discussion group

https://github.com/joneschmidt/ApproachIndicator My github site for Approach Indicator

https://www.modelrailroadcontrolsystems.com/approach-indicator-controller/ MRCS references

https://www.modelrailroadcontrolsystems.com/soundbytes-ctc-bell-by-iowa-scaled/

https://www.iascaled.com/store/ Iowa Scaled Engineering store

https://www.cvrailroad.com/ Website for the Ce4ntral Vermont in NorCal

http://nnrwy.trxndesign.com/ Website for my Nicasio Northern Railway

Questions?

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Nicasio Northern Railway

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