A More Prototypical Approach to Car Forwarding Software

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I gave this clinic at the PCR, PNR, and NMRA National conventions in 2019.

I recently added the notes to most pages to help explain what I talked about so that the slides will make some sense to a reader.

Overview

- Why a new computer program
- What it does
- Program Features
  - Fundamentals
  - Advanced Features
  - Analysis
- Q & A

Note:

This clinic **assumes** that you have a working understanding of how **traditional** paper based **Car Cards** and **Waybills** work.

Why a New Computer Program

CC&WB can be very prototypical.... But:

- Too much manual work
- Crews often unsure what to do with a Car
- Hard to update for changes
- No insight into overall traffic flow

The most common question to the host that I hear during an operating session is some form of *“What do I do with this car?”*

A big problem with paper cards is that it is a *lot* of work to make any changes and update the information as there are usually several hundred individual pieces of paper for an average size layout.

Paper systems cannot provide any kind of insight into the overall flow of cars to help with improving the desired operator experience.

And, of course there is always the fun when someone drops a stack of cards, or takes them home in their pocket.

So..... Automate it!

- Keep the **richness** of the CC&WB system, but:
  - **Eliminate** the manual effort for set up
  - Operate using **Switch Lists**
  - **Analyse** Car movements over time for planning
- And **no** artificial assumptions or approximations
  - Car movements must always be based on **prototypical Shipments**

I had two main goals for the program when I started.

1) The effort to restage should be *zero*, meaning that there is no time required between one session and the next. *Time is continuous*.
2) The car movements should be as prototypical as possible and the program should not impart any model railroad approximations, assumptions, or artificial shortcuts. All car movements fulfill *Shipments* between industries using a variety of *Waybills*.

What the Program Does

The Program:

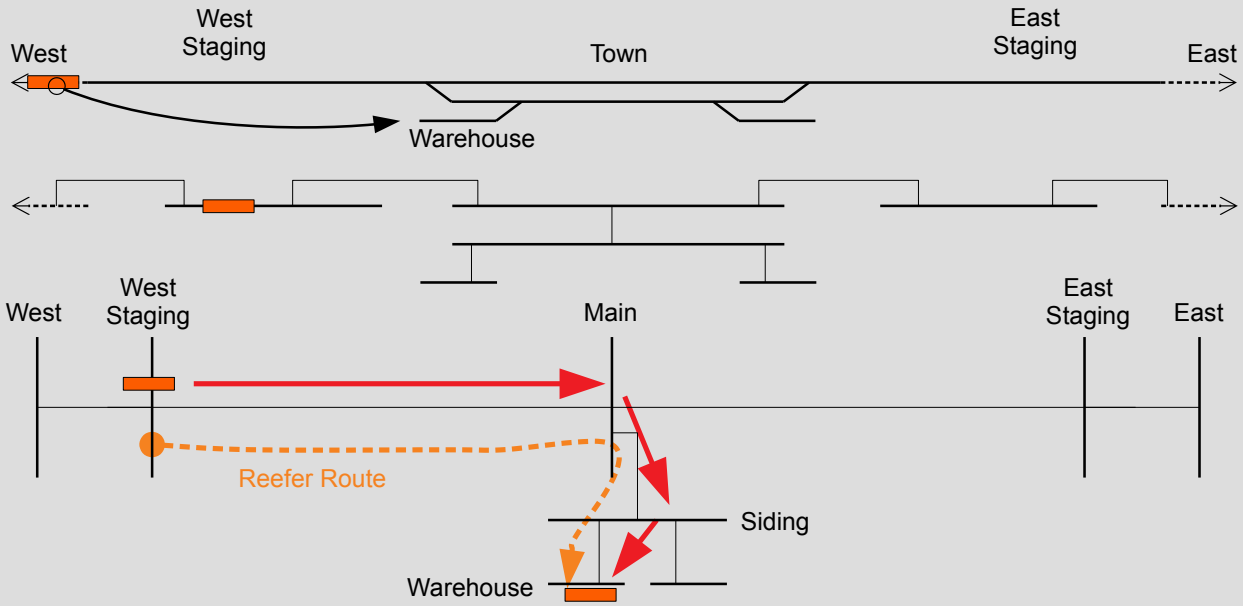
- **Selects** *suitable* **Shipments** for Cars in staging
- **Generates** necessary **Waybills** for Shipments
- **Runs Trains** to pick up and deliver Cars *according to their Waybills*
- **Prints Switch Lists**
- **Records** an **Event Log** that can be *analysed*

The operators work by following a simple switch list that contains everything they need to know to run their train and move the cars. No more questions about *“What do I do with this car?”*

All of the car movement events are recorded in a log that can be used to analyse the behaviour of the layout over time.

Fundamental Features

Track Network and Car Routing



A *Network* of interconnected *Tracks* is used to decide the routing of cars across the layout. This is not specified by the user, but is calculated by analysing the *connections* between tracks.

Cars want to follow a *path* to their destination, based on their waybills.

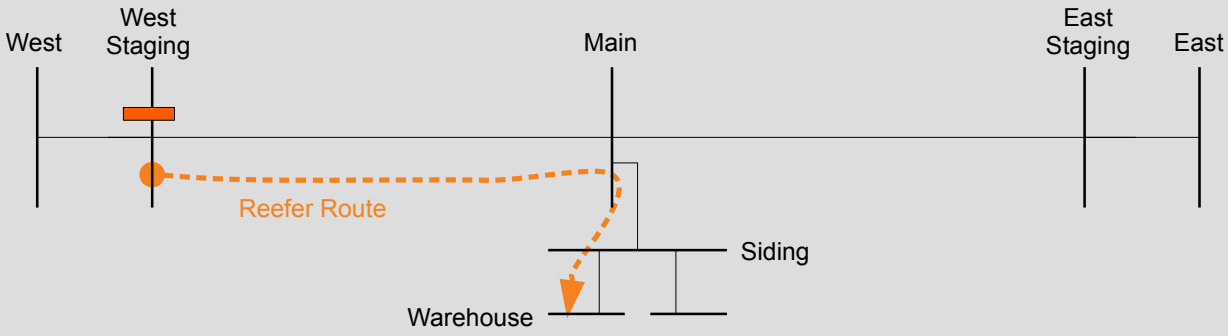
Trains move along paths from track to track according to their *Timetables*, picking up and delivering cars as they go, according to the car's waybill.

In this example, the orange car wants to go from somewhere out west to the Warehouse in Town.

The normal track diagram is converted into a network of tracks, and the path is determined to be from West, to West Staging, to Town Main, to Town Siding, and finally to Town Warehouse. This is shown by the red arrows and is the *Route* of the car.

Car Routing and Trains

- What Trains are involved in moving the Car?
- Answer:
  - We don’t know (yet), but the Car does not care!

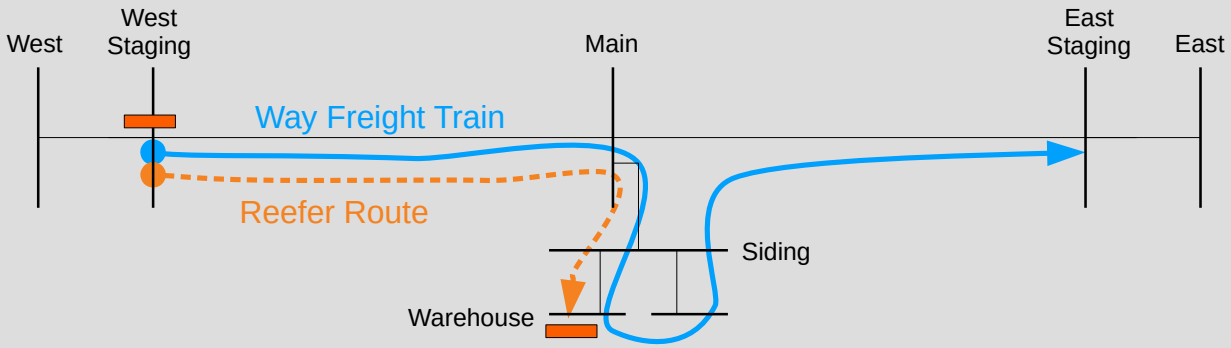


Running Trains

- Trains try to “**advance**” Cars along their route
- Each Train follows a specific Timetable consisting of an ordered list of Stops
- **No guarantee any Car will ever be moved!**
- Think “**Hitchhiking**”

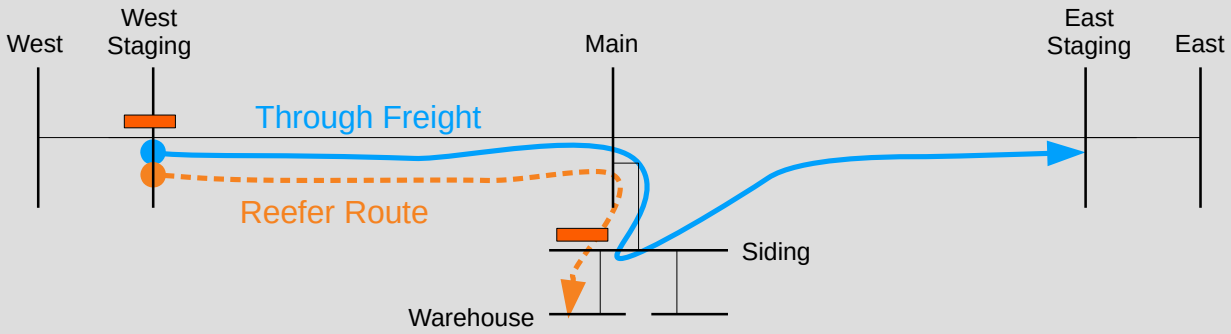
The following slides show four trains and how they could move that car to the Warehouse.

Eastbound Way Freight



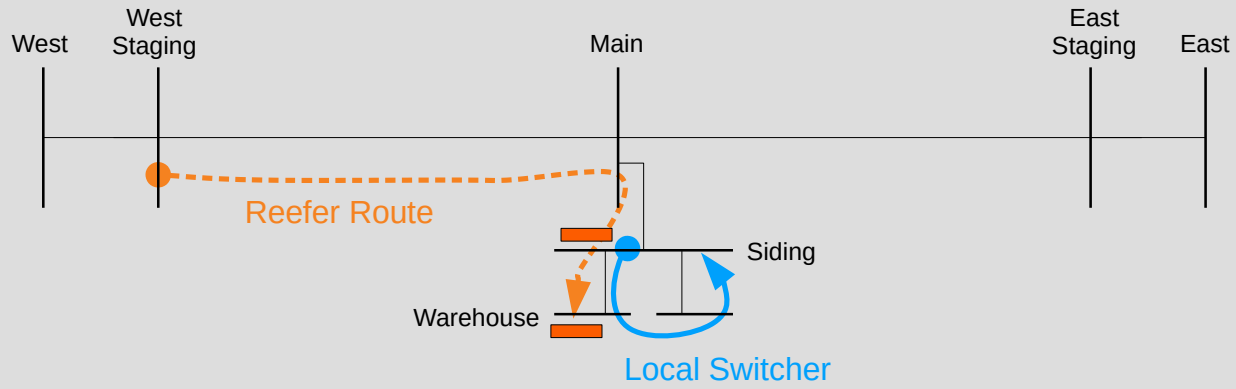
A *Way Freight* may visit the industries at a town, so it may be able to take the car all the way to its destination on one train.

Eastbound Through Freight



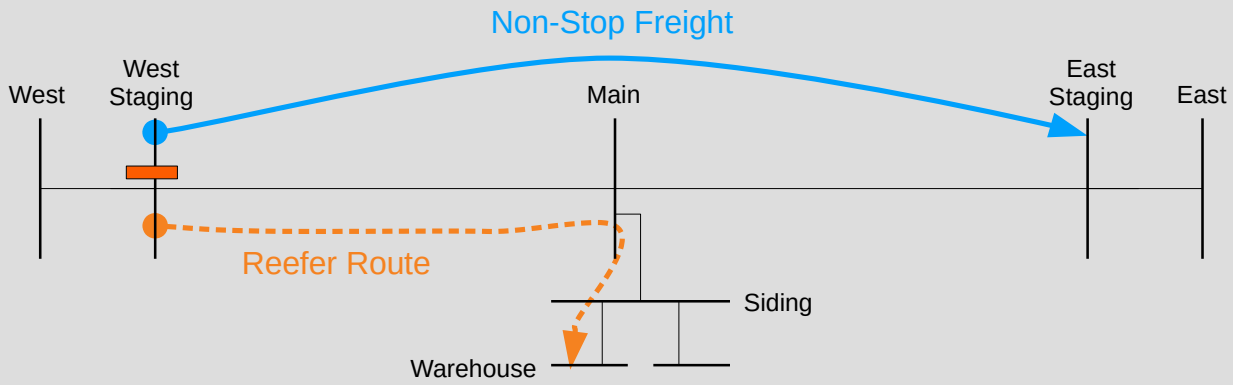
A *Through Freight* will usually not visit individual industries but just switch a track in town, such as the Siding. The Siding is along the car's route, so the Through Freight can advance the car, but not all the way to its destination.

...followed by a Local Switcher



A *Local Switcher* would be responsible for servicing the local industries by delivering and picking up cars, and collecting them for pickup by a Through Freight.

Eastbound Non-Stop Freight



Not all trains heading in the direction the car wants to go will take the car. If the train cannot advance the car *along its route* then it will leave it behind..

A *Non-stop Freight* may not do any switching in the Town at all, meaning that it cannot advance the car, so it will not take with it.

There is no guarantee that *any* train will take a particular car. There must be at least one combination of train routes that covers the car's entire route to ensure that the car will keep moving. The program has checks for cars that don't move and are considered *stuck* so that the user can be alerted.

Car Restaging Process

- Each Car must be given a new "**role**" to play
- Find all Candidate Shipments that:
  - are **Suitable** for the Car, **and**
  - the **Train** can **advance** the Car
- Select one Candidate Shipment at random
- If no candidates, Car is removed to **Storage**

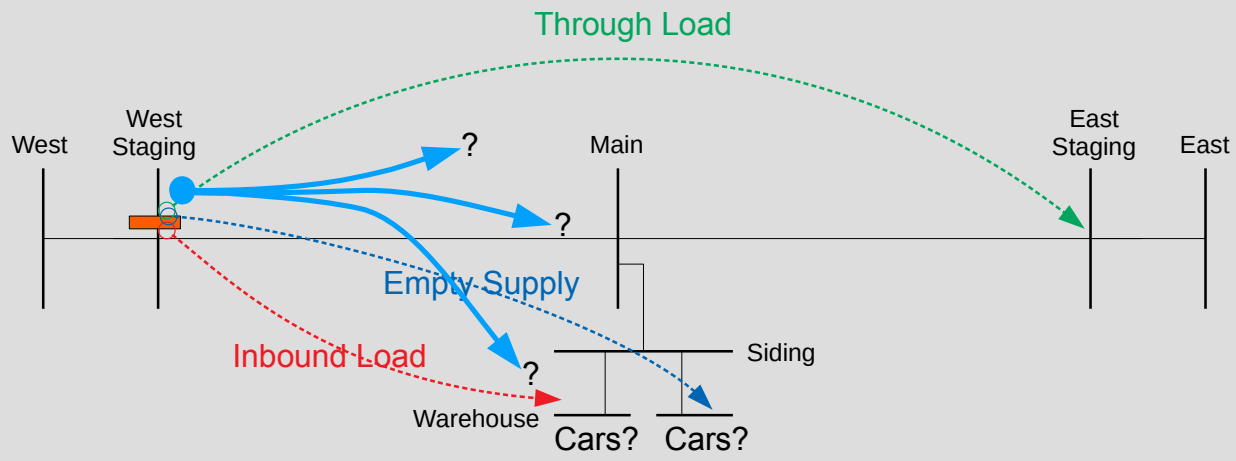
So, how does a car get its waybills?

All cars in staging are given a new *Role* just before they return onto the layout. Each role will generate the waybills, based on the desired destinations and the track network.

Each train that is being restaged will follow a known timetable, so we can select only those waybills (roles) that the train can advance a car for.

From all of these possible roles for a given car, we select one at random and assign it to the car. *This is the only place in the program where anything is randomly selected.*

Candidate Shipment Selection



A given car in staging can play a number of different types of roles. The four typical scenarios are:

Inbound load to a receiver and then *Return* to staging.

Through load to a different staging track.

Empty Supply to a shipper for an *Outbound* load to staging.

Empty Supply to a shipper for a *Local* load to another industry, followed by a *Return* to staging.

Switch Lists

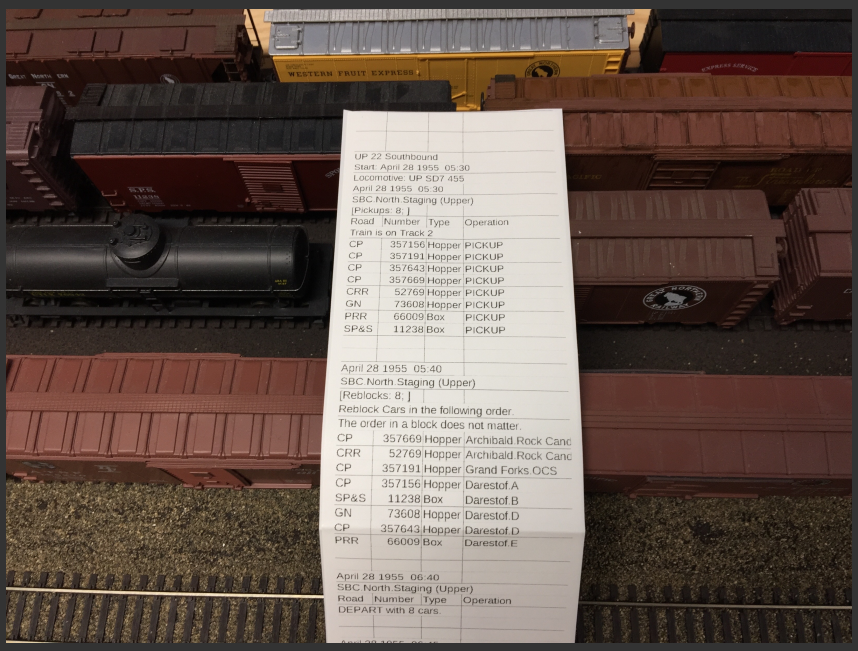
- Different for **Road Trains** and **Switchers**
- Simple files processed as a spreadsheet
- Printed using a receipt printer

The primary output for the operators is a *Switch List*. Two main types are currently generated.

Road Trains that visit multiple *Stations* use one format with a chronological sequence to the moves, as they usually do not go back and forth between stations but deal with everything at one station in one visit. (Turns that visit one station twice can easily be handled, but usually still have an order to their work.)

Switchers that classify cars and work local industries are usually free to process the car moves in any order that makes sense to the yardmaster, so they use a format that simply states where everything must end up by a certain time and leave the details to the crew.

Road Switch List Sample



Here is a sample of a road switch list.

Road Switch List

Nanaimo Turn			
April 21 1965 00:15			
BCH.S Yard.Nanaimo Build			
[Pickups: 11]			
Road	**Number**	**Type**	**Operation**
CN	480715	Box	PICKUP
CN	480927	Box	PICKUP
CN	522781	Box	PICKUP
CP	223422	Box	PICKUP
CP	249463	Box	PICKUP
CP	283300	Reefer	PICKUP
CP	51662	Box	PICKUP
CP	51856	Box	PICKUP
PGE	8003	Box	PICKUP
SLSF	153197	Box	PICKUP
SOU	272418	Box	PICKUP

April 21 1965 06:10			
BCH.McKay.Sears			
[Pickups: 1 Deliveries: 4]			
Road	**Number**	**Type**	**Operation**
CN	480927	Box	DELIVER
CN	522781	Box	DELIVER
CP	249463	Box	DELIVER
CP	42610	Box	PICKUP
PGE	8003	Box	DELIVER
BCH.McKay.Kelly Douglas.Grocery			
[Deliveries: 2]			
Road	**Number**	**Type**	**Operation**
CP	51662	Box	DELIVER
SLSF	153197	Box	DELIVER
BCH.McKay.Kelly Douglas.Produce			
[Pickups: 2 Deliveries: 1]			
Road	**Number**	**Type**	**Operation**
CP	283300	Reefer	DELIVER
PFE	300207	Reefer	PICKUP
WFCX	8813	Reefer	PICKUP

Details of a road switch list, displayed in chunks to fit the slides. The actual switch list is one continuous piece of paper per train.

Notice that it has a pickups and deliveries at a number of stations, along with the scheduled times.

The train is a local that leaves **S Yard,** works its way through a number of stations and industries, ... (next slide)

Road Switch List

BCH.McKay.Nabob			
[Deliveries: 1]			
Road	**Number**	**Type**	**Operation**
CP	223422	Box	DELIVER
BCH.Nanaimo.Central Park Team Track			
[Pickups: 4 Deliveries: 1]			
Road	**Number**	**Type**	**Operation**
CP	221856	Box	PICKUP
CP	286137	Reefer	PICKUP
CP	297510	Box	PICKUP
CP	51856	Box	DELIVER
GN	3594	Box	PICKUP
BCH.Nanaimo.McGregor			
[Pickups: 1 Deliveries: 1]			
Road	**Number**	**Type**	**Operation**
CN	480715	Box	DELIVER
UP	474037	Box	PICKUP

BCH.Nanaimo.Associated Foundries			
[Pickups: 1 Deliveries: 1]			
Road	**Number**	**Type**	**Operation**
GN	75658	Gondola	PICKUP
SOU	272418	Box	DELIVER
April 21 1965 06:15			
BCH.S Yard.Main			
[Deliveries: 9]			
Road	**Number**	**Type**	**Operation**
CP	221856	Box	DELIVER
CP	286137	Reefer	DELIVER
CP	297510	Box	DELIVER
CP	42610	Box	DELIVER
GN	3594	Box	DELIVER
GN	75658	Gondola	DELIVER
PFE	300207	Reefer	DELIVER
UP	474037	Box	DELIVER
WFCX	8813	Reefer	DELIVER
**********			

...and arrives back at **S Yard** with the cars that it picked up.

All *trains* start with *zero cars* and end with *zero cars*. A train leaving staging is assumed to be created with no cars, and then picks up the cars from a staging track before leaving. This gives a list of pickups at the start that lets the crew verify that they are stating with the correct cars. The same applies at the end of the run with a list of deliveries, again to help confirm the correct cars.

Classify Switcher Switch List

GF Switcher After CP 82 Eastbound					
Start AFTER Train CP 82 has departed.					
April 24 1955 02:00					
Road	**Number**	**Type**	**From**	**To**	**Final Destination**
CP	357643	Hopper	Grand Forks.Siding	Grand Forks.SBC-Norths	Archibald.Rock Candy Mine
CP	357786	Hopper	Grand Forks.Siding	Grand Forks.SBC-Souths	Darestof.C
CP	50537	Box	Grand Forks.Siding	Grand Forks.Locals	Grand Forks.Boundary Electric
CP	89065	Box	Grand Forks.Siding	Grand Forks.Locals	Grand Forks.Boundary Electric
GN	5010	Box	Grand Forks.Siding	Grand Forks.Locals	Grand Forks.Boundary Electric
GN	73982	Cov Hopper	Grand Forks.Siding	Grand Forks.SBC-Souths	Darestof.C
MILW	716966	Box	Grand Forks.Siding	Grand Forks.Locals	Grand Forks.Boundary Electric
UTLX	76942	Tank	Grand Forks.Siding	Grand Forks.Locals	Grand Forks.Esso

Switch lists for car classification look very different, but are generated from the same underlying train logic. Every car to be classified is already *en route* and has one or more active waybills. The switcher is simply advancing the cars one step further along their journey. Many will be picked up by various trains that visit the same yard.

Interchange between railroads is not handled in any explicit way, but simply works because the various trains that move a given car can be from different railroads. Careful arrangement of the different timetables and where each train picks up and delivers cars will produce a continuous flow for the cars.

Local Industries Switch List

GF Industries					
April 24 1955 04:45					
Road	**Number**	**Type**	**From**	**To**	**Final Destination**
ATSF	11025	Box	Grand Forks.Locals	Grand Forks.Sawmill	Grand Forks.Sawmill
ATSF	156270	Box	Grand Forks.Sawmill	Grand Forks.SBC-Souths	South.Staging
BMMX	1809	Tank	Grand Forks.Esso	Grand Forks.CP-Wests	West.Staging (Upper)
CDLX	817	Tank	Grand Forks.Locals	Grand Forks.OCS	Grand Forks.OCS
CP	117832	Box	Grand Forks.Sawmill	Grand Forks.SBC-Souths	South.Staging
CP	240000	Box	Grand Forks.CP-Easts	HOLD	East.Staging (Lower)
CP	281472	Reefer	Grand Forks.CP-Wests	HOLD	West.Staging (Upper)
CP	357156	Hopper	Grand Forks.CP-Wests	HOLD	West.Staging (Upper)
CP	357488	Hopper	Grand Forks.CP-Wests	HOLD	West.Staging (Upper)
CP	357493	Hopper	Grand Forks.CP-Wests	HOLD	West.Staging (Upper)
CP	357669	Hopper	Grand Forks.CP-Wests	HOLD	West.Staging (Upper)
CP	357786	Hopper	Grand Forks.SBC-Souths	HOLD	Darestof.C
CP	50537	Box	Grand Forks.Locals	Grand Forks.Boundary Electric	Grand Forks.Boundary Electric
CP	89065	Box	Grand Forks.Locals	Grand Forks.Boundary Electric	Grand Forks.Boundary Electric
CP	89067	Box	Grand Forks.CP-Wests	HOLD	West.Staging (Upper)
EBAX	6008	Tank	Grand Forks.Locals	Grand Forks.Columbia Brewery	Grand Forks.Columbia Brewery
GACX	42764	Cov Hopper	Grand Forks.OCS	Grand Forks.SBC-Souths	South.Staging
GARE	9105	Reefer	Grand Forks.Locals	Grand Forks.OCS	Grand Forks.OCS
GN	23637	Box	Grand Forks.Locals	Grand Forks.Fruit Coop	Grand Forks.Fruit Coop
GN	5010	Box	Grand Forks.Locals	Grand Forks.Boundary Electric	Grand Forks.Boundary Electric
GN	73608	Hopper	Grand Forks.CP-Easts	HOLD	East.Staging (Lower)
GN	73982	Cov Hopper	Grand Forks.SBC-Souths	HOLD	Darestof.C
KPCX	1901	Tank	Grand Forks.Locals	Grand Forks.Esso	Grand Forks.Esso

Both classification and local industry switch lists show the disposition of *all* cars in the area, not just the ones that are to be picked up and delivered.

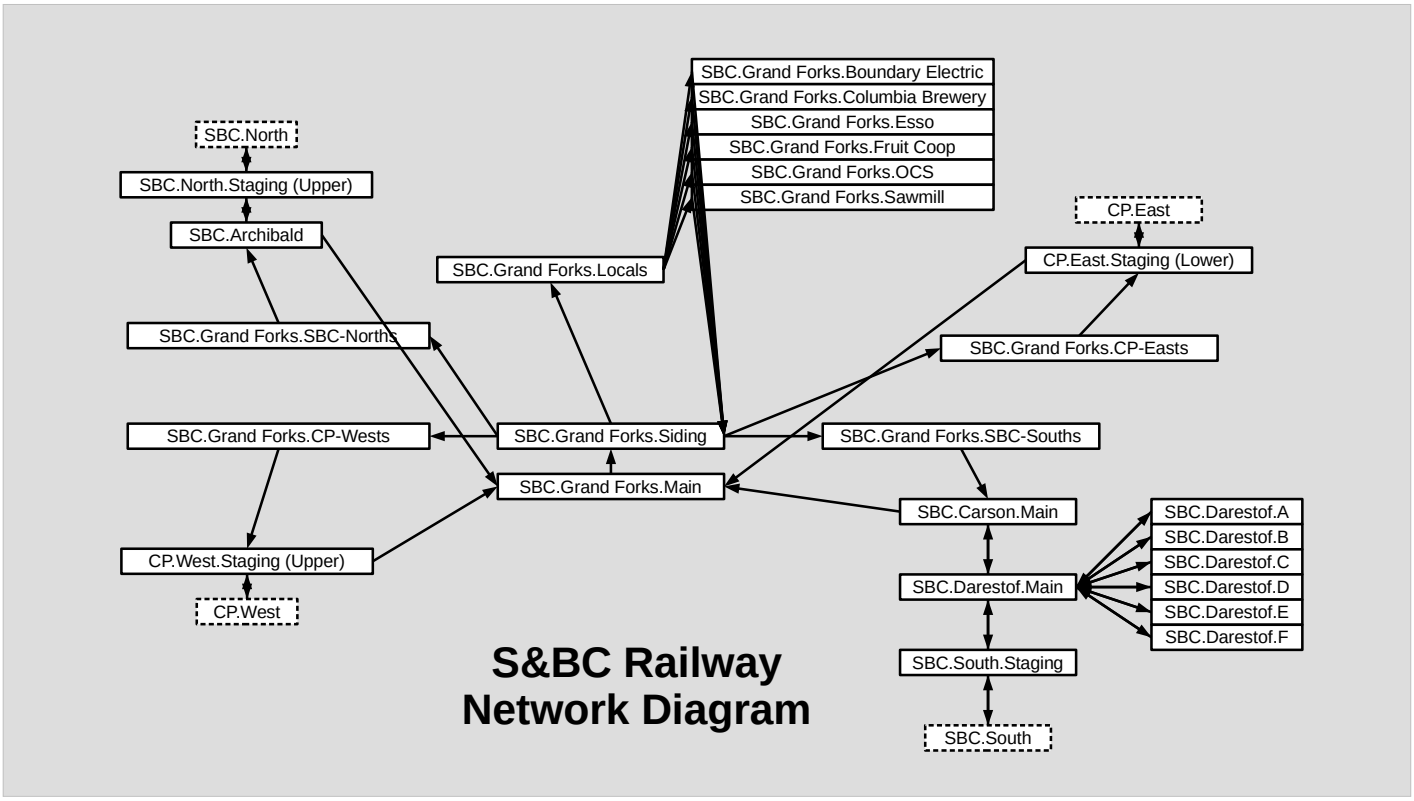
Most cars will show a *From Track* and a *To Track* and the crew can manage the moves in any way they see fit.

Cars that are not moving are marked with *Hold* to indicate that they should remain or end up on their tracks. This is very helpful if the cars need to be moved during switching as it shows where they should be returned to.

Advanced Features

Other features beyond the basic switch lists are explained in the following slides:

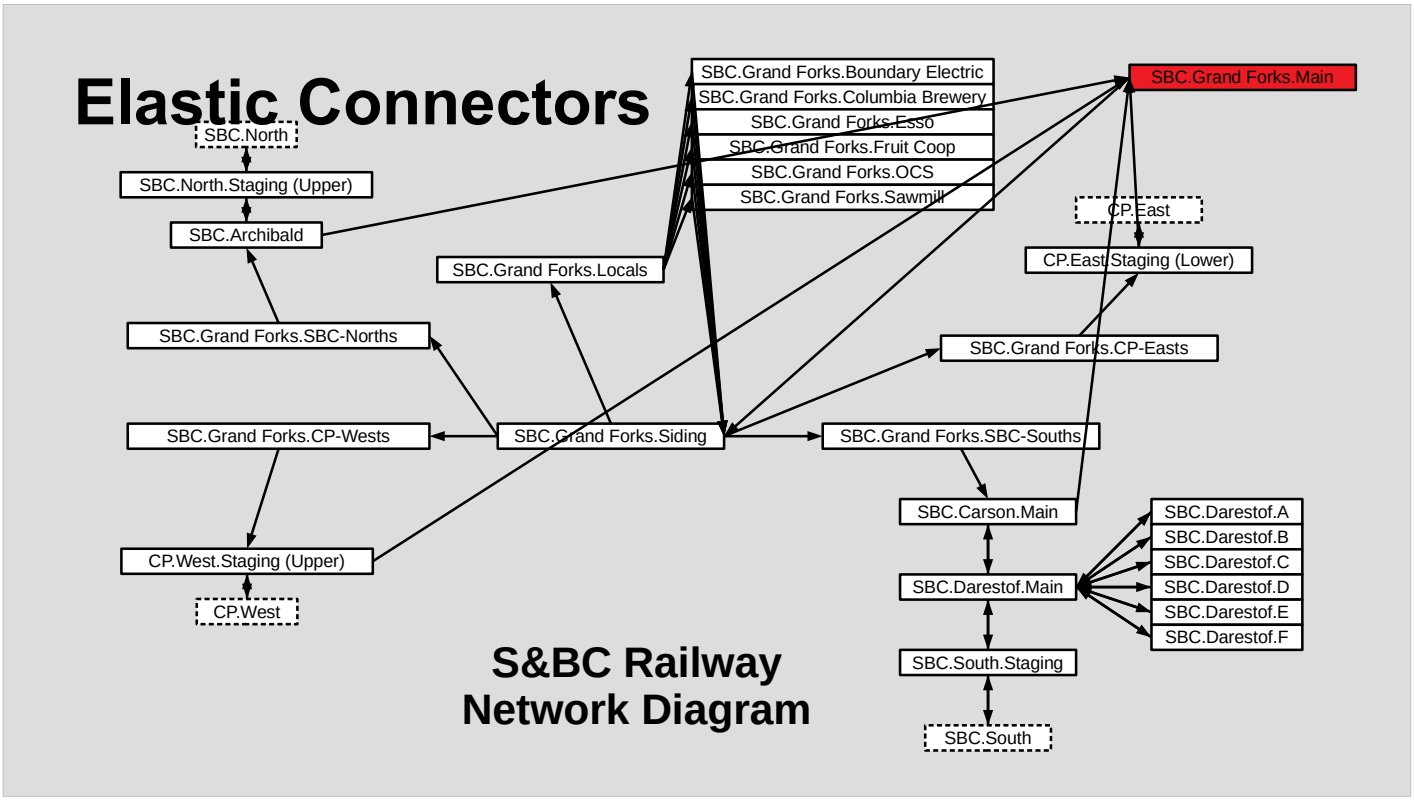
- Track *Network Diagrams*
- Train schedule *String Diagrams*
- *Car Exchange*
- *Car Orders*
- *Train Lineups*



The track and connection data can be processed into a basic *network diagram* that makes it easy to visualize how cars can flow over the layout.

It currently uses the open source LibreOffice Draw program for display and editing, but the basic track blocks and connection lines are created by my program.

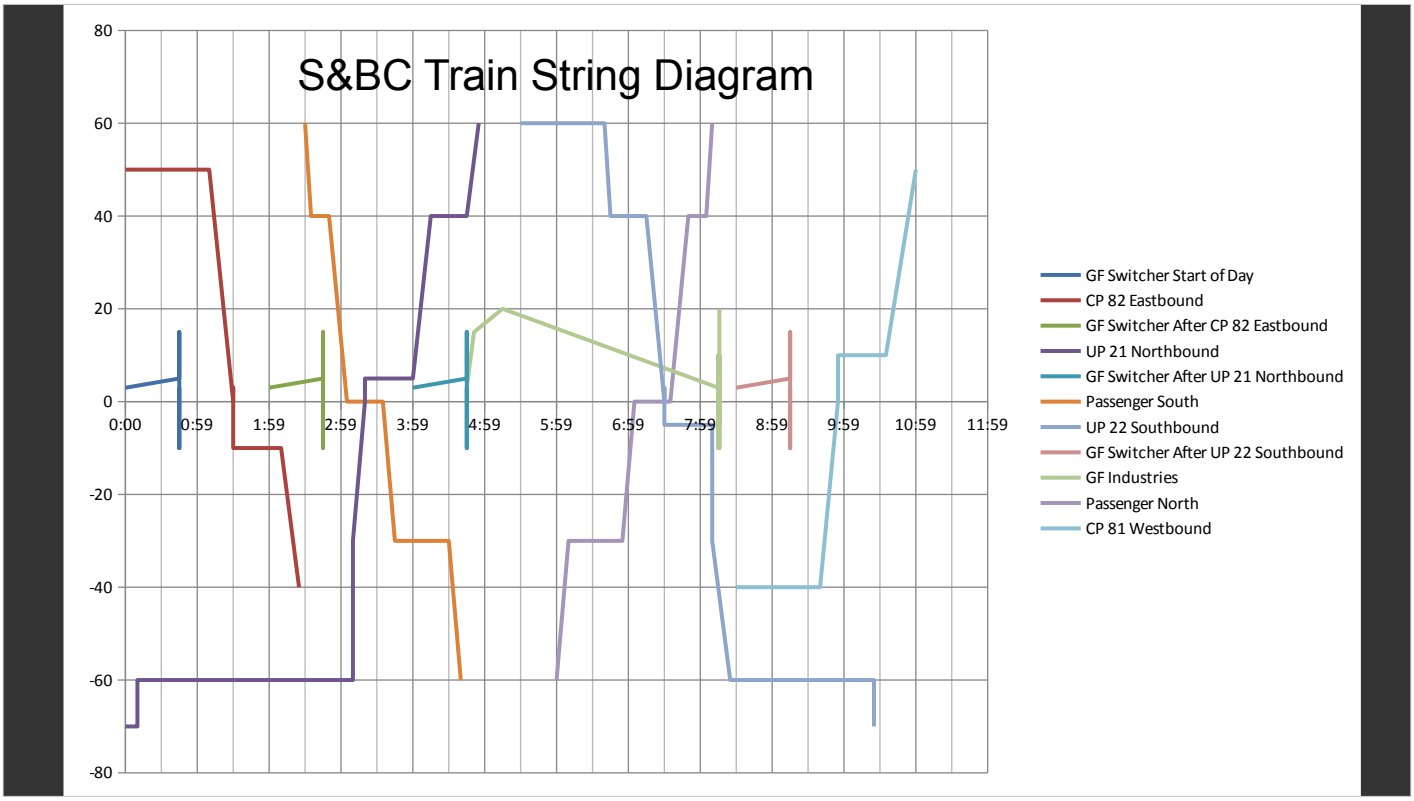
This may develop into a full featured graphical editor within the program some day.



Track placement is left to the user to do in LibreOffice because the program has no way of knowing how the tracks should be arranged. The locations of the tracks are maintained though updates, but the connections are all completely redrawn each time the diagram is updated.

LibreOffice Draw manages the track connections as *drawing connectors* that are *elastic* and stretch as tracks are moved so that they remain connected. This is a huge help when rearranging a network drawing.

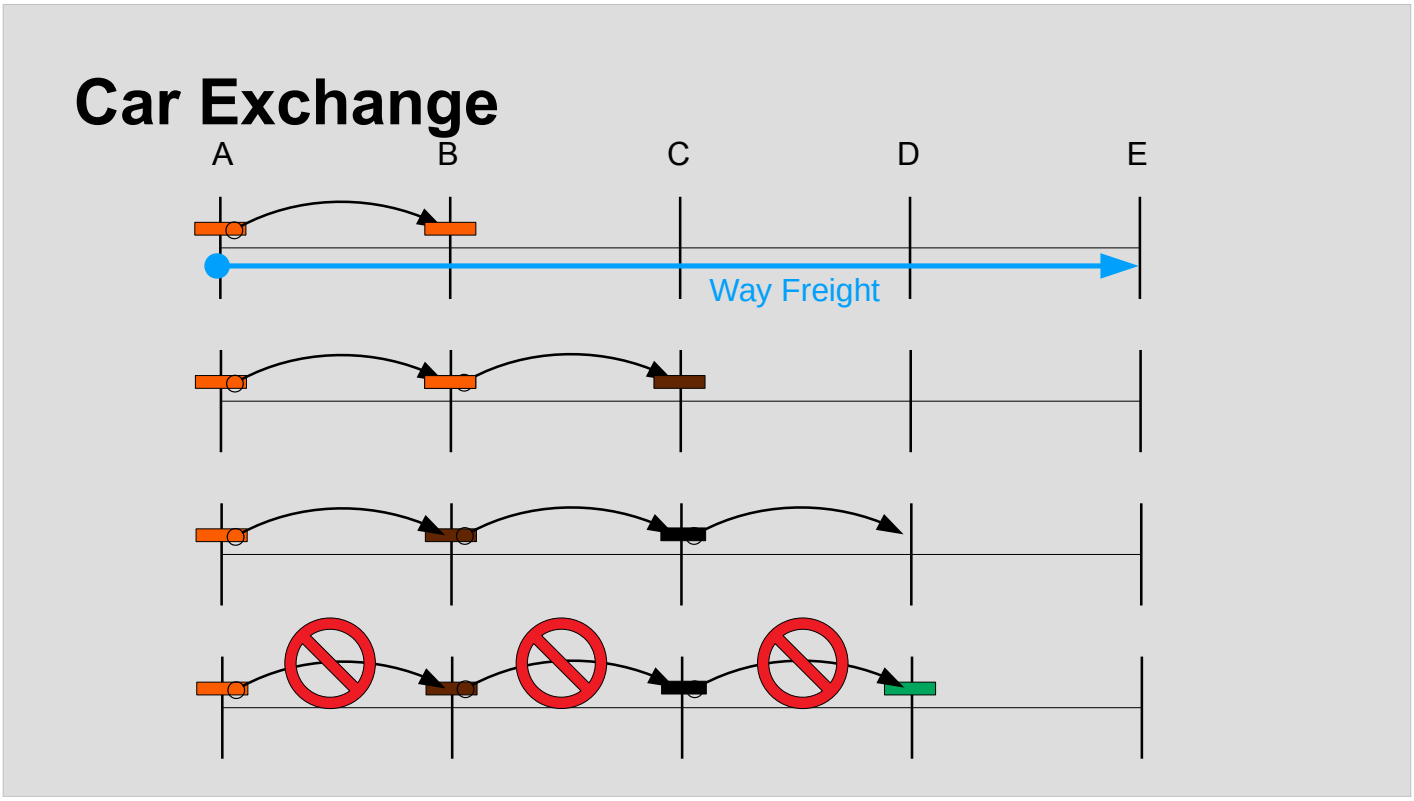
In the sample network above the red Grand Forks Main track has been pulled up and the connections have stretched to keep it connected.



The train timetable data can be processed into a graph that shows the relative train positions over time. This is known as a *String Diagram.*

It can be very useful when planning train sequences to ensure operational coverage while avoiding bottlenecks at stations.

Rather than having to manually enter and update all of this data in a spreadsheet, it is created by the program directly from the timetables.



Layouts are notoriously limited on track space and it is difficult to keep cars moving with little free space.

The program utilizes the notion of *Car Exchange* where it will try to free up space at a destination for incoming cars by seeing if the same train that will deliver the cars will also pick up some of the cars that are in the way at the destination.

In the first example, there is no problem as the car at A can easily move to B because B is empty.

In the second example, there is already at car at B, so the one at A would normally not be able to move to B, assuming space for one car. But, in this case the train will also move the car from B to C, freeing up space for the car at A, so the train will pick it up.

This can be repeated for any number of tracks ahead.

Car Orders

- Give **priority** to Shipment selection
- Both **empties** for outbounds and inbound **loads**
- Helps ensure a uniform supply of cars
- Considered before random selection
- Support “**fuzzy**” selectors

During restaging, *Car Orders* are considered first when assigning roles to cars. The program maintains a list of outstanding car orders and tries to fill them every time a car is restaged anywhere on the layout.

A process similar to that used when matching roles to cars is followed to ensure that the car and the role satisfy the car order.

A list of unfulfilled orders can be generated after the program runs to help tailor the car orders, roles, and cars to keep them in balance.

Car Order Example

- Shipments of Lumber from GF Sawmills to various places
- Want 3 empty cars per day for loads from the sawmill
- Car Order:
  - From: GF Sawmills
  - To: **Anywhere**
  - Load: Lumber
  - Car Type: Boxcar
  - Quantity: 3 per day

Note that the term *Anywhere* in the car order does not mean “any track on the layout”, because that would not make any sense from a prototypical standpoint. It means that it will match any *existing* role that is from GF Sawmills, carrying lumber, in a Boxcar. The roles must be already defined as the car orders cannot create new roles.

Grand Forks Yard Line-up - Arriving

April 24 1955 01:30					
CP 82 Eastbound					
[Deliveries: 8;]					
Road	Number	Type	To	From	Final Destination
CP	357643	Hopper	Grand Forks.Siding		Archibald.Rock Candy Mine
CP	357786	Hopper	Grand Forks.Siding		Darestof.C
CP	50537	Box	Grand Forks.Siding		Grand Forks.Boundary Electric
CP	89065	Box	Grand Forks.Siding		Grand Forks.Boundary Electric
GN	5010	Box	Grand Forks.Siding		Grand Forks.Boundary Electric
GN	73982	Cov Hopper	Grand Forks.Siding		Darestof.C
MILW	716966	Box	Grand Forks.Siding		Grand Forks.Boundary Electric
UTLX	76942	Tank	Grand Forks.Siding		Grand Forks.Esso
**********					

A *Train Line-up* differs from a regular switch list in that it gives a view of one *location* whereas a timetable gives a view of one *train*.

Lineups show all of the train activity at one station, or any group of tracks, along with the times.

These can be a great aid to a yard crew in that they can easily see what cars will be arriving and which ones must be readied for pickup.

Like regular switch lists, they also indicate which cars are on *Hold* and are not to be moved. An inbound train may not be able to take all of the cars waiting for it, due to limits, and the line-up will help the yard crew separate the departing cars from the remainder.

Grand Forks Yard Line-up - Departing

April 24 1955 01:40					
CP 82 Eastbound					
[Pickups: 10; Holds: 4;]					
Road	Number	Type	To	From	Final Destination
ATSF	11074	Box	East.Staging (Lower)	Grand Forks.CP-Easts	East.Staging (Lower)
CNW	84028	Box	East.Staging (Lower)	Grand Forks.CP-Easts	East.Staging (Lower)
CP	240000	Box	Grand Forks.CP-Easts	HOLD	East.Staging (Lower)
CP	51856	Box	East.Staging (Lower)	Grand Forks.CP-Easts	East.Staging (Lower)
CRR	52769	Hopper	East.Staging (Lower)	Grand Forks.CP-Easts	East.Staging (Lower)
DTDX	38134	Tank	East.Staging (Lower)	Grand Forks.CP-Easts	East.Staging (Lower)
GN	73608	Hopper	Grand Forks.CP-Easts	HOLD	East.Staging (Lower)
MON	3029	Gondola	Grand Forks.CP-Easts	HOLD	East.Staging (Lower)
MP	112350	Box	East.Staging (Lower)	Grand Forks.CP-Easts	East.Staging (Lower)
NWP	1904	Box	East.Staging (Lower)	Grand Forks.CP-Easts	East.Staging (Lower)
TCX	270	Tank	Grand Forks.CP-Easts	HOLD	East.Staging (Lower)
UP	101	Cov Hopper	East.Staging (Lower)	Grand Forks.CP-Easts	East.Staging (Lower)
UP	185038	Box	East.Staging (Lower)	Grand Forks.CP-Easts	East.Staging (Lower)
UP	419	Cov Hopper	East.Staging (Lower)	Grand Forks.CP-Easts	East.Staging (Lower)

Analysis

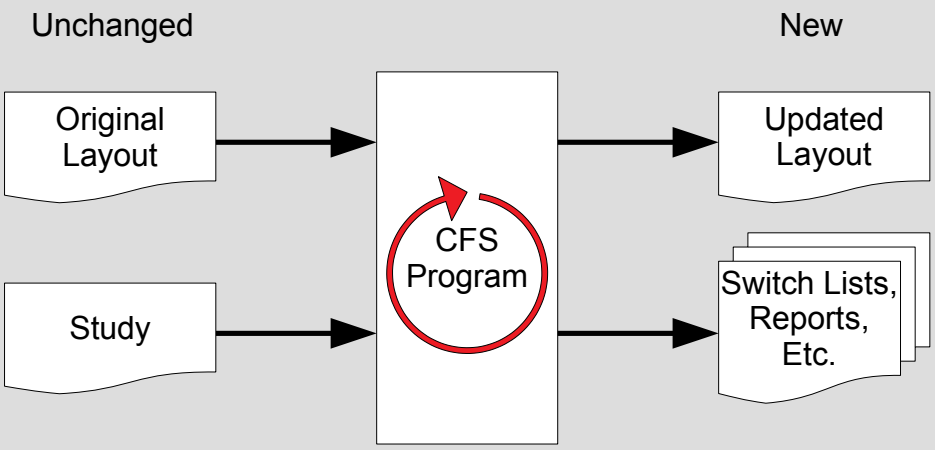
The program is really a *layout simulator* and not just a switch list generator. Running it with a sequence of trains to generate switch lists is called a *Study* as it goes far beyond just the switch lists.

For example, the same trains can be run repeatedly with different numbers of cars to assess the loading on the layout.

As time is continuous, it is very easy to run a study for multiple days to see longer term effects.

There are various files generated from a study that can be post-processed into charts and graphs to help visualize what is going on, by using a spreadsheet program.

Study Concept



The notion of a study was intended also to be a layout design tool by being able to simulate the entire layout operations before anything is built. Yard and staging capacity is always hard to guess in advance, but can be better estimated by being able to easily change capacities while running various studies and analysing the results.

Note that the input to the program is not changed by running a study, so that it is easy to rerun the same study with slightly different values to experiment with different scenarios to see their effect.

I run 30 day studies when designing train sequences and after changes to the layout to see how things trend over time, and then run the same study for one day at a time to generate switch lists for operating sessions.

S&BC Study for 7 Days

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<study comment="This is a test..." cycles="7" layout="sbclayout.csv" version="1.0">
   <message message="Starting Study" start="01:00"/>
   <runtrain start="00:00" format="switcher" timetable="GF Switcher" />
   <runtrain start="00:00" format="road" timetable="CP Eastbound" />
   <runtrain start="02:00" format="switcher" timetable="GF Switcher" />
   <runtrain start="00:00" format="road" timetable="SBC Northbound" />
   <runtrain start="04:00" format="switcher" timetable="GF Switcher" />
   <runtrain start="02:30" format="road" timetable="Passenger Southbound" />
   <runtrain start="05:30" format="road" timetable="SBC Southbound" />
   <runtrain start="08:30" format="switcher" timetable="GF Switcher" />
   <runtrain start="04:45" format="switcher" timetable="GF Switcher Industries" />
   <runtrain start="06:00" format="road" timetable="Passenger Northbound" />
   <runtrain start="08:30" format="road" timetable="CP Westbound" />
</study>
```

The only computer file in the entire presentation!

This shows the simple format of a study. The layout file is referenced near the start, and then there is a list of trains that get run according to timetables.

The same timetable can be reused any number of times by starting each train at a different time.

This is used to good effect for yard switchers that classify cars to the same tracks after each arriving train.

Eventually, this will have a nice user interface, but for now it must be edited by hand.

CP Eastbound Timetable

CP Eastbound	0:00	CP	West	Staging (Upper)	Note	Train is on Track 1
CP Eastbound	0:00	CP	West	Staging (Upper)	RESTAGE	
CP Eastbound	0:10	CP	West	Staging (Upper)	REBLOCK	GFEastBound
CP Eastbound	1:10	CP	West	Staging (Upper)	Depart	
CP Eastbound	1:30	SBC	Grand Forks	Main	Arrive	Check with GF Yard
CP Eastbound	1:30	SBC	Grand Forks	Main	VISIT	
CP Eastbound	1:30	SBC	Grand Forks	Siding	DELIVER	
CP Eastbound	1:30	SBC	Grand Forks	Siding	VISIT	
CP Eastbound	1:40	SBC	Grand Forks	CP-Easts	PICKUP	
CP Eastbound	1:55	SBC	Grand Forks	CP-Easts	Depart	
CP Eastbound	2:25	CP	East	Staging (Lower)	Arrive	Keep left when entering
CP Eastbound	2:25	CP	East	Staging (Lower)	Note	Train goes to Track 1
CP Eastbound	2:25	CP	East	Staging (Lower)	DELIVER	

The data for a simple timetable.

Note the usual operations to *Pick Up* and *Deliver* cars at the various tracks.

There are other types of operations possible, mostly to give the crew some extra information. More can be added as necessary.

The times in a timetable are not absolute, but indicate the time after the start of the train. This allows a timetable to be reused with different starting times.

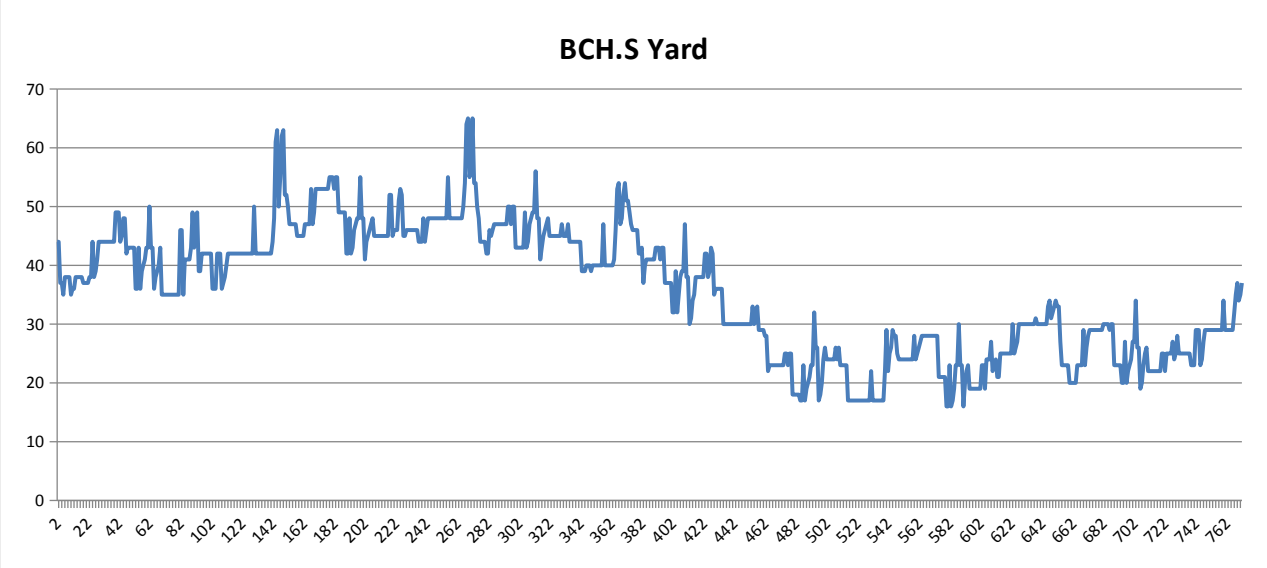
Reports

- Various **metrics** can be plotted against time
- Shows if the operations are in “**balance**”
- Produced by post-processing of the **Event Log**

Lots of reports on what is going on during a study.

Currently these are simple text files that are imported into a spreadsheet for analysis and display, but some of the functionality will be added into the program, for plots, charts, etc.

Simple Car Counts Over Time

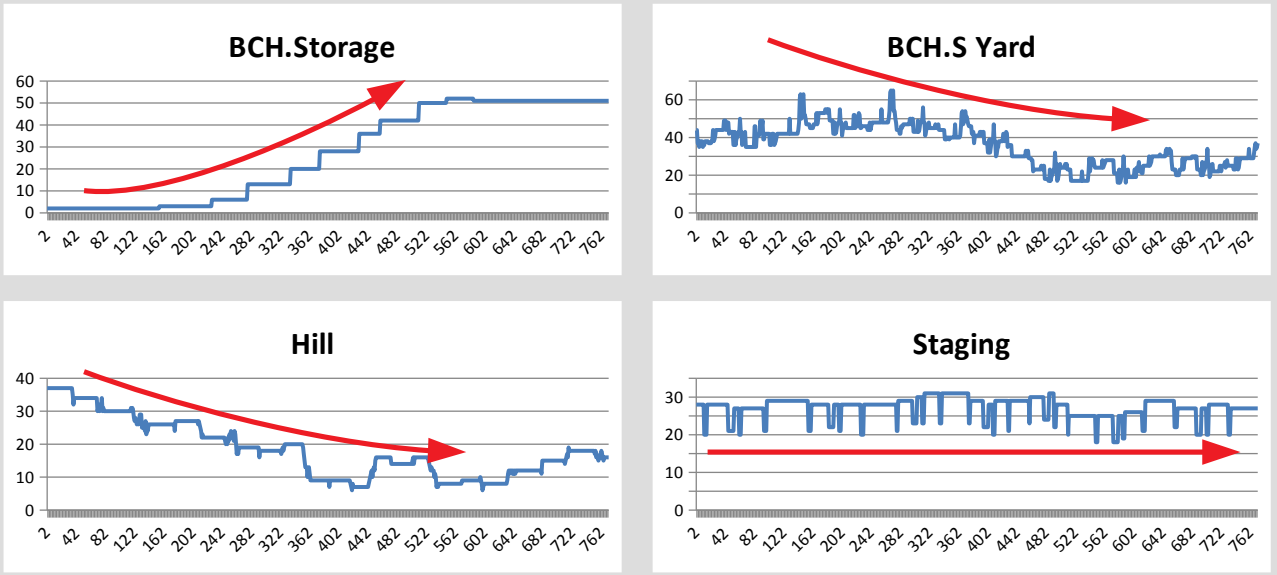


One of the most useful plots is the number of cars at a track or station over time. This gives a simple insight into how well the layout is *balanced.*

In this actual sample, taken from a friend's layout when were just getting started, there is obviously something going on as the number of cars in the yard trends downward then levels off.

We expect short term fluctuations as cars come and go, but the long term average should be more of less constant.

Inbound and Outbound Conflict

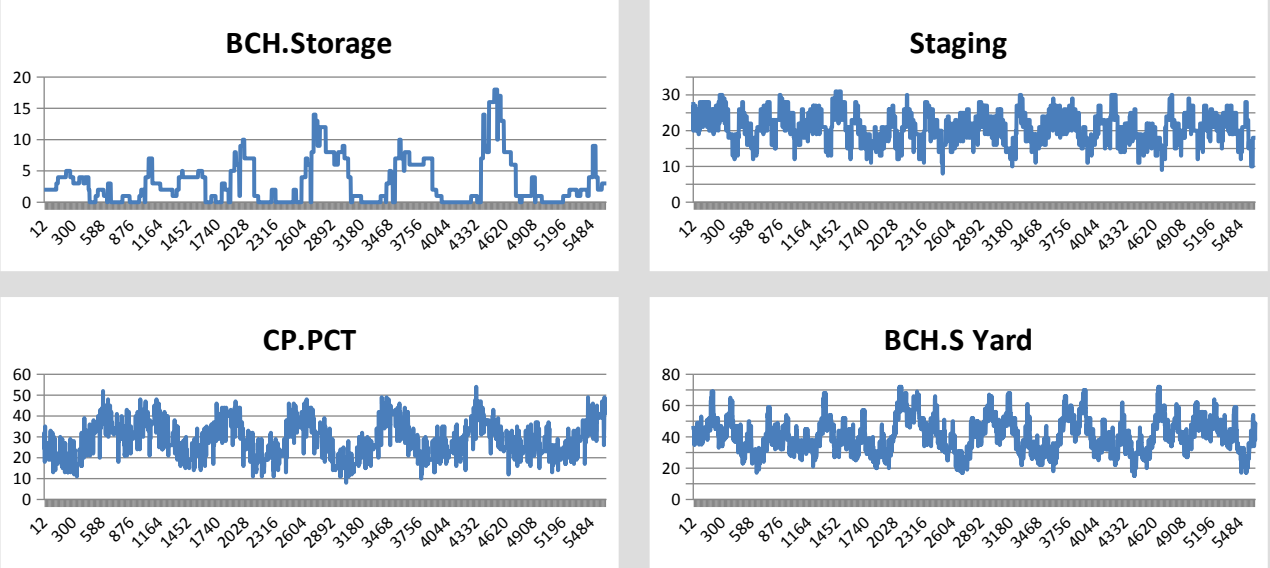


Further digging into different parts of the layout showed that a large number of cars end up in storage and do not return to the layout. This accounts for the drop in cars in the yard, as the entire layout is being starved for cars.

Interestingly, the number of cars in staging remain pretty constant, indicating that it is well balanced between departures and arrivals.

More searching revealed that the underlying cause was insufficient space in a secondary yard. The solution was to have some trains bypass this yard so as to not overload it. More studies proved the idea, which has since been borne out in practice.

Oscillations

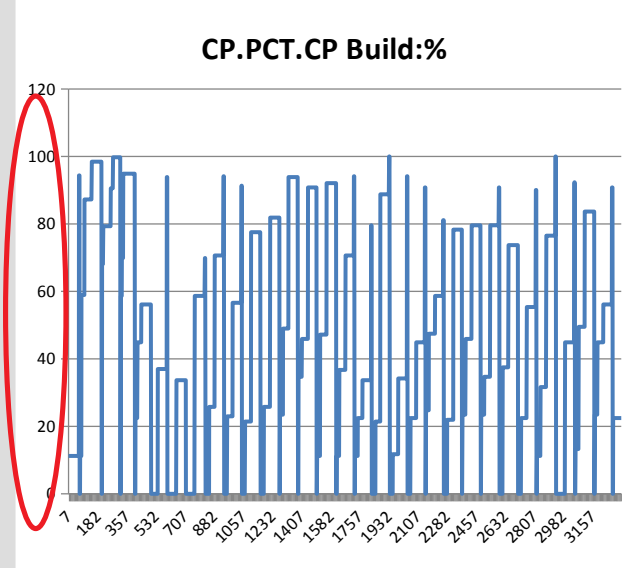


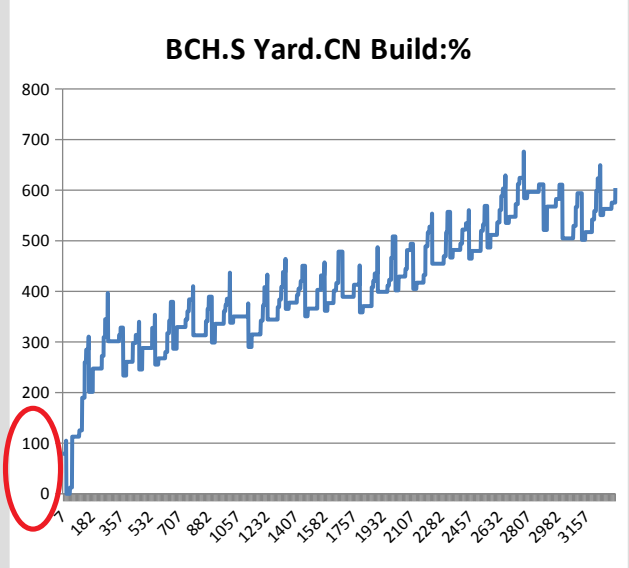
Once the imbalances were sorted out, there then seemed to be some sort of underlying oscillation with a period of around 6 days. This showed in almost all of the major stations.

Cars are going into storage, but they are also coming back in equal numbers, unlike the previous problem.

No specific cause was ever found for this and we just decided to live with it as a natural variation.

Not Clearing Outbound Cars to CN





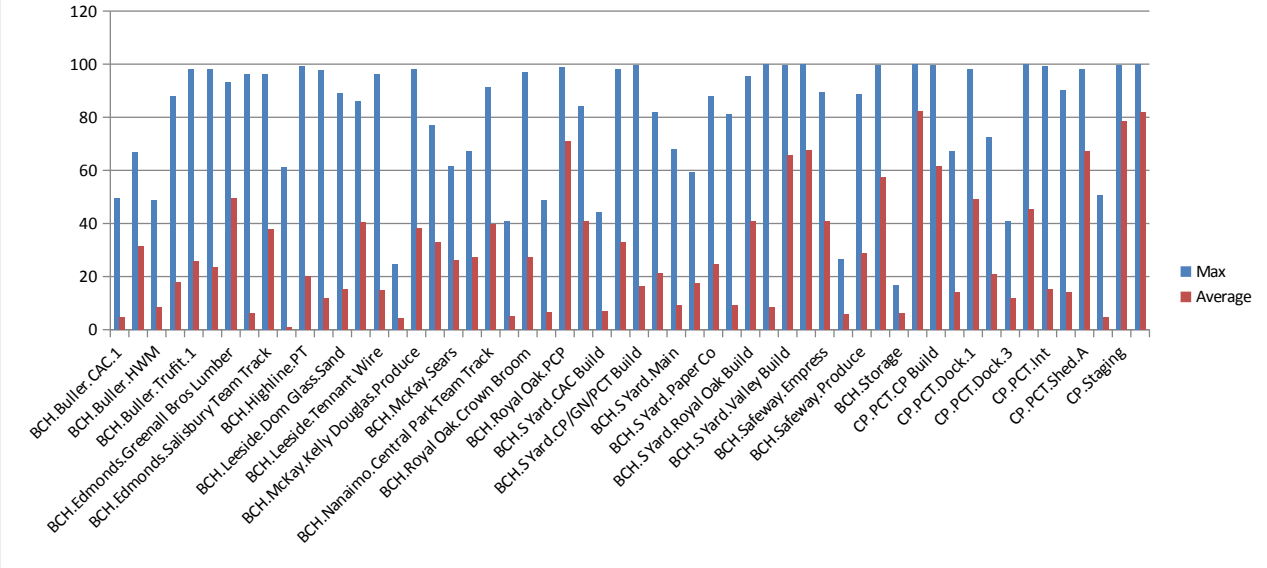
The plot on the left is cars waiting to go to CP staging, and the one of the right to CN staging.

The CP track is normal, in that it fills with cars by the switcher, and then they are removed by the transfer train and taken to staging. It oscillates between nearly full and empty with realistic variations.

Something funny is going on in the CN case. It behaves as expected for one day, then cars start to pile up and are never cleared.

The cause turned out to be having both the inbound and outbound cars trying to occupy the same limited capacity track at the same time. The solution was to adjust when the trains ran.

Average and Maximum Track Occupancy



The plot shows the Maximum and Average occupancy of each track on the layout from a 30 day study. The blue is maximum, and the red is average.

This makes it easy to spot tracks that are not getting much traffic, as well as those that tend to be very full.

Interestingly, some tracks have a very low average occupancy, but occasionally are full, so this implies a very uneven usage.

This can be investigated by adjusting the number of specific car types, roles, etc., to see how it changes, and therefore gain more insight.

Restaging Shipment Counts

stn	ind	dir	total	Boxcar	Cov Hopper	Flat	Gondola	Hopper	Log	Ore	Reefer	Stock	Tank
HOPE	STAGING	INBOUND	10	9	0	0	0	0	0	0	1	0	0
HOPE	STAGING	THROUGH	19	17	0	0	0	0	0	0	2	0	0
HOPE	STAGING	OUTBOUND	315	261	0	0	0	42	2	5	0	5	0
ODLUM THROUGH	STAGING	INBOUND	19	10	0	0	2	0	0	0	1	0	6
ODLUM THROUGH	STAGING	THROUGH	42	31	5	0	4	0	0	0	0	0	2
ODLUM THROUGH	STAGING	OUTBOUND	315	261	0	0	0	42	2	5	0	5	0
ODLUM	STAGING	INBOUND	5	1	0	0	2	0	0	0	0	0	2
ODLUM	STAGING	THROUGH	2	1	1	0	0	0	0	0	0	0	0
ODLUM	STAGING	OUTBOUND	315	261	0	0	0	42	2	5	0	5	0
PENTICTON	STAGING	INBOUND	24	5	0	3	15	0	0	0	0	0	1
PENTICTON	STAGING	THROUGH	79	35	1	5	14	1	0	0	23	0	0
PENTICTON	STAGING	OUTBOUND	315	261	0	0	0	42	2	5	0	5	0
PRINCETON	STAGING	INBOUND	1	1	0	0	0	0	0	0	0	0	0
PRINCETON	STAGING	THROUGH	29	25	0	0	2	0	0	0	2	0	0
PRINCETON	STAGING	OUTBOUND	315	261	0	0	0	42	2	5	0	5	0
SPENCES BRIDGE	STAGING	INBOUND	11	7	0	3	0	0	0	0	0	0	1
SPENCES BRIDGE	STAGING	THROUGH	88	67	0	13	2	0	0	0	1	4	1
SPENCES BRIDGE	STAGING	OUTBOUND	315	261	0	0	0	42	2	5	0	5	0

It is important to have enough variety of roles for specific car types so that there is usually something available to be assigned to every car when it is restaged.

If a given car type can only be sent to a few places on the layout, then it is more likely to be moved to storage.

Track Shipment Counts

stn	ind	inbounds	outbounds
BROOKMERE	BROOKMERE OIL TRACK	2	0
BROOKMERE	MAINTENANCE OF WAY DEPT	4	0
DIAMONDVALE	DIAMONDVALE COAL AND IRON	0	11
DIAMONDVALE	DIAMONDVALE COKE AND COAL	2	0
HOPE	BC ELECTRIC	1	0
HOPE	IMPERIAL OIL	2	0
HOPE	MAINTENANCE OF WAY DEPT	3	0
HOPE	OCS Track	2	0
HOPE	PRINCETON SAWMILLS	1	47
HOPE	RAINBOW RANCH	0	1
IAGO	Spur	5	0
JULIET	MURRAY LAKE LOGGING	0	2
KINGSVALE	Spur	2	23
MERRITT	ASPEN PV LUMBER	0	47
MERRITT	BA OIL	2	0
MERRITT	CITY OF MERRITT	1	0
MERRITT	Freight House	20	0
MERRITT	IMPERIAL OIL	4	0
MERRITT	MERRITT DIAMOND SAWMILL	0	50

This shows the numbers of shipments to and from the various industries.

If there are not enough shipments available to be selected during restaging, then industries can become starved for cars.

Car History for Two Shipments

time	car	cartype	stn	ind	train	operation
1955-05-13 00:00:00	CP-89065	Box	South	Staging	UP 21 Northbound	RESTAGED
1955-05-13 00:00:00	CP-89065	Box	South	Staging	UP 21 Northbound	PICKUP
1955-05-13 03:20:00	CP-89065	Box	Grand Forks	Siding	UP 21 Northbound	DELIVER
1955-05-13 04:00:00	CP-89065	Box	Grand Forks	Siding	GF Switcher After UP 21	PICKUP
1955-05-13 04:45:00	CP-89065	Box	Grand Forks	Locals	GF Switcher After UP 21	DELIVER
1955-05-13 04:51:00	CP-89065	Box	Grand Forks	Locals	GF Industries	PICKUP
1955-05-13 05:15:00	CP-89065	Box	Grand Forks	Sawmill	GF Industries	DELIVER
1955-05-14 05:15:00	CP-89065	Box	Grand Forks	Sawmill	GF Industries	PICKUP
1955-05-14 08:15:00	CP-89065	Box	Grand Forks	SBC-Norths	GF Industries	DELIVER
1955-05-15 03:30:00	CP-89065	Box	Grand Forks	SBC-Norths	UP 21 Northbound	PICKUP
1955-05-15 04:55:00	CP-89065	Box	North	Staging (Upper)	UP 21 Northbound	DELIVER
1955-05-15 05:30:00	CP-89065	Box	North	Staging (Upper)	UP 22 Southbound	RESTAGED
1955-05-15 05:30:00	CP-89065	Box	North	Staging (Upper)	UP 22 Southbound	PICKUP
1955-05-15 07:30:00	CP-89065	Box	Grand Forks	Siding	UP 22 Southbound	DELIVER
1955-05-15 08:30:00	CP-89065	Box	Grand Forks	Siding	GF Switcher After UP 22	PICKUP
1955-05-15 09:15:00	CP-89065	Box	Grand Forks	Locals	GF Switcher After UP 22	DELIVER
1955-05-16 04:51:00	CP-89065	Box	Grand Forks	Locals	GF Industries	PICKUP
1955-05-16 05:15:00	CP-89065	Box	Grand Forks	Sawmill	GF Industries	DELIVER
1955-05-17 05:15:00	CP-89065	Box	Grand Forks	Sawmill	GF Industries	PICKUP
1955-05-17 08:15:00	CP-89065	Box	Grand Forks	CP-Easts	GF Industries	DELIVER
1955-05-18 01:40:00	CP-89065	Box	Grand Forks	CP-Easts	CP 82 Eastbound	PICKUP
1955-05-18 02:25:00	CP-89065	Box	East	Staging (Lower)	CP 82 Eastbound	DELIVER

It is easy to follow any particular car to see where all it goes and what roles it plays over time.

This sample is for one CP box car that played two roles over a number of days. Note that it takes five days to complete the two assignments.

Summary

- **Selects** suitable **Shipments** for Cars in staging
- **Generates** necessary **Waybills** for Shipments
- **Runs Trains** to pick up and deliver Cars according to their Waybills
- **Prints Switch Lists**
- **Records** an **Event Log** that can be analysed

Not Covered

- Districts for Car selection and home routing
- Car wait times are configurable
- Additional Waybills for icing, cleaning, etc.
- Car location summary
- CSV and XML file formats

Work has started to incorporate the car selection and routing rules as found in the 1953 ORER, but this has not gone very far yet.

The time a car must wait after delivery before it can be picked up by another train is configurable for each role. This allows a car to remain on spot for a week at some small industry, or for a reefer being iced to be ready in a couple of hours. Cars do not move only once per session, but when they are ready to move.

More waybill types can be added for things like icing, cleaning, etc.

The program currently can read and write both CSV and XML file formats. I may add the ability to import other formats for convenience.

Not Covered

- Track Pools and “elastic” Tracks
- Diagnostics to help find data errors
- “Stuck” Cars
- Developed in Java using Netbeans on a Mac

Track Pools enable the member tracks to become *elastic* and borrow space from the other member tracks in the pool so that they can hold more cars than their natural capacity. This is useful where trains run at different times of the day and not all of the space is required at the same time time.

There are many data consistency checks built in to help catch data errors.

Stuck Cars are reported if they have not moved after a certain length of time, usually indicating a lack of train coverage of their location.

The program has been tested on Mac, Linux, and Windows with no changes.

Q & A

Gregory Madsen
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I am working on a web site for my railroad that includes a number of blog posts describing some of the more esoteric discussions that we have had about how best to handle some fine points in the most prototypical manner.

It is at: www.sbcrailway.ca