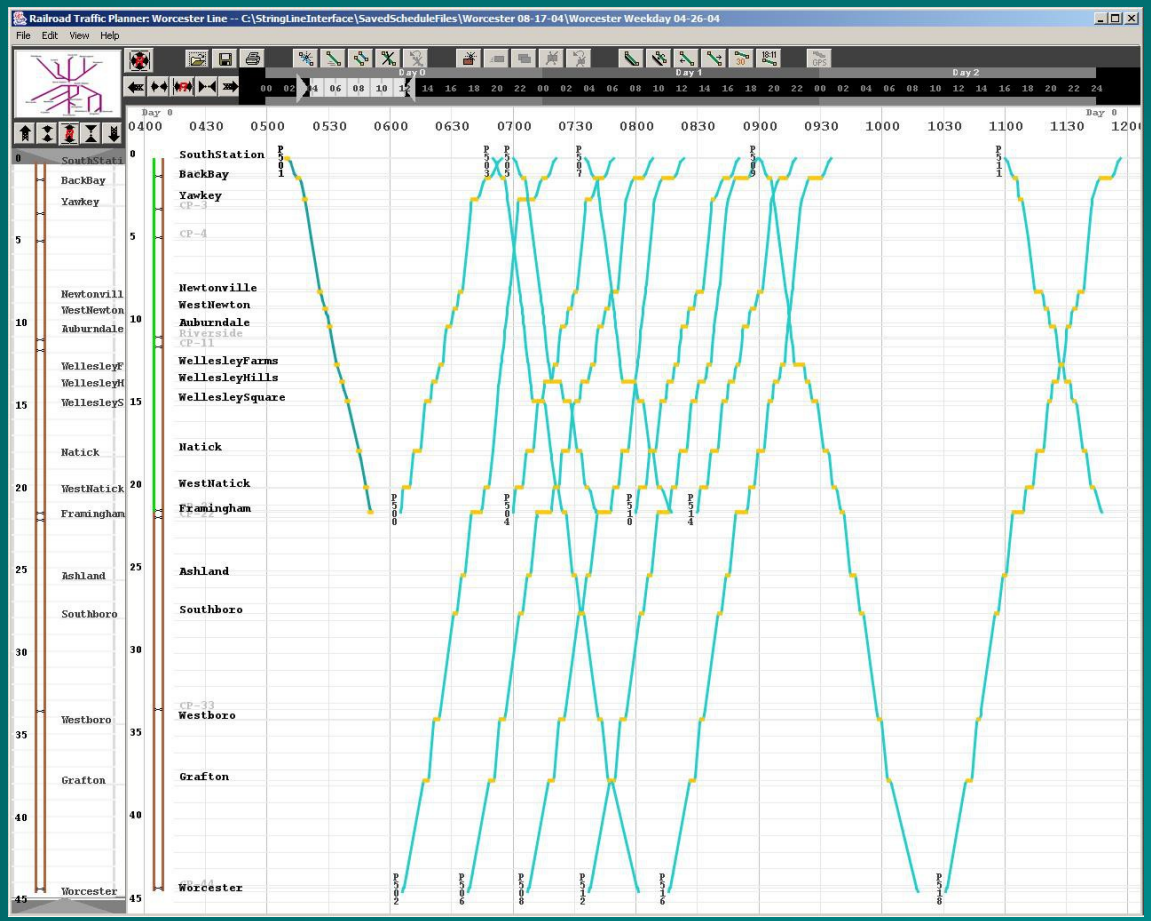
Visualizing Railroad Operations

A Tool for Traffic Planners and Dispatchers



Federal Railroad Administration

Volpe Center
Research and Special Programs Adminstration

Massachusetts Institute of Technology

Technology Integration Analysis
Fulcrum Corporation

Mary T. Lee, John A. Volpe National Transportation System Center

Presentation for *Railroad Dispatching Operations: Putting Research into Practice*, September 30, 2004, Scottsdale, Arizona

Presentation Topics

- Background Information
- The *Railroad Traffic Planner* Tool
- Possible Uses for Dispatching
- Conclusions

Background Information…

Brief Project History

- The Volpe Center and MIT have been developing the *Railroad Traffic Planner* for the FRA since 1996 as part of a project to explore the benefits of various "knowledge display interfaces"
- Traffic planners at MBTA Commuter Rail and Guilford Rail System participated in the design and testing of early versions of the application
- Fulcrum Corporation joined the team in 2003 to support "technology transfer" to additional railroads
- North Shore Railroad and the Paducah and Louisville Railway are the latest demonstration sites

Goals

- Proof-of-concept software to identify potential benefits of this type of planning tool
- Iterative, user-centered approach

Railroad Traffic Planning

- The application was initially developed for traffic planners who create and modify train schedules (not dispatchers)

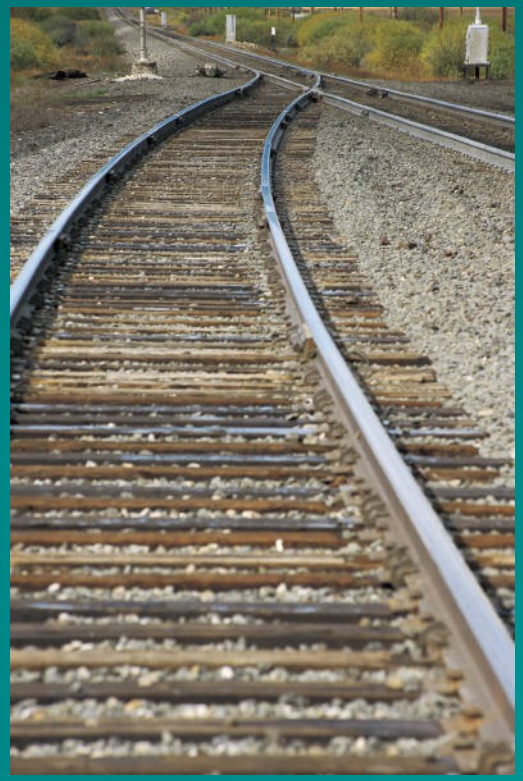
- Traffic Planning requires complex decision-making and many trade-offs
  - Even small changes can take many hours when using paper schedules
  - They rarely have time to explore schedule alternatives and find the “best” solutions

	SATURDAY		SATURDAY AND SUNDAY						
	1802	1804	1806	1808	1810	1812	1814	1816	1818
INBOUND			2806	2808	2810	2812	2814	2816	2818
READ DOWN	A.M.	A.M.	A.M.	P.M.	P.M.	P.M.	P.M.	P.M.	P.M.
Dep: South Attleboro	6 45	8 45	11 30	1 05	2 45	4 30	7 05	8 45	10 10
Attleboro	6 53	8 53	11 38	1 13	2 53	4 38	7 13	8 53	10 18
Mansfield	7 00	9 00	11 45	1 20	3 00	4 45	7 20	9 00	10 25
Sharon	7 08	9 08	11 53	1 28	3 08	4 53	7 28	9 08	10 33
Canton Junction	7 15	9 15	12 00	1 35	3 15	5 00	7 35	9 15	10 40
Route 128	7 20	9 20	12 05	1 40	3 20	5 05	7 40	9 20	10 45
Hyde Park	7 25	9 25	12 10	1 45	3 25	5 10	7 45	9 25	10 50
Ruggles	7 35	935	12 22	1 55	3 35	5 20	7 55	9 35	11 00
Back Bay	7 38	9 38	12 25	1 58	3 38	5 23	7 58	9 38	11 03
Arr: South Station	7 43	9 43	12 30	2 03	3 43	5 28	8 03	9 43	11 08

	1801	1803	1805	1807	1809	1811	1813	1815	1817
OUTBOUND			2805	2807	2809	2811	2813	2815	2817
READ DOWN	A.M.	A.M.	A.M.	P.M.	P.M.	P.M.	P.M.	P.M.	P.M.
Dep: South Station	6 45	10 05	11 05	1 00	2 30	4 45	6 45	8 45	11 00
Back Bay	6 50	10 10	11 10	1 05	2 35	4 50	6 50	8 50	11 05
Ruggles	6 53	10 13	11 13	1 08	2 38	4 53	6 53	8 53	11 08
Hyde Park	7 01	10 21	11 21	1 16	2 46	5 01	7 01	9 01	11 16
Route 128	7 06	10 26	11 26	1 21	2 51	5 06	7 06	9 06	11 21
Canton Junction	7 11	10 31	11 31	1 26	2 56	5 11	7 11	9 11	11 26
Sharon	7 16	10 36	11 36	1 31	3 01	5 16	7 16	9 16	11 31
Mansfield	7 24	10 44	11 44	1 39	3 09	5 24	7 24	9 24	11 39
Attleboro	7 31	10 51	11 51	1 46	3 18	5 31	7 31	9 31	11 46
Arr: South Attleboro	7 40	11 00	12 00	1 55	3 28	5 40	7 40	9 40	11 55

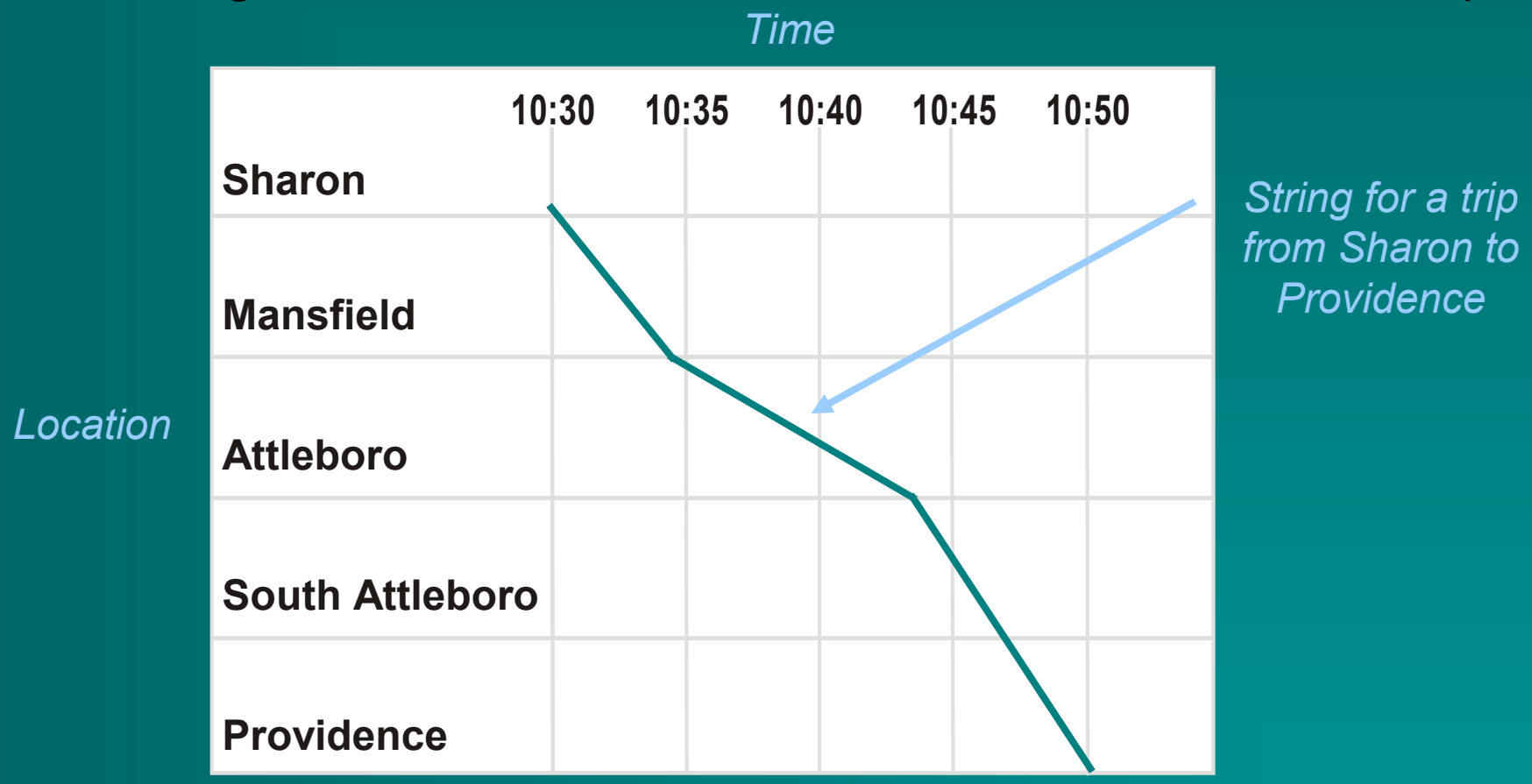
Estimating the Future

- Planners need to determine the operational sequence of future events
  - Who will arrive where and when?
  - How will track restrictions impact the schedule?
  - How can the flow best be managed?



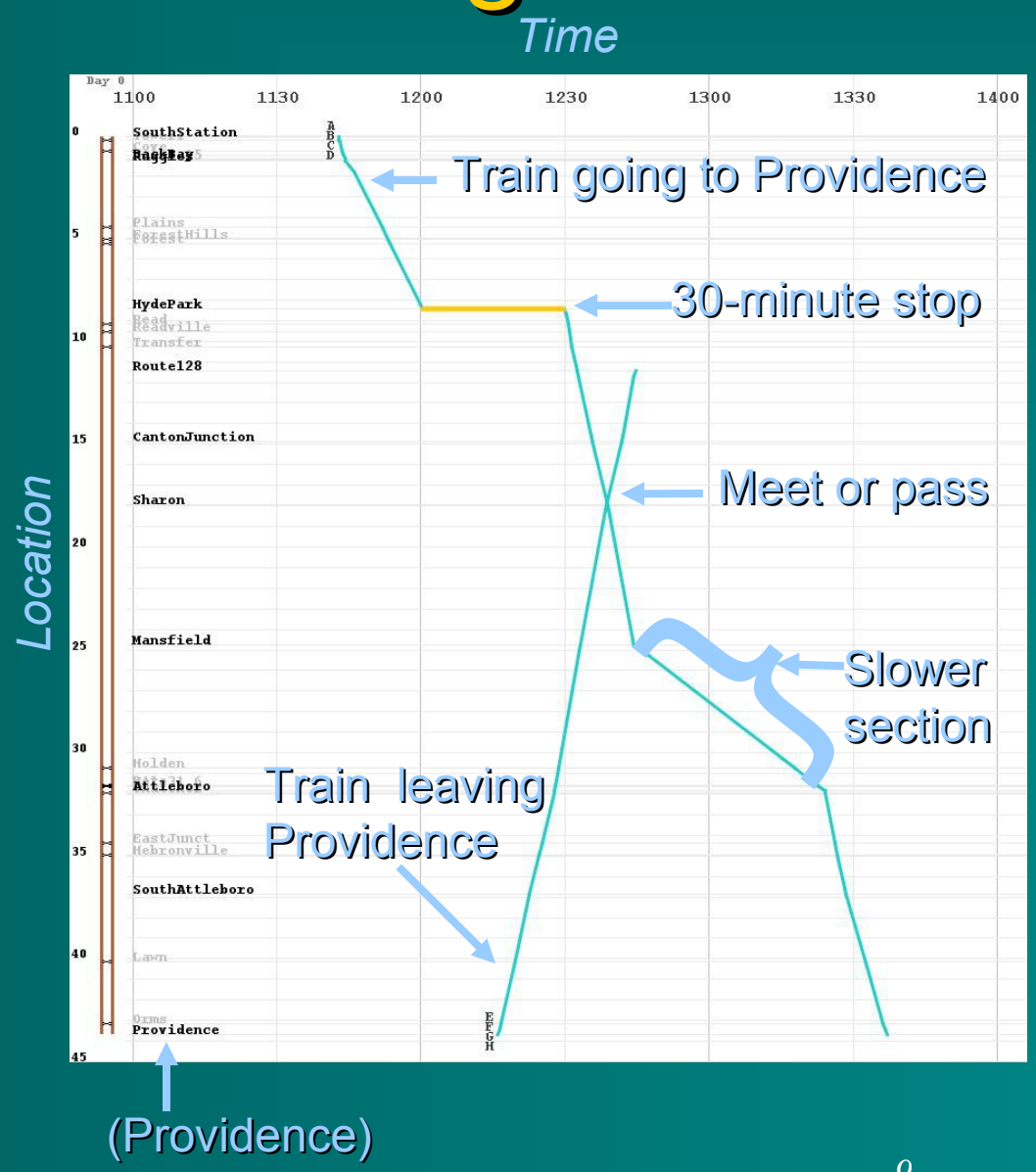
Stringline Diagrams

- A string shows the times <u>and</u> locations of a scheduled trip



- Railroads have used non-computerized stringline diagrams for many years

Strings Show Many Things



- Span along time axis represents duration
- Span along location axis represents distance
- Horizontal line indicates that train is stopped
- Intersecting lines show that trains will meet if on same track or pass if on separate tracks
- Slope of line indicates direction and relative speed

Side-By-Side Comparison

Paper Schedule

	SATURDAY		SATURDAY AND SUNDAY						
	1802	1804	1806	1808	1810	1812	1814	1816	1818
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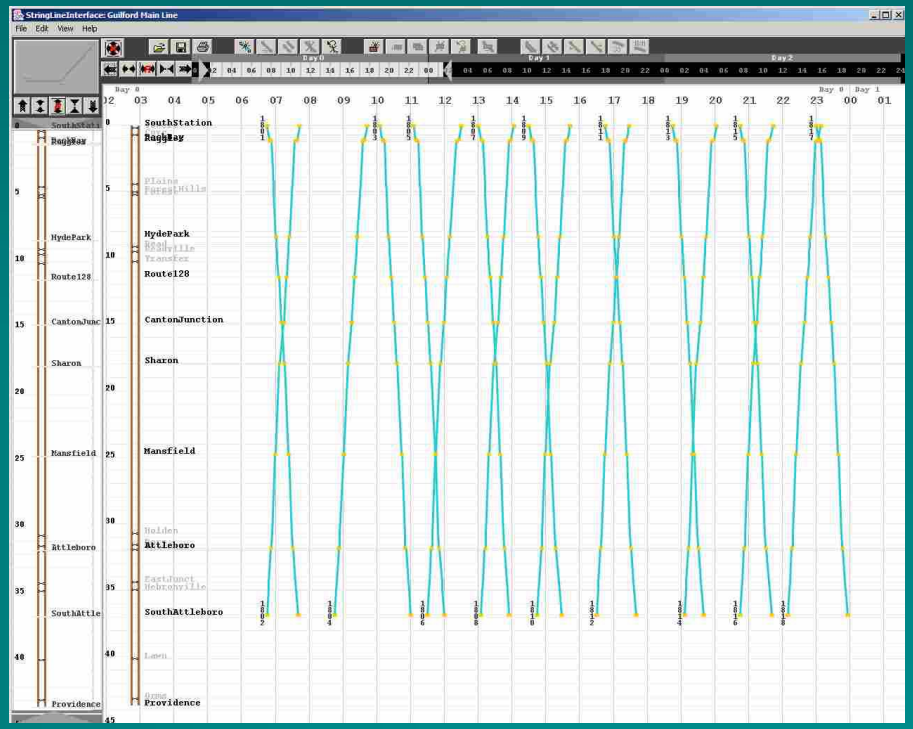
READ DOWN	A.M.	A.M.	A.M.	P.M.	P.M.	P.M.	P.M.	P.M.	P.M.
Dep: South Attleboro	6 45	8 45	11 30	1 05	2 45	4 30	7 05	8 45	10 10
Attleboro	6 53	8 53	11 38	1 13	2 53	4 38	7 13	8 53	10 18
Mansfield	7 00	9 00	11 45	1 20	3 00	4 45	7 20	9 00	10 25
Sharon	7 08	9 08	11 53	1 28	3 08	4 53	7 28	9 08	10 33
Canton Junction	7 15	9 15	12 00	1 35	3 15	5 00	7 35	9 15	10 40
Route 128	7 20	9 20	12 05	1 40	3 20	5 05	7 40	9 20	10 45
Hyde Park	7 25	9 25	12 10	1 45	3 25	5 10	7 45	9 25	10 50
Ruggles	7 35	935	12 22	1 55	3 35	5 20	7 55	9 35	11 00
Back Bay	7 38	9 38	12 25	1 58	3 38	5 23	7 58	9 38	11 03
Arr: South Station	7 43	9 43	12 30	2 03	3 43	5 28	8 03	9 43	11 08

	1801	1803	1805	1807	1809	1811	1813	1815	1817
OUTBOUND			2805	2807	2809	2811	2813	2815	2817
READ DOWN	A.M.	A.M.	A.M.	P.M.	P.M.	P.M.	P.M.	P.M.	P.M.
Dep: South Station	6 45	10 05	11 05	1 00	2 30	4 45	6 45	8 45	11 00
Back Bay	6 50	10 10	11 10	1 05	2 35	4 50	6 50	8 50	11 05
Ruggles	6 53	10 13	11 13	1 08	2 38	4 53	6 53	8 53	11 08
Hyde Park	7 01	10 21	11 21	1 16	2 46	5 01	7 01	9 01	11 16
Route 128	7 06	10 26	11 26	1 21	2 51	5 06	7 06	9 06	11 21
Canton Junction	7 11	10 31	11 31	1 26	2 56	5 11	7 11	9 11	11 26
Sharon	7 16	10 36	11 36	1 31	3 01	5 16	7 16	9 16	11 31
Mansfield	7 24	10 44	11 44	1 39	3 09	5 24	7 24	9 24	11 39
Attleboro	7 31	10 51	11 51	1 46	3 18	5 31	7 31	9 31	11 46
Arr: South Attleboro	7 40	11 00	12 00	1 55	3 28	5 40	7 40	9 40	11 55

Railroad Traffic Planner Schedule

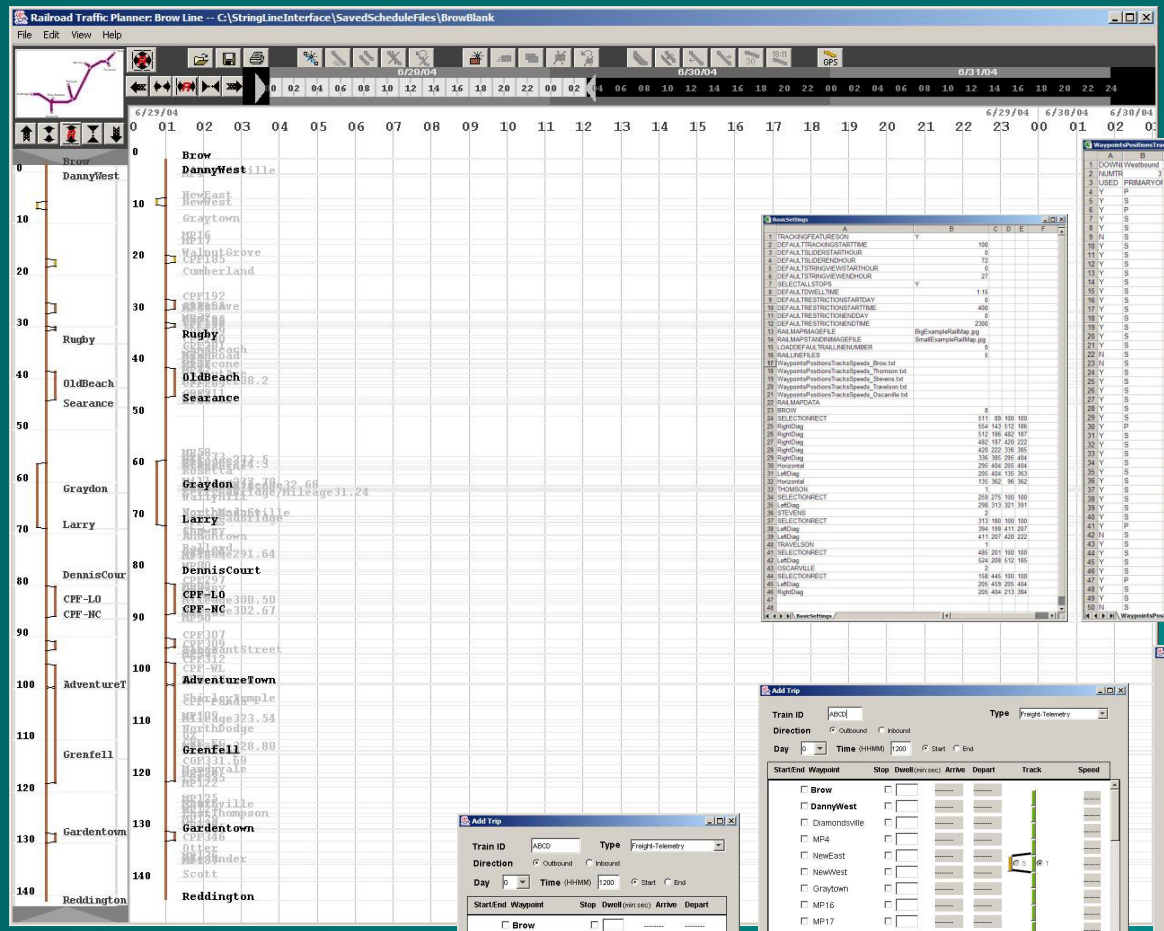


- Strings show entire trips, rather than just the stops
- With strings, it is easier to see where and when trains will be close together
- On the computer, strings can be moved around easily

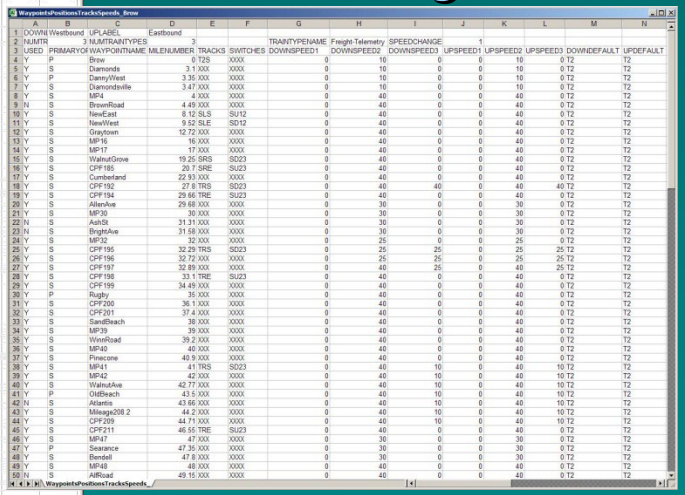
The *Railroad Traffic Planner* Tool…

Overview Image

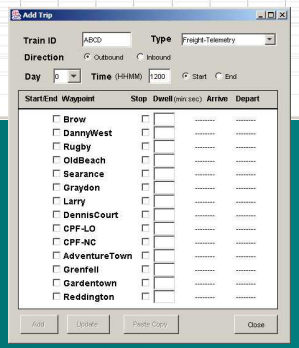
Main Window

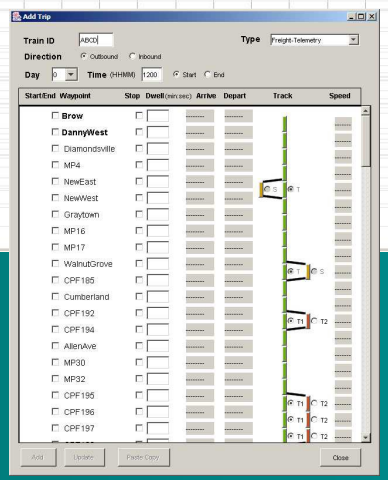


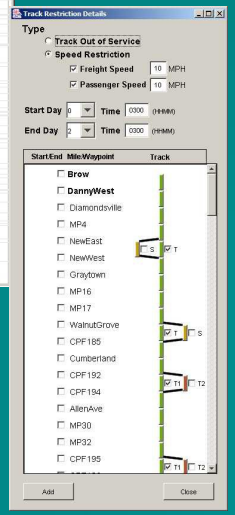
Settings Files

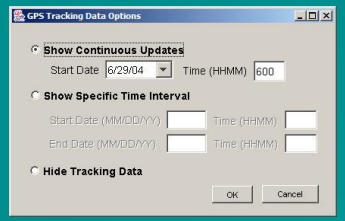


Popup Windows



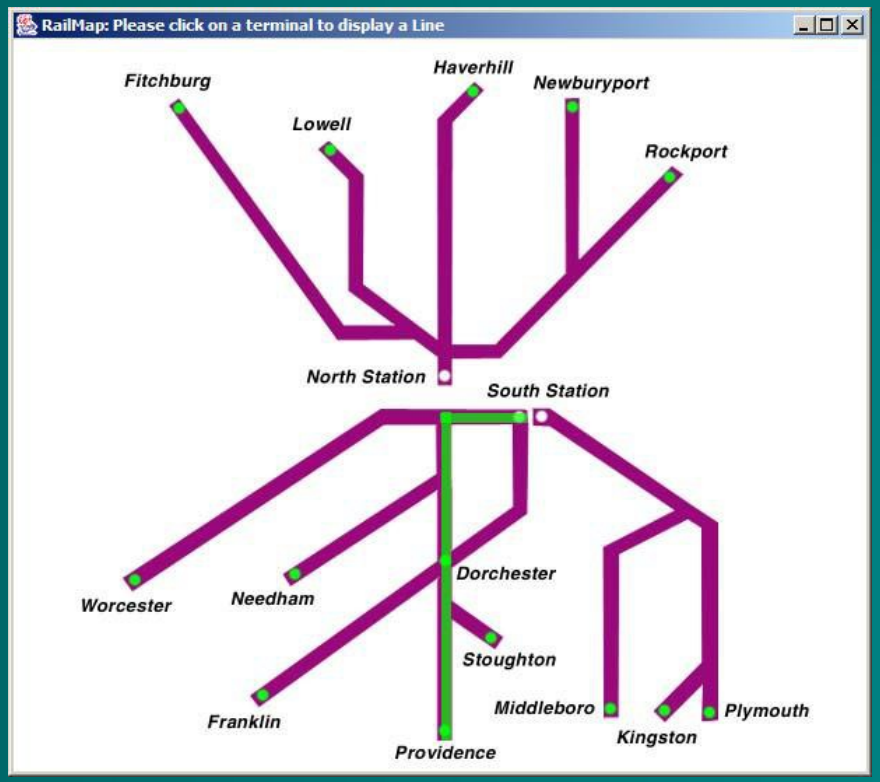




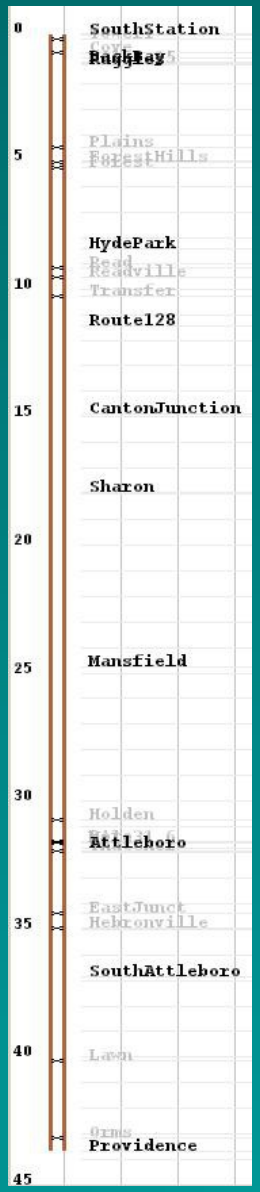


Selecting a Line

- Select a line from the *Rail Map* to set the *location* axis of the stringline diagram



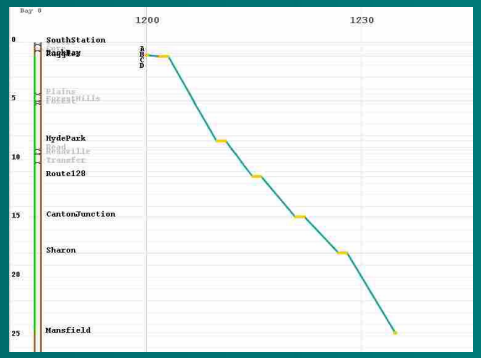
- "Location" includes:
  - Mile numbers
  - Track configuration
  - Waypoint names



Adding Trips (Strings)

- Provide the following information to create a new string
  - Train Type
  - Train ID
  - Direction
  - Start or End Day and Time
  - Start and End Waypoints
  - Dwell Times at Stops
  - Tracks

Press Add to make the string



Add Trip

Train ID: ABCD Type: Passenger

Direction: Outbound / Inbound

Day: 0 Time (HHMM): 1200 Start / End

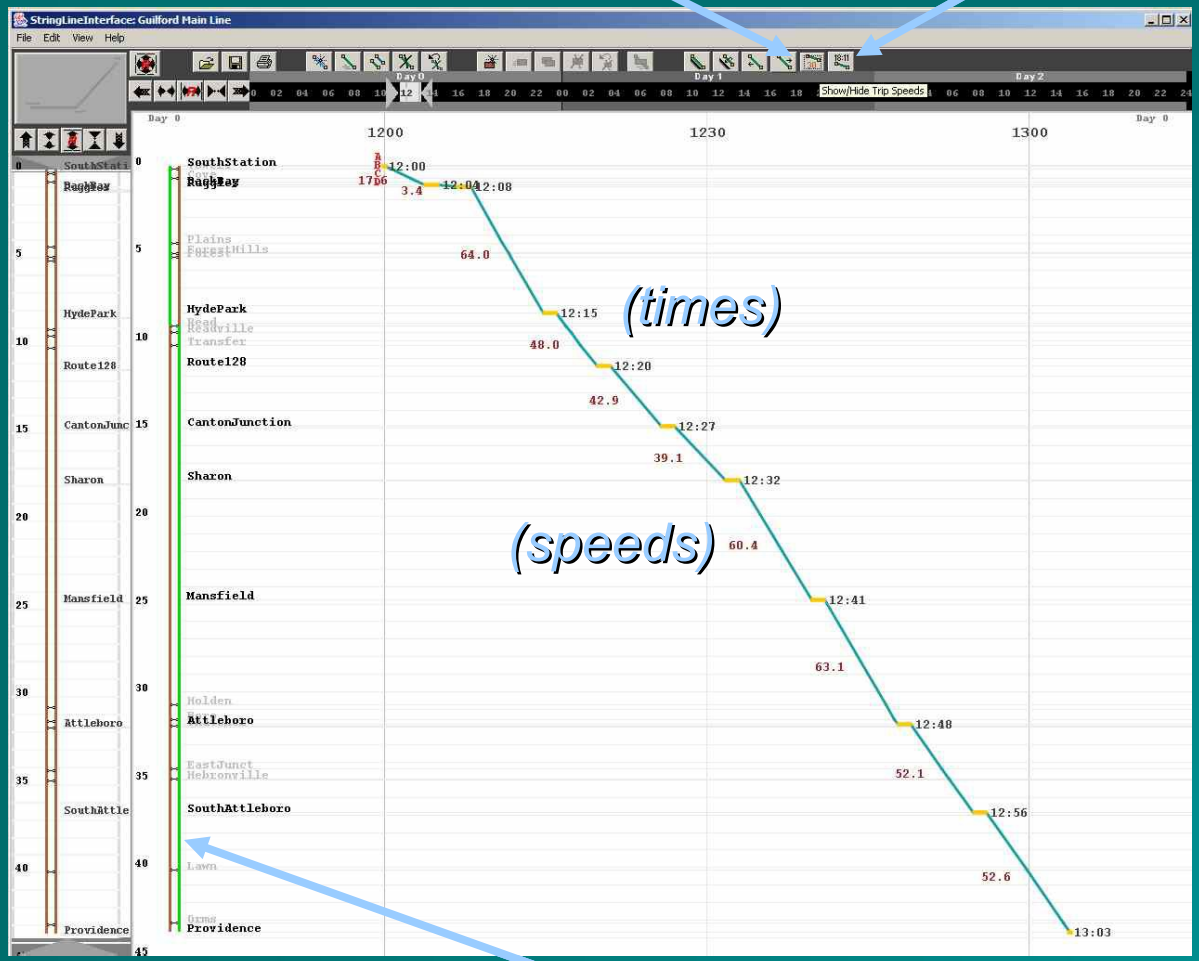
Start/End	Waypoint	Stop	Dwell (min:sec)	Arrive	Depart	Track	Speed
	SouthStation					T1 T2	
	Tower1					T1 T2	
	Cove					T1 T2	
Start	BackBay				12:00:00	T1 T2	3.4
	Ruggles	☑	1:15	12:01:45	12:03:00	T1 T2	64.0
	Plains			12:06:00	12:06:00	T1 T2	64.0
	ForestHills			12:06:33	12:06:33	T1 T2	64.0
	Forest			12:06:45	12:06:45	T1 T2	64.0
	HydePark	☑	1:15	12:09:44	12:10:59	T1 T2	48.0
	Read			12:11:52	12:11:52	T1 T2	48.0
	Readville			12:12:22	12:12:22	T1 T2	48.0
	Transfer			12:13:15	12:13:15	T1 T2	48.0
	Route128	☑	1:15	12:14:44	12:15:59	T1 T2	42.9
	CantonJunction	☑	1:15	12:20:45	12:22:00	T1 T2	39.1
	Sharon	☑	1:15	12:26:44	12:27:59	T1 T2	60.4
End	Mansfield			12:34:45		T1 T2	
	Holden					T1 T2	
	Boro					T1 T2	
	Attleboro					T1 T2	
	Thatcher					T1 T2	

Add | Update | Paste Copy | Clear | Close

Showing Tracks, Times and Speeds

Click to Show Speeds

Click to Show Times

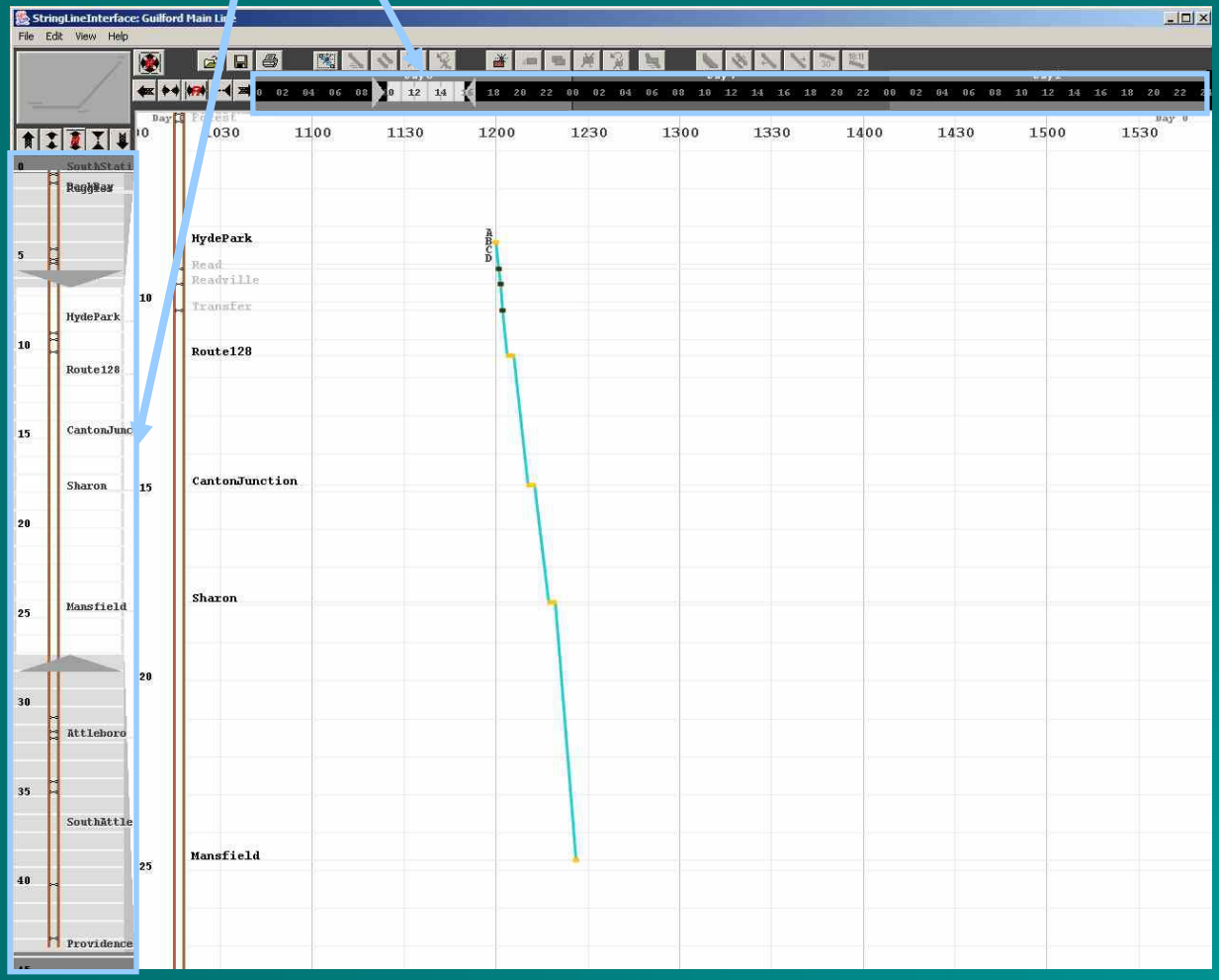


Corresponding tracks turn green when string is selected

Adjusting the View

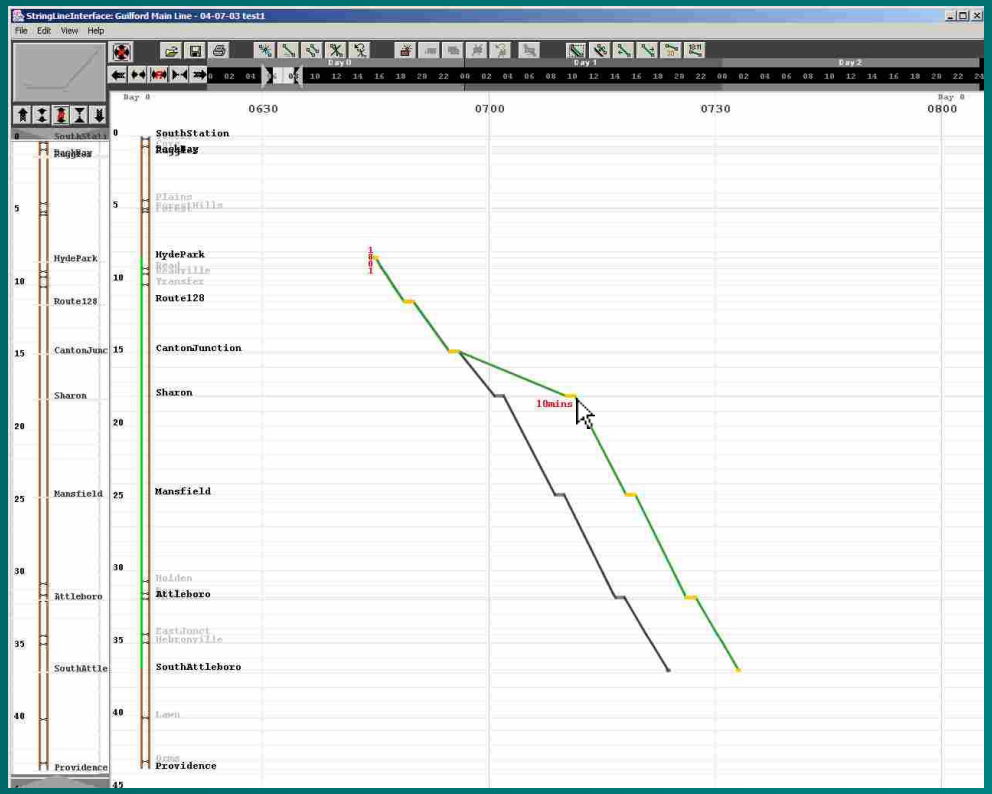
- Zoom to focus on parts of the schedule

Sliders show extent of zoom

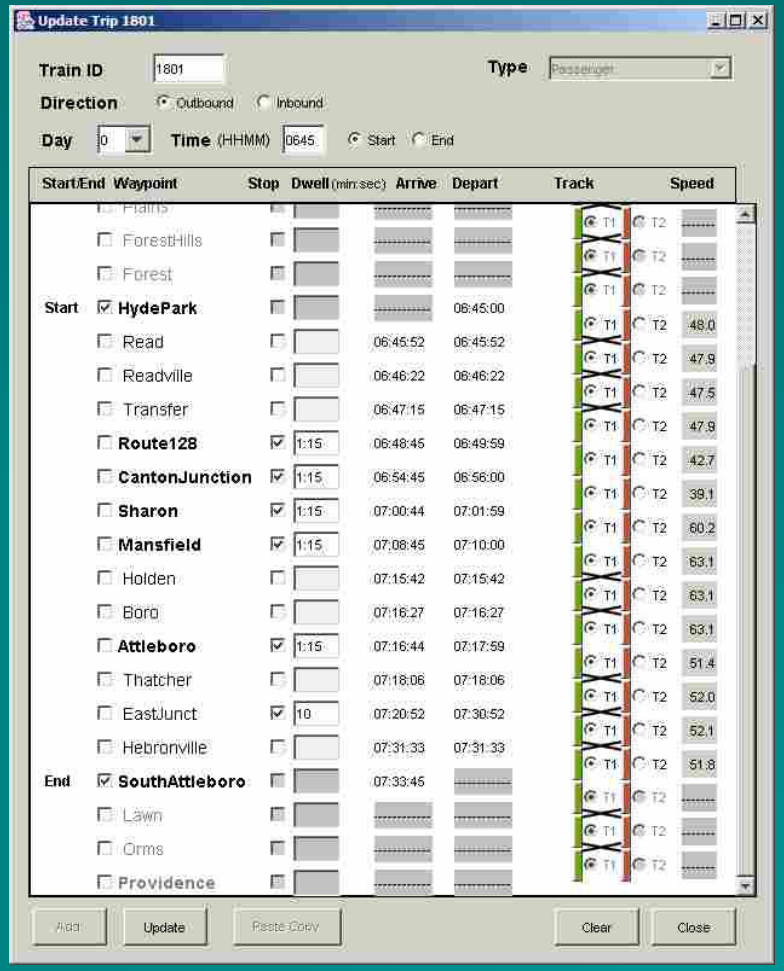


Several Ways to Revise Trips

- Click and drag



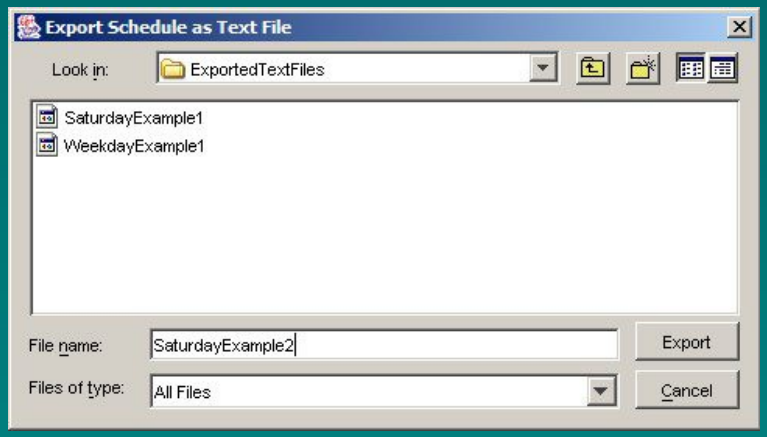
- Enter changes



- Use toolbar buttons

Exporting to Table Format

- Schedules can be exported and then opened as text files or spreadsheets
- Traditional tabular format can be easily shared with others



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	OUTBOUND		1801		1803		1805		1807		1809		1811		1813		1815		1817
2	READDOWN		Arrive	Depart	Arrive	Depart	Arrive	Depart	Arrive	Depart	Arrive	Depart	Arrive	Depart	Arrive	Depart	Arrive	Depart	Arrive
3	SouthStation		x	645	x	1005	x	1105	x	1300	x	1430	x	1645	x	1845	x	2045	x
4	BackBay		648	650	1009	1010	1109	1110	1304	1305	1433	1435	1649	1650	1849	1850	2048	2050	2304
5	Ruggles		651	653	1012	1013	1112	1113	1307	1308	1436	1438	1652	1653	1852	1853	2051	2053	2307
6	HydePark		659	701	1020	1021	1120	1121	1315	1316	1444	1446	1700	1701	1900	1901	2059	2101	2315
7	Route128		704	706	1025	1026	1125	1126	1320	1321	1449	1451	1705	1706	1905	1906	2104	2106	2320
8	CantonJunction		710	711	1030	1031	1130	1131	1325	1326	1454	1456	1710	1711	1910	1911	2110	2111	2325
9	Sharon		715	716	1035	1036	1135	1136	1330	1331	1500	1501	1715	1716	1914	1916	2115	2116	2330
10	Mansfield		723	724	1043	1044	1142	1144	1338	1339	1508	1509	1723	1724	1922	1924	2123	2124	2338
11	Attleboro		730	731	1050	1051	1149	1151	1345	1346	1517	1518	1730	1731	1930	1931	2130	2131	2345
12	SouthAttleboro		740	x	1100	x	1200	x	1355	x	1528	x	1740	x	1940	x	2140	x	2355
13	Providence		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
14																			
15	INBOUND		1802		1804		1806		1808		1810		1812		1814		1816		1818
16	READDOWN		Arrive	Depart	Arrive	Depart	Arrive	Depart	Arrive	Depart	Arrive	Depart	Arrive	Depart	Arrive	Depart	Arrive	Depart	Arrive
17	Providence		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
18	SouthAttleboro		x	645	x	845	x	1130	x	1305	x	1445	x	1630	x	1905	x	2045	x
19	Attleboro		651	653	851	853	1136	1138	1311	1313	1451	1453	1636	1638	1912	1913	2051	2053	2216
20	Mansfield		658	700	859	900	1144	1145	1318	1320	1458	1500	1643	1645	1919	1920	2058	2100	2224
21	Sharon		706	708	907	908	1152	1153	1327	1328	1506	1508	1652	1653	1927	1928	2107	2108	2232
22	CantonJunction		713	715	914	915	1159	1200	1334	1335	1513	1515	1658	1700	1934	1935	2114	2115	2239
23	Route128		718	720	919	920	1204	1205	1339	1340	1518	1520	1703	1705	1939	1940	2119	2120	2244
24	HydePark		723	725	924	925	1209	1210	1344	1345	1523	1525	1708	1710	1944	1945	2124	2125	2249
25	Ruggles		733	735	934	935	1220	1222	1354	1355	1533	1535	1718	1720	1954	1955	2134	2135	2259
26	BackBay		737	738	937	938	1224	1225	1357	1358	1536	1538	1721	1723	1957	1958	2137	2138	2301
27	SouthStation		743	x	943	x	1230	x	1403	x	1543	x	1728	x	2003	x	2143	x	2308
28																			
29																			

SaturdayExample2

Adding Track Restrictions

- Provide the following information to take a track out of service or restrict the speed

Restriction Type

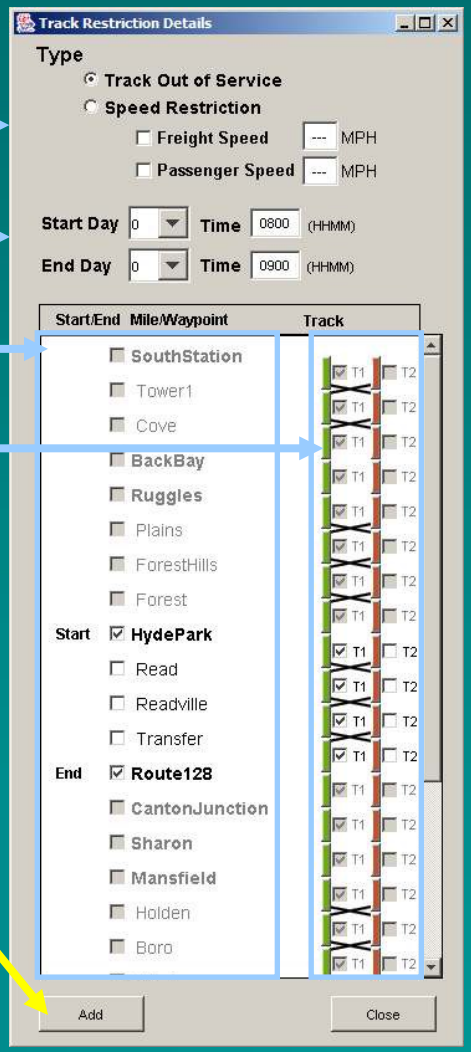
Start and End Day and Time

Start and End Waypoints

Tracks

Press Add to make the track restriction

In this example, Track 1 is out of service from Hyde Park to Route 128 from 8:00 to 9:00 am

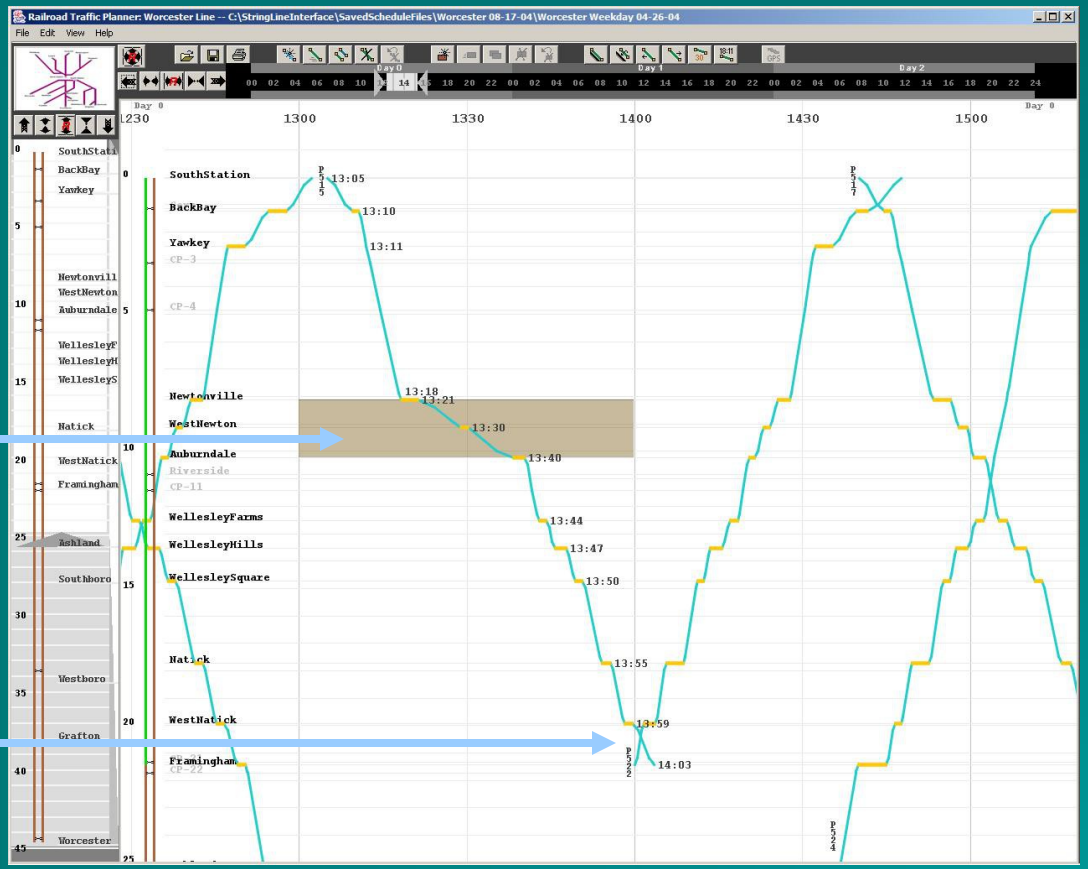


Effects of Track Restrictions

- In this example, a speed restriction slows down a train and creates a new meet

Speed is restricted to 10 mph on Track 1

Trip is 13 minutes longer and there is a new meet



GPS Tracking

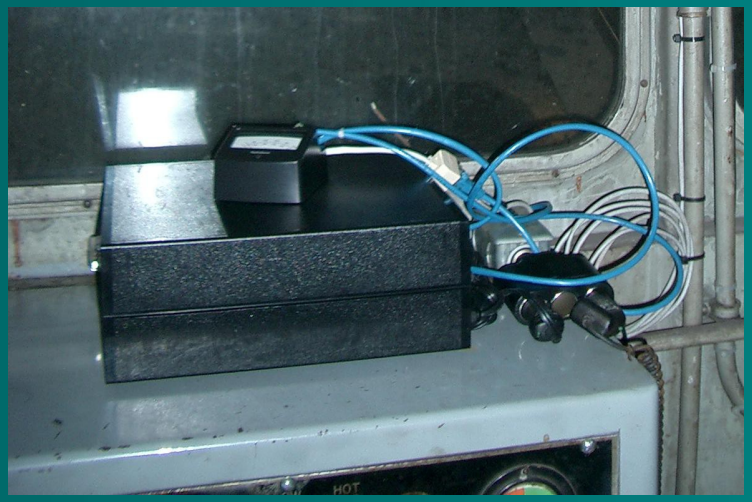
- "Near-real-time tracking" hardware and software can be included to support planning activities
  - Automatically draws strings

- Devices can be installed on locomotives, inspection vehicles, and maintenance equipment

- Not appropriate for safety-critical applications
  - Supplements existing data, but is not adequate to replace existing safety processes

GPS Devices on a Locomotive

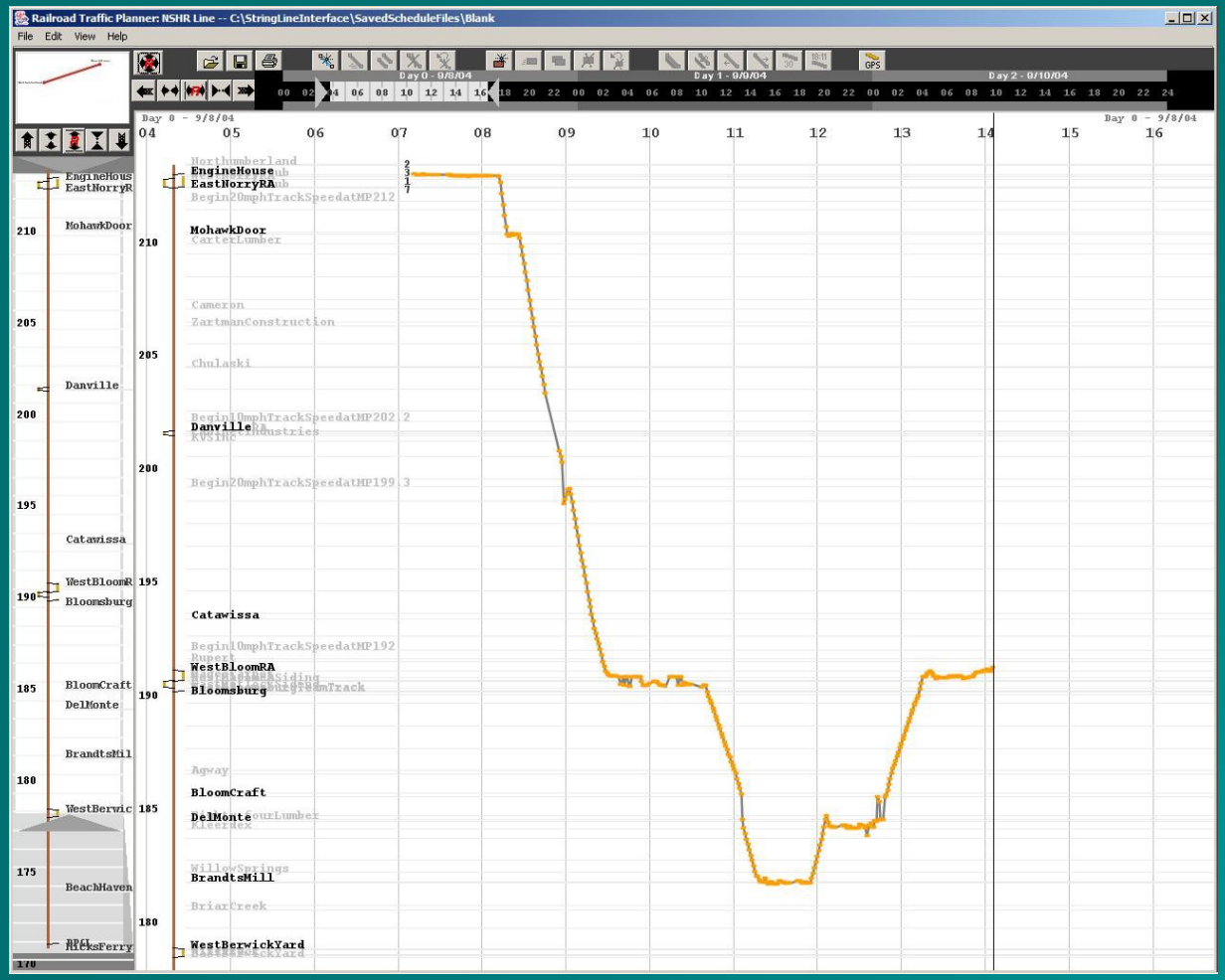
- Cell phone enclosed in a weather-resistant “pod” on the outside of the train



- A battery pack with overload protection and other features is plugged into the locomotive power supply

GPS Tracking Display

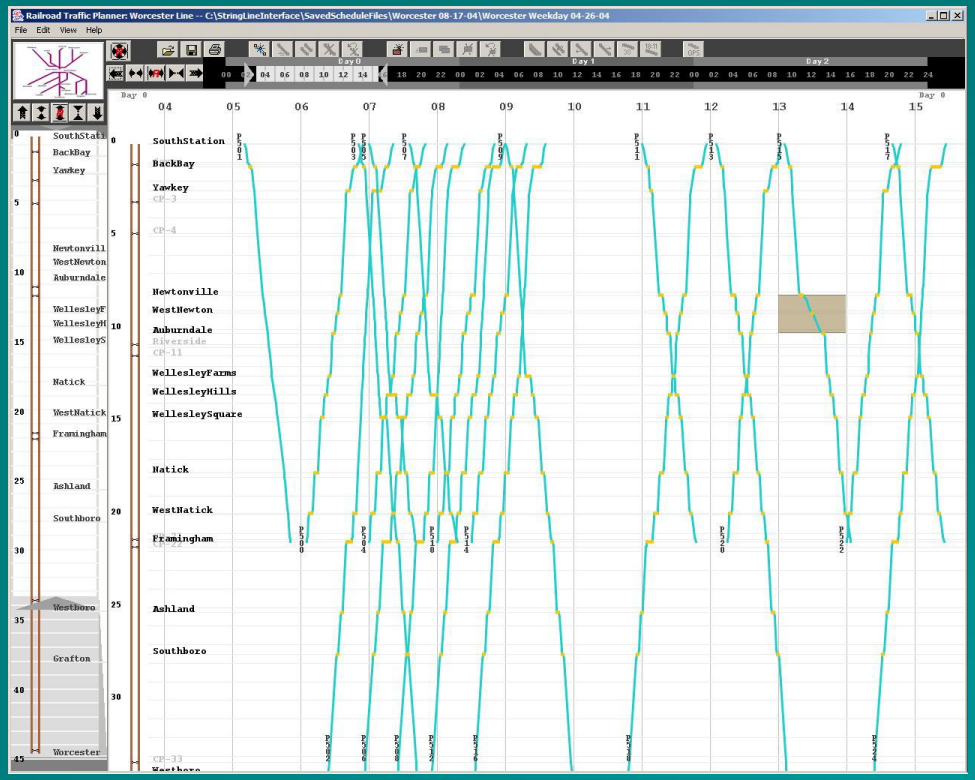
- Display near-real-time or archived data



Possible Uses for Dispatching…

Dispatcher Training Tool

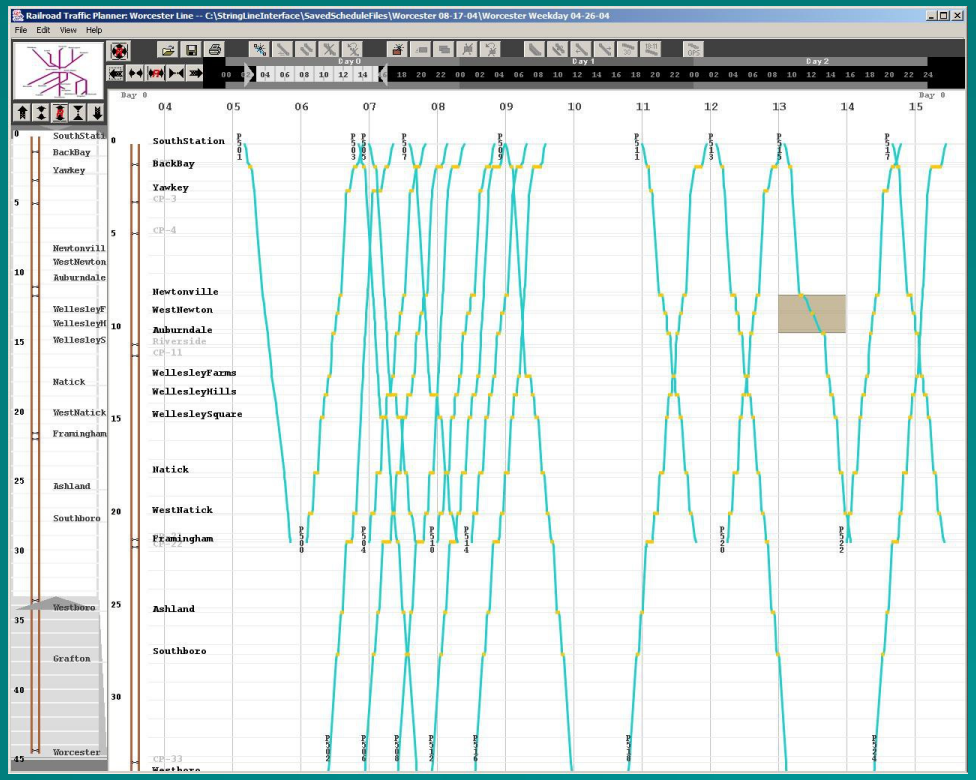
- Show how to identify places where additional activities can be inserted
- Help new employees learn to estimate future positions and anticipate problems
- Teach how decisions can impact traffic flow in various territories



Dispatcher Planning Tool

- Stringline display could support both preliminary planning and reacting to unexpected events

- Sample activities:
  - Analyze meets and passes
  - Decide how to insert unscheduled events
  - Estimate future positions



Conclusions…

Potential Benefits

- Preliminary findings show that this type of tool has the potential to provide safety and productivity benefits

- It can help users:
  - Compare different options
  - Identify windows of opportunity
  - Set more realistic expectations for customers and other railroads

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We want to learn more about how this type of tool might be useful for dispatchers.

Please share your questions and comments with us.

Thank you!