System analysis of Lonavla-Karjat ghat section in Central railway

Metro Rail Operations Management 2023

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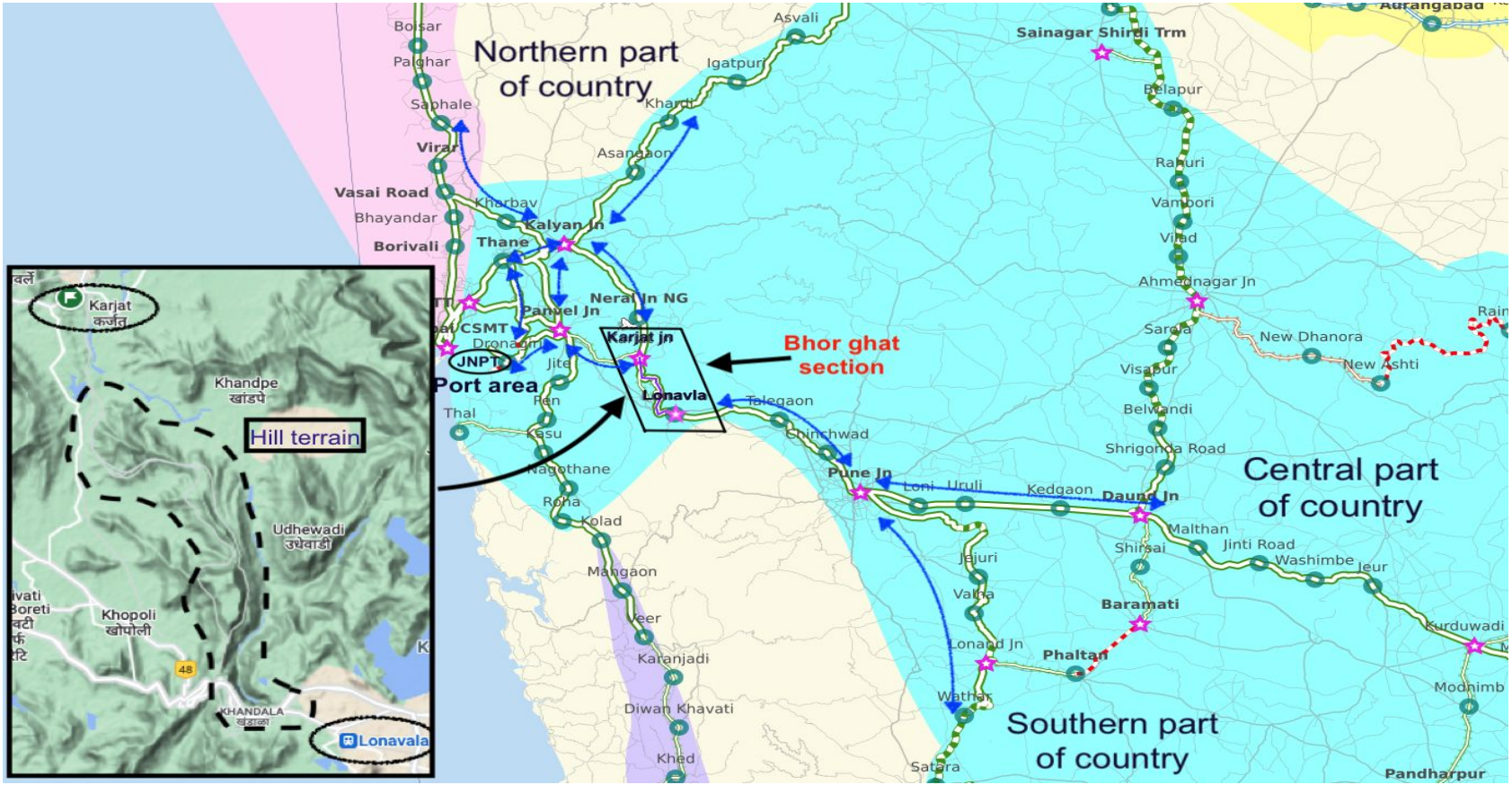
Problem statement

- ➔ Lonavla-Karjat is a **ghat section** with a very **steep gradient**(1:37).
- ➔ **Operations** at the section are **different from the regular railway operations** due to its unique features
- ➔ **Freight trains halts for extended hours** on the the section, due to which this section has become a bottleneck for freight traffic.

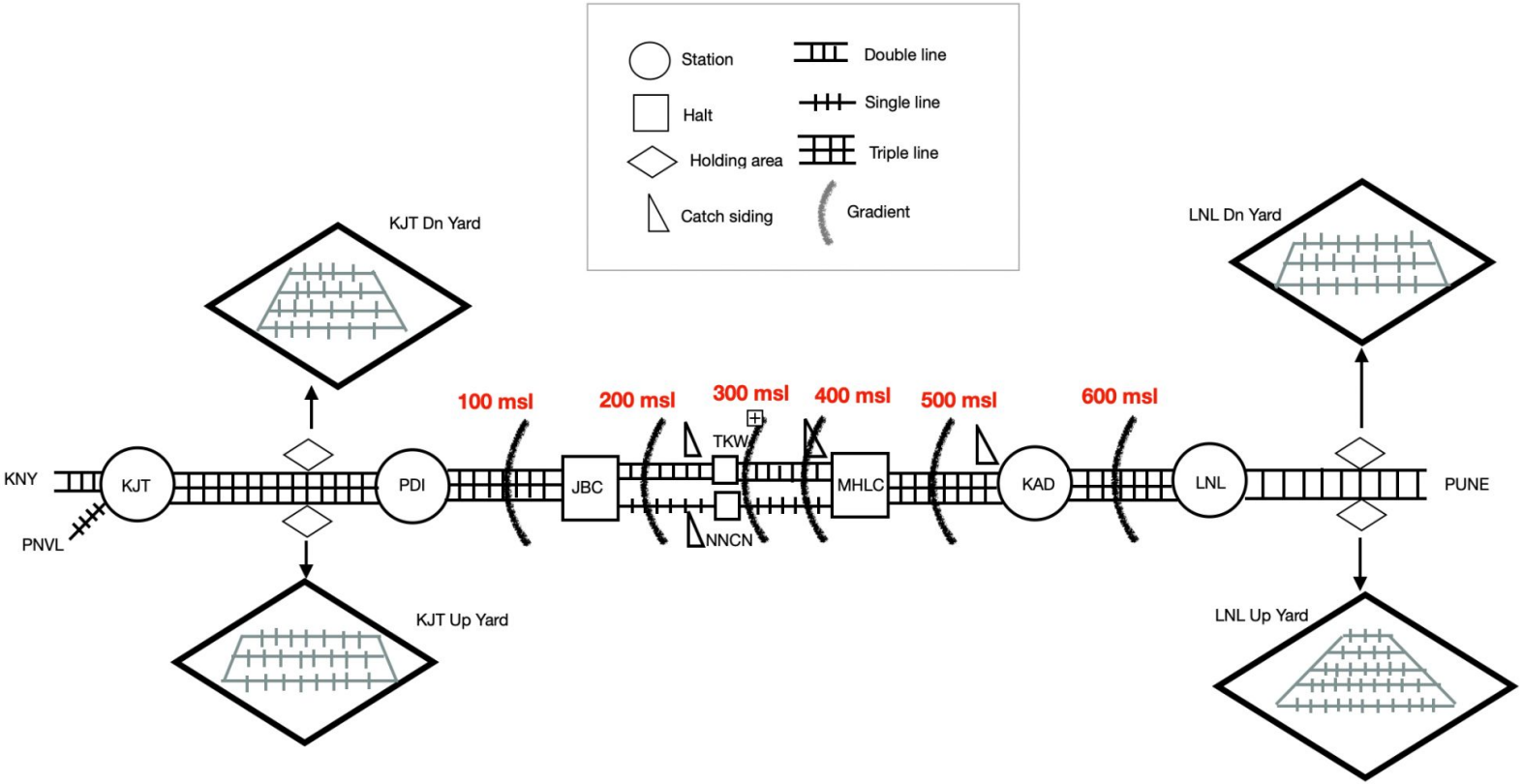
Objective of the study

- ➔ A **systematic analysis** of the Lonavla-Karjat section to **analyse the main bottleneck** resource.
- ➔ Based on the analysis, device solutions to improve the scheduling of the freight trains to increase throughput of the section.

Lonavla-Karjat connects the port and northern part of country to southern India



Increasing gradient from 100 MSL (Mean Sea Level) at Karjat to around 600 MSL at Lonavla



Features of the section

- **Speed limitation** for downhill movement and uphill movement
- **Extra locomotives** (known as **bankers and pushers**) are required to push trains in downhill and uphill direction
- Limited locomotives
- **Break testing at Lonavla yard** and between stations while moving in **downhill direction-to ensure train won't lose control**
- Limited holding line with uneven lengths causing limited use of holding area
- Three track lines in between one used in each direction and third is used in maintenance purpose and other empty banker movements
- **Different headway**, overtaking is not allowed in between section- **Limited path availability**

System Study required

Over time, almost all potential resources are bottlenecks

Not clear which one to address at a given time

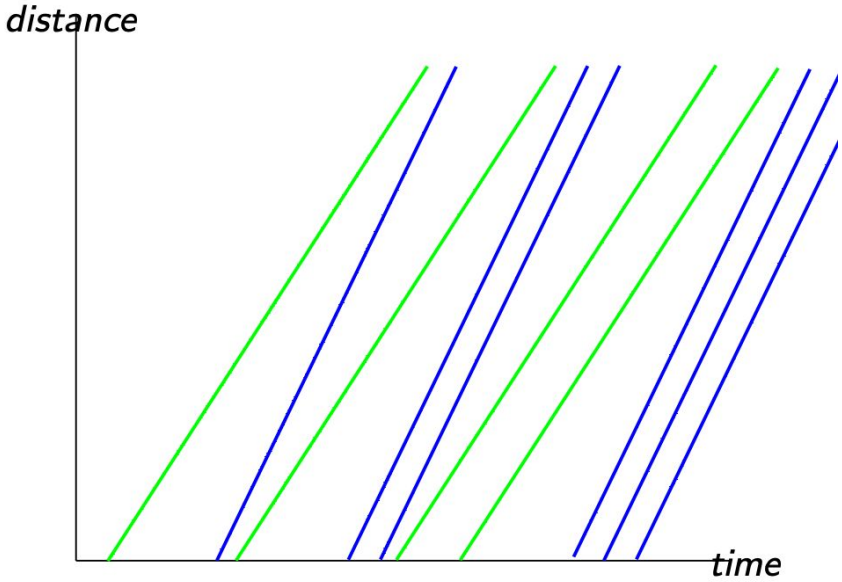
Operations and resource usage are different

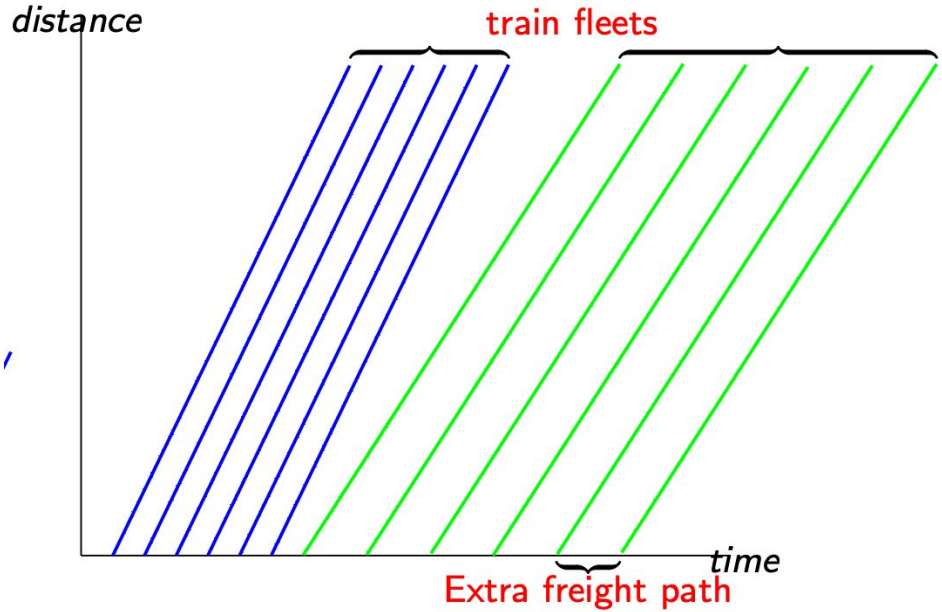
- **Banker relocation** is required, 5 triplers and 3 couplers
- High **speed heterogeneity** in system:
  - Downhill speed < Uphill speed
  - Freight speed < Passenger speed

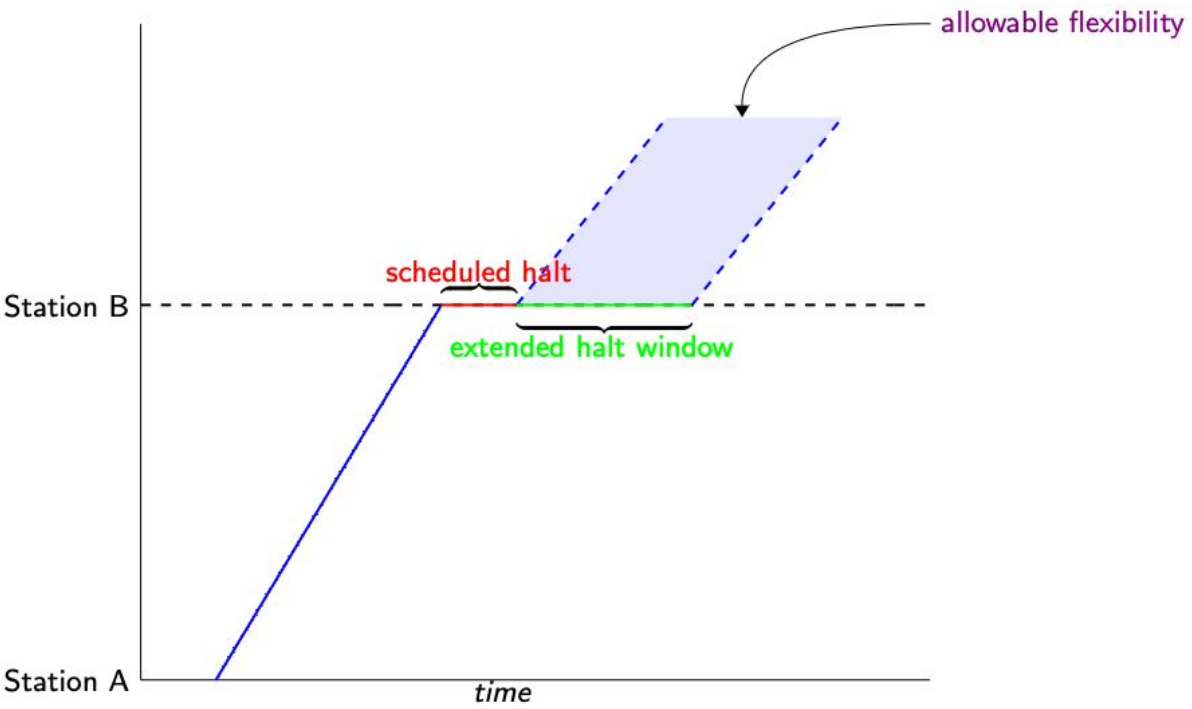
	Passenger trains (and empty freight trains)	**Freight trains**
Lonavla	Not required	1 Tripler (3 locomotives)
Karjat	1 Coupler (2 locomotives)	1 Tripler (3 locomotives)
Brake testing and in-between halts	Not required	Required (only at Lonavla)

Methods to improve

- Modifying **operating procedure**:
  - Fleeting same type of trains (can be done to some extent as it as passenger timing should be convenient of sub urban travellers and also depends on the number of banker available)
  - Increasing small delays to passenger trains (can not delay passenger train by huge amount as it affects the whole system as passenger timetable is neatly defined)
  - Changing banker composition
  - Empty banker movement policy
- **Adding resources**:
  - Lines expensive
  - Holding lines expensive
  - Bankers can be added but how much to add: too many can not be handled and too less may result in no performance increment
- Modifying layout:
  - Increasing length of holding lines


distance
time


distance
train fleets
time
Extra freight path


allowable flexibility
scheduled halt
Station B
extended halt window
Station A
time

Simulation Model

Event based scheduling

- Events occur based on event list that keeps updating after each event
- Actions are taken according to the current event and also looking ahead
- Some actions are obvious given the current states:
  - Scheduling passenger train when it arrives at station
- Some actions are taken by considering future requirement as well (optimal policy needs to be define for such events):
  - Empty coupler and tripler movement
  - Scheduling Freight trains
  - Scheduling empty banker movement

Input of the model	Output of the model
Passenger timetable, random arrival of freight trains, number of bankers available, number of track lines available, policies for scheduling passenger train, freight trains and empty banker movement, headway constraint	Schedule of freight trains at both station, Average waiting time of freight trains at both stations, average number of freight trains scheduled in both directions

Results

- Simulation model is run for 8 day period (with 1000 replications, with random freight arrivals at both stations)
- Freight inspection activities are not considered in this simulation model and
- Holding capacity constraint is also not considered

	Average freight waiting time		Average freight trains scheduled	
	KJT	**LNL**	**KJT**	**LNL**
Original timetable	Mean: 65 minutes Var: 347 minutes	Mean: 86 minutes Var: 1000 minutes	Mean: 136 Var: 17	Mean: 138 Var: 40
With fleeting	Mean: 51 minutes Var: 278 minutes **22 % reduction**	Mean: 71 minutes Var: 850 minutes **17.5 % reduction**	Remain same	Remain same
Allowing small passenger delays (max: 10 minutes)	Mean: 42 minutes Var: 183 minutes **35.4 % reduction**	Remain same	Remain same	Remain same
Adding banker	Mean: 15 Minutes Var: 24 minutes **77 % reduction**	Mean: 55 Minutes Var: 554 minutes **36 % reduction**	Mean: 141 Var: 18 **3.67 % increment**	Mean: 142 Var: 41 **2.8 % increment**

Conclusion

- With mixed traffic on the network, it is recommended passenger train timetables should be constructed so that separate freight corridors can be obtained. Furthermore, enough resources (bankers and crew) should be present to move traffic in those corridors.

- In actual operations, providing additional flexibility to permit small delays in passenger train operations can sometimes provide some benefit in freight train waiting times. The benefit depends on other resources being available (e.g. bankers)

- While analyzing a bottleneck section, its future requirements should also be assessed carefully, as there will be multiple resources that can limit section performance

- For a rail network with complex day-to-day operations, creating a tool that helps in system base analysis is beneficial

Acknowledgement

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Thankyou