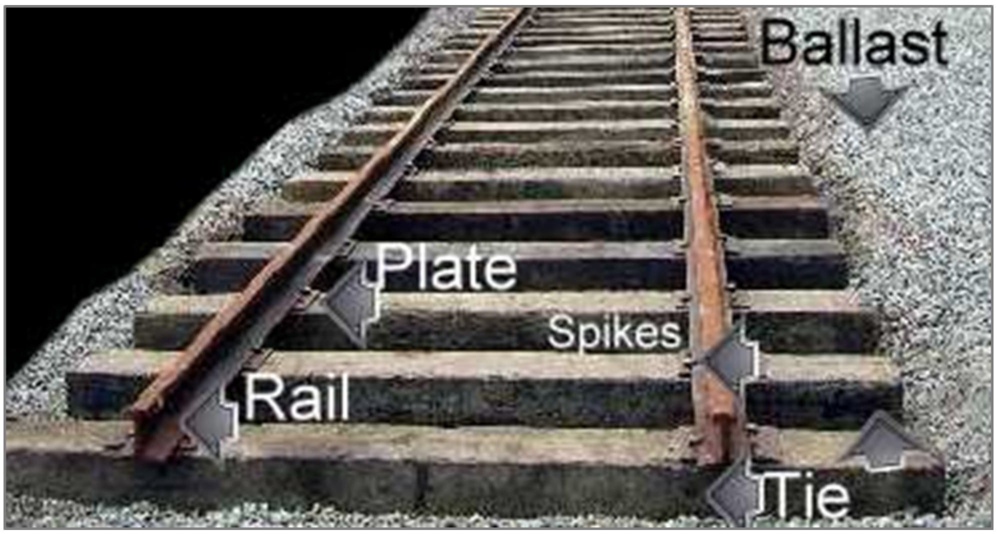
CSX Project: Ballast cleaning scheduling optimization

Background

Track ballast forms the track-bed upon which railroad ties are laid. It is packed between, below, and around the ties. It is used to bear the load from the railroad ties, to facilitate drainage of water, and also to keep down vegetation that might interfere with the track structure. This also serves to hold the track in place as the trains roll by. It is typically made of crushed stone.



Over time, ballast becomes worn, and loses its angularity, becoming rounded. This hinders the tessellation of pieces of ballast with one another, and thus reduces its effectiveness. Fine pieces of granite, like sand, are also created by attrition, known simply as "fines". Combined with water in the ballast, these fines stick together, making the ballast like a lump of concrete. This hinders both track drainage and the flexibility of the ballast to constrain the track as it moves under traffic.

Ballast cleaning removes this worn ballast, screens it and replaces the "dirty" worn ballast with fresh ballast. The advantage of ballast cleaning is that it can be done by an on-track machine without removing the rail and sleepers, and it is therefore cheaper than a total excavation.

How a ballast cleaner works

http://www.loram.com/Services/Default.aspx?id=244

Problem statement

CSX currently operates two ballast cleaners across its network at a cost of roughly $2-3 million per unit per year. The expense of each unit is largely fixed, making utilization critical to the economics of this asset. Today, CSX's ballast cleaners are scheduled/planned manually, as are dynamic changes to the schedule/plan (which happen often). The goal of this project is to build an optimization model for CSX's ballast cleaning units that can be used to plan the annual work plan for these units, and also can be dynamically re-run as needed as conditions on the railroad change. An optimized plan for these ballast cleaners will boost productivity of these assets, ultimately reducing maintenance cost of CSX's network. If the current two ballast cleaners don't satisfy the CSX network demand, a sensitivity analysis on required number of cleaners will be desired.

Model input

Towards the latter part of the year, all Division Engineers submit ballast cleaning projects to CSX engineering HQ for consideration. All of these projects are aggregated into a list, and then given priority order by the Chief Engineers. In addition to the priority assigned by Engineering Department leadership, projects are also prioritized as follows (in descending order):

- Projects in the same location as tie replacement work ("curfew work") must be scheduled and completed **before** the tie replacement work is done
- Projects within 50 miles of a curfew, but not included in the curfew limits, should be scheduled at the same time as the curfew as the track time will already be available
- All other projects

The final list of projects will include the priority of the project, exactly where the project is (subdivision, and track number), how many miles the project covers, etc. This file will be fed to the optimizer to select and schedule/order projects to maximize utilization of the ballast cleaners.

Constraints

There are many constraints that need to be captured in the model to ensure the model output is as actionable as possible

- Network geography
    - CSX will provide characteristics of our network – i.e. connectivity and length of all subdivisions
- Ballast cleaners work 5 days a week, 10 hours per day
- There are 2 ballast cleaners available
- Ballast cleaners are rail-bound.

- Curfew grid and details of curfews
    - Ballast cleaning scheduling is highly interconnected to the "curfew grid" (scheduling of replacement of ties and rail). An important part of this project will be to integrate the ballast cleaning project request list with the curfew database
    - Ballast cleaners can hide in single tracks with curfews. (40% utilization vs 25% utilization)
    - Sending ballast cleaners to double tracks with curfew and more than 150 miles away on adjacent subdivisions should be avoided.
    - Use performance index (daily) for each subdivision to find best day/time to work on that subdivision
    - If the model is not able to figure out how to schedule the ballast cleaner to work alongside the curfew (the 50 mile area), then the ballast cleaner must stay clear of the subdivision that is curfewed, and all adjacent subdivisions
- Ballast cleaners can't clean frozen ballast – i.e. they have to start the year in the south, and end the year in the south
    - Can be flexible though if winter starts/ends early/late
- Ballast cleaners require dry conditions to clean – i.e. they cannot work in the rain
    - This makes it necessary for the optimizer to be dynamic. Rain out days occur often, and the model will need to be re-run each time this happens to re-optimize the schedule
    - You may also want to consider bringing historical weather/precipitation data by location into the model to help ballast cleaners avoid any particular areas where there is a high probability of precipitation at a given time of year
- There are effectively three types of "track" – double track, single track, and single track with sidings. Single track will be the most difficulty to get track time (we can quantify this later).
- If any union employee is furloughed on a division, ballast cleaners (which utilize contract labor) cannot be run
    - This will require a flag in the model to be able to "turn off" different subdivisions
- User will require a variable parameter to enter ballast cleaner speed (XX miles per hour). There are different types of cleaners on the market, that operate at different speeds (and have different costs)
    - Fastest unit can clean 3-4 miles of track per hour (30-40 miles per day max)
- Rule of thumb to test… We typically try to look for a week's worth of project work in an given area to move the ballast cleaner

Other resources

- "Giving Dirty Ballast the Cold Shoulder." IRJ, August 2008, p. 42-43. http://www.nxtbook.com/nxtbooks/sb/irj0808/#/42