Denver Transit Operators

Operations Systems Integration for Commuter Rail Operations & Maintenance

June 12, 2018
Denver Commuter Rail Network
System Statistics

- 66 Hyundai Rotem Electric Multiple Units Cars
- 65 Track Miles of Main Line Track
- 57 Turnouts from #9 to #20
- 37 Grade Crossings (29 Highway/Rail)
- 40 Railroad Bridges – Box Culverts with 10-ft Spans
- 25kV Overhead Catenary System
- Positive Train Control and Automatic Train Control
O&M Scope of Work – Revenue Service Period

- Operate Trains
- Dispatch
- Report to RTD

- Maintain Rolling Stock
- Maintain Track, ROW and Bridges
- Maintain Facilities – Stations/CRMF

- Maintain Systems
  - Communications
  - Signals and Train Control
  - Traction Power
## Service and Operations Plan

<table>
<thead>
<tr>
<th></th>
<th>Univ of Colorado A Line</th>
<th>B Line</th>
<th>G Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running Time</td>
<td>37 minutes</td>
<td>12 minutes</td>
<td>26 minutes</td>
</tr>
<tr>
<td>Headways</td>
<td>15 minutes</td>
<td>30 minutes</td>
<td>15 minutes</td>
</tr>
</tbody>
</table>
Performance Standards - Availability

- 97.7% Availability Required for 100% Payment

- Availability Components
  - Rolling Stock Availability =
    - Actual Compliant Car Miles/Scheduled Car Miles
  - On-Time Availability =
    - % of Arrivals at Time Points within 5 minutes of Schedule.
  - Station Availability = % of Station Days with:
    - Elevators operational
    - More than 75% Lights Working
    - Access routes safely clear of snow and ice

- Additional Performance Deductions Apply for
  - Failure to respond to and remedy defects within limits
Performance Standards – Service Task Orders

- Up to 5% of payment can be deducted based on total STO Points each month

<table>
<thead>
<tr>
<th>Problem</th>
<th>Response Time</th>
<th>Remedy Time</th>
<th>STO Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevator Shutdown</td>
<td>2 hours</td>
<td>12 hours</td>
<td>5</td>
</tr>
<tr>
<td>Foul Odor or Heavy Litter</td>
<td>4 hours</td>
<td>4 hours</td>
<td>2</td>
</tr>
<tr>
<td>Rolling Stock PMs Late</td>
<td>None</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>CCTVs not Functional</td>
<td>12 hours</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Graffiti Tags: Offensive or &gt; 12” in diameter</td>
<td>8 hours</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Parking Lot Lights Out or Flickering</td>
<td>24 hours</td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>
Reporting Requirements

- **On-Time Performance**
  - By time point
  - Over 1,000 measurements per day
  - Today’s OTP available in real time
  - Reported daily to RTD
  - Shows excused and unexcused

- **FRA Compliance**
  - Records - Hours of Service, Record of Train Movement
  - Efficiency Testing
  - Many required documents - (e.g., PTEPP, Drug & Alcohol Compliance Plan, etc.)
Reporting Requirements - Examples

- **Maintenance Performance**
  - Mean Distance Between Failures
  - Rolling Stock failures by type
  - Compliant Car Miles

- **Compliance with Preventive Maintenance Schedule**
On-Time Performance

On-Time Performance (Monthly)

MAY (Current) 98.0%

On-Time Performance (Yearly)

2016 87.1%
2017 94.9%
YTD 2018 96.8%
Ridership

RTD Monthly Commuter Rail Ridership

Thousands of Boardings

<table>
<thead>
<tr>
<th>Month</th>
<th>A Line</th>
<th>B Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr-16</td>
<td>493</td>
<td>107</td>
</tr>
<tr>
<td>May-16</td>
<td>501</td>
<td></td>
</tr>
<tr>
<td>Jun-16</td>
<td>514</td>
<td></td>
</tr>
<tr>
<td>Jul-16</td>
<td>469</td>
<td></td>
</tr>
<tr>
<td>Aug-16</td>
<td>532</td>
<td></td>
</tr>
<tr>
<td>Sep-16</td>
<td>519</td>
<td></td>
</tr>
<tr>
<td>Oct-16</td>
<td>520</td>
<td></td>
</tr>
<tr>
<td>Nov-16</td>
<td>519</td>
<td></td>
</tr>
<tr>
<td>Dec-16</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Jan-17</td>
<td>443</td>
<td></td>
</tr>
<tr>
<td>Feb-17</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Mar-17</td>
<td>517</td>
<td></td>
</tr>
<tr>
<td>Apr-17</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>May-17</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>Jun-17</td>
<td>504</td>
<td></td>
</tr>
<tr>
<td>Jul-17</td>
<td>507</td>
<td></td>
</tr>
<tr>
<td>Aug-17</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>Sep-17</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Oct-17</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>Nov-17</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>Dec-17</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>Jan-18</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Feb-18</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Mar-18</td>
<td>46</td>
<td></td>
</tr>
</tbody>
</table>
## Ridership

<table>
<thead>
<tr>
<th>Month</th>
<th>A Line</th>
<th>B Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>May-17</td>
<td>15.02%</td>
<td></td>
</tr>
<tr>
<td>Jun-17</td>
<td>16.35%</td>
<td></td>
</tr>
<tr>
<td>Jul-17</td>
<td>13.94%</td>
<td></td>
</tr>
<tr>
<td>Aug-17</td>
<td>32.93%</td>
<td>21.31%</td>
</tr>
<tr>
<td>Sep-17</td>
<td>14.85%</td>
<td>23.40%</td>
</tr>
<tr>
<td>Oct-17</td>
<td>19.48%</td>
<td>22.82%</td>
</tr>
<tr>
<td>Nov-17</td>
<td>19.91%</td>
<td>29.18%</td>
</tr>
<tr>
<td>Dec-17</td>
<td>6.92%</td>
<td>41.08%</td>
</tr>
<tr>
<td>Jan-18</td>
<td>35.33%</td>
<td>41.32%</td>
</tr>
<tr>
<td>Feb-18</td>
<td>12.21%</td>
<td>30.86%</td>
</tr>
<tr>
<td>Mar-18</td>
<td>10.01%</td>
<td>31.25%</td>
</tr>
</tbody>
</table>
Constraints

- Competitive Procurement
- Lean Staffing
  - For O&M
  - For IT support (3 people user support, upgrades, troubleshooting for Admin and Ops. systems)
- Limited $ for customization
- Vital to respond promptly to defects
Approach

- Off-the shelf systems
- Integration
- Little customization
  - Key interfaces only
  - In-house report writing
- Data automatically moves between systems
  - Data is not entered into multiple systems
Approach - Automatic Data Flow

Field Alert → OCC Incident → Maintenance → Reporting
Products

- Trapeze Enterprise Asset Management (EAM)
  - Asset & Maintenance Management
    - Preventive maintenance scheduling & work documentation
    - Defect tracking & repair documentation
    - Condition tracking & renewals management
    - 3rd Party Work project management
  - Inventory & Tool Management
  - Procurement & Warranty Management
  - Scheduled and Ad Hoc Reporting
    - PM Compliance reports
    - STO Point penalty reporting
    - Equipment failures & status

- Hyundai Rotem – Quester Tangent
  - Monitoring & Diagnostic System (MDS)
Products

- **Hastus**
  - Train and Crew Scheduling
  - Crew Management
    - Bidding work and vacations
    - Daily dispatch (feeds payroll)
  - Hours of Service Tracking
  - Feeds daily train & crew schedule to TMDS

- **Wabtec TMDS/TPMS**
  - Dispatching & Performance Reporting
  - Interface to Positive Train Control
  - Traction Power Management
  - SCADA & NMS – real time infrastructure alerts
Vehicle onboard systems: Sample of Real-Time Alerts

- HVAC Fault
- Propulsion Fault
- Aux Power System (APU Fault)
- DUC-R1, R2, L1, L2 (Door Fault)
- Friction Brakes (FBU Fault)
Integrating Alerts into EAM

Vehicle faults → Integration server (Captures Alerts) → Trapeze EAM

Integration server (Captures Alerts) → Trapeze EAM

- Train Control & Infrastructure Alerts (SCADA)
- Maintenance triggered and team alerted

Analyze fault data
### Service Requests/Defects

<table>
<thead>
<tr>
<th>Row #</th>
<th>Shop</th>
<th>Priority ID</th>
<th>Equipment ID</th>
<th>Symptom</th>
<th>Status</th>
<th>Date and time entered</th>
<th>Reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>R</td>
<td>2</td>
<td>4064</td>
<td>COMM FAULT</td>
<td>PENDING</td>
<td>05/04/2018 12:12</td>
<td>MDS</td>
</tr>
<tr>
<td>25</td>
<td>R</td>
<td>S2</td>
<td>4064</td>
<td>HVAC FAULT</td>
<td>PENDING</td>
<td>05/04/2018 12:12</td>
<td>MDS</td>
</tr>
<tr>
<td>26</td>
<td>R</td>
<td>3</td>
<td>4063</td>
<td>CCTV FAULT</td>
<td>PENDING</td>
<td>05/04/2018 12:12</td>
<td>MDS</td>
</tr>
</tbody>
</table>

**Date and time entered:** 05/04/2018 12:12

**Entered by:** MAXQ

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### Basic Info

- **Equipment ID:** 4064
  - **2014 HR EMU EMU MB CAR**
- **Shop:** R (RAILCAR MAINTENANCE SHOP)
- **Work order ID:**
- **Symptom:** HVAC FAULT
- **Task ID:** R08-002 (HVAC UNIT)
- **Priority ID:** S2
- **Date and time required:** 05/04/2018 14:12
- **Estimated hours:** 0.00
- **Posted hours:** 0.00

**Note:** 2 HOURS STO REMEDY TIME INTERNAL SHOP PR

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### Comments

**Description:**
- FAULT TO DETECT OPEN DAMPER

**Comments:**
- REMOVE FRESH AIR FILTER AND VIA PTE OPERATE DAMPER TO CONFIRM OPERATION.

**Train System Alert Message**

**Auto-generated Technician Message (how to respond to alert)**
“Smart Infrastructure”

**SCADA Alert types:**
- Power Substation (22)
- Crossing House (12)
- Master Locations (12)
- Interlockings (140)
- Comm House (7)
- OCS (4)
- Elevator (2)
- Sump Pump (3)

**NMS Alert types:**
- CCTV Camera (1) & Recorder (5)
- Ruggedcom Radio (7)
- PA Amplifier (5)
- VMS signs
- UPS (4)
- Network & Switches (20)
## Infrastructure: Sample of Real-Time SCADA Alerts

<table>
<thead>
<tr>
<th>Infrastructure</th>
<th>System</th>
<th>Alarm Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communications House</td>
<td>Fire Alarm</td>
<td>Intrusion, AC Power, High/Low Temp, Fire, Smoke</td>
</tr>
<tr>
<td>Traction Power</td>
<td>Power</td>
<td>Disconnect Switch Open/Closed, Disconnect Switch Local/Remote, Equipment Trouble, Intrusion</td>
</tr>
<tr>
<td>Interlocking</td>
<td>Interlocking</td>
<td>Main/Aux Active or Standby, Link failure, Fault, Power Fail…</td>
</tr>
</tbody>
</table>
### Infrastructure: Sample of Real-Time SCADA Alerts

<table>
<thead>
<tr>
<th>Infrastructure</th>
<th>System</th>
<th>Alarm Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade Crossings</td>
<td>Crossing Housing</td>
<td>Gate Down/Up</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crossing Deenergized</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fire or Smoke Alarm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intrusion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AC or DC Power Out</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crossing Out of Service</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ground Fault</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Loop Health</td>
</tr>
</tbody>
</table>
Incident Flow

Field alert -> OCC -> Maintenance Process -> Reporting

1) Incident (TMDS)
   Captures:
   - Asset impacted
   - Symptom
   - Trains Delayed
   Creates Service Request

2) Service Request (EAM)
   Asset + Symptom:
   Calculates Remedy Time
   Emails responsible Maintenance group
   Creates work Order

3) Work Order (EAM)
   Records work done
   Stops Remedy Clock
   Feeds daily reporting
1) Incident (TMDS)

**SCADA Captures:**
- Asset: Fox St Elevator #1
- Symptom: Fault

Check CCTV for occupancy and escalate accordingly

Creates Service Request

2) Service Request (EAM)

**Asset + Symptom:**
- Calculates Remedy Time = 2 hours from report
- Emails responsible Maintenance group

Creates work Order

3) Work Order (EAM)

Records work done

Stops Remedy Clock

Feeds daily reporting
Interlocking Alert

1) Incident
SCADA Captures:
Asset: Bright Interlocking
Symptom: Main Electrologix Standby Active Indicator

Creates Service Request

2) Service Request
Asset + Symptom:
Emails responsible Maintenance group
Creates Work Order

3) Work Order
Records work done
Feeds daily reporting
### Service Task Order Remedy Times

#### STO Remedy Times

Every combination of Asset and Symptom has been assigned a unique TASK ID and is programmed with a Remedy Time.

When a Service Request is created, the Remedy Time is added to the date & time reported to calculate the date & time due for completion of this work order.

Daily reporting includes all incidents, the asset involved, symptom reported, calculated date and time due and the completion date & time.

If the Completion time is later than the Remedy Time permits then penalties are automatically calculated and applied to the monthly invoice.

<table>
<thead>
<tr>
<th>Station Asset Symptoms</th>
<th>Remedy Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADA ramps/railings - minor</td>
<td>12 hrs</td>
</tr>
<tr>
<td>ADA ramps/railings - major</td>
<td>48 hrs</td>
</tr>
<tr>
<td>Cleanliness/Litter</td>
<td>4 hrs</td>
</tr>
<tr>
<td>Dumpster full</td>
<td>8 hrs</td>
</tr>
<tr>
<td>Graffiti - Station</td>
<td>8 hrs</td>
</tr>
<tr>
<td>Lighting any platform lights out or flickering</td>
<td>24 hrs</td>
</tr>
<tr>
<td>Lighting 75% of platform lights out</td>
<td>Immediate</td>
</tr>
<tr>
<td>Obstruction to safe access to station</td>
<td>Immediate</td>
</tr>
<tr>
<td>Recycle bin 75% full</td>
<td>4 hrs</td>
</tr>
<tr>
<td>Rodent infestation</td>
<td>24 hrs</td>
</tr>
<tr>
<td>Schedules/Maps</td>
<td>24 hrs</td>
</tr>
<tr>
<td>Signage</td>
<td>24 hrs</td>
</tr>
<tr>
<td>Snow/Ice on platform, ramps, parking lot…</td>
<td>2 hrs</td>
</tr>
<tr>
<td>Snow/Ice preventing safe train access</td>
<td>Immediate</td>
</tr>
<tr>
<td>Trash o bin 75% full</td>
<td>4 hrs</td>
</tr>
<tr>
<td>Waiting area/shelter - minor</td>
<td>12 hrs</td>
</tr>
<tr>
<td>Waiting area/shelter - major</td>
<td>48 hrs</td>
</tr>
</tbody>
</table>
Achievements in Automation & Integration

- Smart infrastructure provides real-time fault detection
  - Automatically sends alerts to the OCC

- Highly automated data capture
  - Avoids errors
  - Minimizes administrative labor requirement

- Automatic notification to maintenance staff
  - Speeds response times
  - Facilitates corrective action before failure
  - Increases system up time
  - Maximizes performance

- Highly automated reporting process
  - Increases confidence in /utility of reports