Punctuality and maintenance

Infrastructure and rolling stock

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Trafikverket
Swedish transport administration

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Project manager
Maintenance
Southern iron ore line and Haparanda line
Iron ore line Riksgränsen - Luleå

- Most beautiful railway in Sweden
- Core network
- Single line (arctic circle)
- Traffic: Iron ore, copper ore, steel-slabs, goods, timber and passenger traffic
- Produce 25-30 MGT/year

- Operational since 1887
- Electrified since 1915
- 53 stations
- 750 m trains
- 30 - 32.5 tons axle load
- 120 - 130 ton per wagon
- 68 wagons per train
- IORE Locomotive 15,000 Hp

Haparanda line Boden - Haparanda

- New ERTMS line
Availability

Reliability

Maintainability

Maintenance support performance
Predetermined maintenance

- Designed functional level
- Lowest acceptable functional level

Condition vs. Operating time

- Moment when fault occurs
- Moment when failure starts to accelerate

- To soon predetermined maintenance
- Appropriate time to perform maintenance
- To late predetermined maintenance
Condition based maintenance

Condition monitoring in proper intervals and knowledge of degradation -> Decision support for maintenance planning and maintenance execution (remaining time to fault)
Operating environment

- Designed functional level
- Lowest acceptable functional level

Condition monitoring/inspections
Predetermined maintenance
Dewirement
http://www.youtube.com/watch?v=m09W479sqhQ&feature=related

Pantograph damage
http://www.youtube.com/watch?v=XgCPPeYmyKw

Bad track
https://www.youtube.com/watch?v=JuP2ZDMh9I8 1:25
Delays per system

Criticality of infrastructure sub systems

- Contact wire
- Track
- Positioning system
- Signal box & section block
- Turnout

40% caused by rolling stock (canceled trains)

Frequency: Number of faults per year

Consequence: Average delay per fault

40% caused by rolling stock (canceled trains)

Highest Life Cycle Cost
Systems and stakeholders’ interrelations
A combined maintenance process
Study of contact wire/pantograph interface
Statistics input to analysis

Contact wire delay hours attributed to cause,
## Failure modes and detectability

<table>
<thead>
<tr>
<th>Priority</th>
<th>Contact wire failure modes</th>
<th>Detectability</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Pantograph motion path obstructed</td>
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<td>2</td>
<td>Horizontal displacement from working point</td>
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<tr>
<td>3</td>
<td>Rapid change of contact wire height</td>
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<td>4</td>
<td>Hoarfrost</td>
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<td>6</td>
<td>Vertical displacement from working point</td>
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<tr>
<td>7</td>
<td>Contact wire tension is either too high or too low</td>
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<thead>
<tr>
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<tbody>
<tr>
<td>1</td>
<td>Lift pressure too high</td>
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<tr>
<td>2</td>
<td>Damaged carbon slipper</td>
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<tr>
<td>3</td>
<td>Lift pressure too low</td>
<td>4</td>
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<td>4</td>
<td>Incorrect dynamic motion</td>
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Failure mode effect and criticality analysis FMECA

- Systemize the degradation of the system
- Assess criticality of failure modes
- Assess the maintenance concept for the system
- Define the information profile (what information do we need to make the right decisions). **Decision support**
Contact wire failure modes

Possible failure causes:
- Track position displacement, changed sub-grade conditions
- Pole displacement
- Loose mechanical parts
- Minus degrees C° and high air humidity
- Jammed rollers or removed weights
- Natural degradation (caused by rolling stock)
- Increased degradation caused by pantographs or hard spots (hangers in low position)
- Inadequate assembly or design

Failure modes:
- Horizontal displacement from working point
- Vertical displacement (too high or too low)
- Pantograph motion path obstructed
- Hearfrost
- Wire tension (too low or too high)
- Thickness of contact wire (more than 20% wear)
- Rapid change of contact wire height

Local effect:
- Increased degradation of contact wire and pantograph, causing preventive maintenance measures to become insufficient to prevent fault. Insufficient power conduction is also an effect.
- Immediate dewirement (severe cases of failure modes)

End item effect:
- Train delay
Applied contact wire detection methods VS need for information

- Applied methods for detection of failure:
  - STRIX measurements
  - Train driver reports
  - Stereophonic measurement
  - Increased lift pressure monitoring
  - Weather forecasts
  - Manual inspections of tension weights
  - Visual condition assessment

- Failure modes:
  - Horizontal displacement from working point
  - Vertical position (too high or too low)
  - Pantograph motion path obstructed
  - Hoarfrost
  - Wire tension (too low or too high)
  - Thickness of contact wire (more than 20% wear)
  - Rapid change of contact wire height

- Information gap

- Condition monitoring information needed to control failure modes:
  - More frequent non-contact measurements of vertical position, horizontal position and thickness of contact wire. Preferably performed with regular traffic and with GPS.
  - Increased resources for increased up lift pressure monitoring
  - Information to coordinate track tamping actions and contact wire rectification actions
  - Micro-climate weather forecasts
  - More frequent manual inspections
Pantograph failure modes

Possible failure causes:
- Maladjustment of pantograph
- Snow and ice
- Damaged mechanical component
- Rapid change of contact wire height, pantograph motion path obstructed, vertical or horizontal displacement of contact wire, hoarfrost or insufficient contact wire tension

Failure modes:
- Lift pressure too high
- Lift pressure too low
- Damaged carbon slipper
- Incorrect dynamic motion

Local effect:
- Increased degradation of contact wire and pantograph, causing preventive maintenance measures to become insufficient to prevent fault. Insufficient power conduction is also an effect.
- Immediate dewirement (severe cases of failure modes)

End item effect:
- Train delay
Applied pantograph detection methods VS need for information

- **Applied methods for detection of failure**:
  - BUBO measures uplift pressure
  - KIKA - carbon slipper monitoring
  - Visual assessment
  - Train driver reports

- **Failure modes**:
  - Lift pressure too high
  - Lift pressure too low
  - Damaged carbon slipper
  - Incorrect dynamic motion

- **Information gap**

- **Condition monitoring information needed to control failure modes**:
  - More resources to perform lift pressure monitoring, frequency measurements (monitoring of dynamic behavior)
  - More resources for carbon slipper monitoring
  - Equip more trains with automatic drop (ADD)
Results from implementation of results from FMECA on level crossings in 2012

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Questions 😊
Thank you!

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Maintenance, southern iron ore line

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