Rail Resilience to SPACE WEATHER

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Summary

• Research objectives
• Methodology
• Findings
• Recommendations
RESEARCH OBJECTIVE

• To understand the threat by:
  – reviewing what is known about the nature, type and extent of space weather events
  – by identifying the types of rail technologies and systems that may be vulnerable to an event
RAIL HAS BEEN AFFECTED BY SPACE WEATHER

- Documented in southern Sweden and Russia
- Impacts occurred at night
- Disruption to signalling was the primary effect. DC Track Circuits reported false blockages (right-side failure) in sections with no trains present.
- **News paper reports:**
  - 1921 - Fires damage signalling on New York Central
  - 1938 UK railway signals disrupted
- Further impacts may be unattributed
PROJECT ASSESSED ASSET VULNERABILITY

59 assets / technologies identified → Potential vulnerability classified → Detailed vulnerability assessment
DETAILED ASSESSMENT USED HazID

- As a starting point the assessments assumed that a space weather event had already occurred
- Frequency-consequence matrix (based on EN50126) used to determine impact with respect to both safety and operability

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Description</th>
<th>Space Weather</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequent</td>
<td>Interference hazard will take place continually</td>
<td>Phenomena causes impact on system continuously during solar event (lasting many hours)</td>
</tr>
<tr>
<td>Probable</td>
<td>The hazard can be expected to occur often</td>
<td>Phenomena causes impact on system for a prolonged time during solar event (lasting 1-2 hours)</td>
</tr>
<tr>
<td>Occasional</td>
<td>The hazard can be expected to occur several times</td>
<td>Phenomena causes impact on system for a short time during solar event (lasting minutes)</td>
</tr>
<tr>
<td>Remote</td>
<td>The interference hazard can reasonably be expected to occur</td>
<td>Phenomena causes a momentary impact on system during solar event (lasting for less than 1 minute)</td>
</tr>
<tr>
<td>Improbable</td>
<td>The interference hazard may exceptionally occur</td>
<td>Phenomena causes no noticeable impact on system during solar event</td>
</tr>
<tr>
<td>Incredible</td>
<td>It can be assumed that interference may not occur</td>
<td></td>
</tr>
</tbody>
</table>
POWER

- Transformers are at risk of failure due to quasi DC currents being induced
- Loss of traction current will result in electrically powered trains becoming stranded
- Train batteries will last for about 90-120 minutes (if new) from when power fails; toilets, air conditioning, heating and main lighting will lose power much sooner
- Stations could also be affected
SIGNALLING

• Potentially affected by power supply outage
• Damage to track circuit feed transformer resulting in loss of train detection -> right-side failure
• GIC induced or directly coupled into a rail -> potential wrong side failure?
ROLLING STOCK

• DC current flowing in the Overhead Contact System (OCS) will also flow in the primary winding of the rolling stock main transformer which may result in overheating. On-board sensors may then result in train shut-down.

• Quasi DC currents may be interpreted as incorrect train operation by Line Current Monitoring equipment (designed to protect against interference with train detection systems), resulting in train shut-down.
GNSS FAILURE

• Not identified as a safety concern but disruption to:
  – Telephone Transmission System – the lineside telecommunications system also relies upon GPS for timing.
  – Selective Door Opening (SDO) – uses GPS to determine the location of the train on the network and uses this information to lock out sets of doors.
  – Variable Traction Current Limiting – GPS is used to switch the limiting on in the train propulsion software.
  – GSM-R (and ERTMS). GPS plays a key role in maintaining timing on the GSM-R network.
GSM-R which employs directional antennas would only be affected during sunrise and sunset, but loss could be critical in an emergency.
TRACK-SIDE STAFF
Geomagnetically Induced Currents flowing in conductors may lead to touch potential issues and there is the potential for the unexpected operation of protection systems.
RECOMMENDATIONS: RESEARCH

• Knowledge gaps:
  – Single event effects: impact on the types of electronic components used in rail infrastructure; this would have to involve equipment manufacturers
  – Track circuit interference: unclear if the limits for maximum levels of longitudinal DC voltages on track circuits would be exceeded during a major space weather event.
  – GNSS dependency: can backup timing derived from other oscillators in rail system support vital communications and data during a GNSS outage.

• Refinement of impacts:
  – Geographic variation
  – Multiple impacts
  – Economic costs
RECOMMENDATIONS: FORECASTING, WARNING

• Rail industry is fragmented. Unclear how to respond to a warning, such as given by the Met Office of NOAA SWPC.
• A system should be implemented to notify track maintainers of space weather events so that appropriate safety measures can be put in place.
RECOMMENDATIONS: MONITORING AND MEASURING

• Review whether any historical disruption or failures of railway assets are the result of space weather.
• Attempts could be made to measure Geomagnetically Induced Currents in existing infrastructure.
For more information

www.atkinsglobal.com

Download report (registration required) at:
http://p.sparkrail.org/record.asp?q=PB021844

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