Extreme weather, climate change and the railways

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  • Climate change effects on the railway network
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The nature of climate change

- Future climate predicted through the use of global climate models, calibrated using climate trends from the last half century
- Different GHG emission scenarios are considered (high, medium and low) for different time slices (2020, 2050, 2080)
- Most current work based on UKCIP02 predictions
- More accurate predictions from UKCP09
Global temperature rise, degrees (°C)

- IPCC A1FI emissions
- A2 emissions
- B2 emissions
- B1 emissions

Start to diverge from mid-century
50% probability level predictions for the period 2070-2099 under the High emissions scenario. From left to right (a) Change in summer mean maximum temperature (b) Change in summer mean precipitation (c) Change in wettest days of winter. [UK Climate Projections 2009]
The nature of climate change

- For the medium / high emissions scenarios
  - A rise of about 1.5 degrees Celsius in the average winter temperature and of 2.5 degrees Celsius for the average summer temperature.
  - Average winter rainfall to increase by around 15% and average summer rainfall to decrease by around 25%.
  - The 20 year return period daily rainfall will increase by around 10% to 15% in the winter and decrease by about the same amount in the summer.
  - Effects become less severe further north, and more severe for the later time slices
  - Sea level rise of 0.4m in 2050
Climate change and transport systems

- Hotter, drier summers
  - Pavement deterioration and melting / Rail buckling
  - Ground shrinkage
  - Passenger thermal comfort
- Warmer, wetter winters
  - Increased surface water and flooding
  - Fewer cold weather events
  - Increased frequency of landslip
  - Scour and washout
- Increased frequency of extreme events
  - Wind / storm induced accidents
  - Tree fall
- Sea level rise
The effect of climate change on the railways

- 2003 RSSB report identified four major effects
  - The effects of high temperatures on track (buckling etc).
  - The effects of high rainfall on earthworks.
  - The effects of extreme precipitation levels on current drainage systems, and the effects of extreme winds on the overhead system
  - Sea level rise
Hotter drier summers

- Increased buckling of train track
- Desiccation of track earthworks
- Greater need for air conditioning systems
- Increased ventilation problems on underground railway systems
- Increased vegetation due to longer growing season – leaf fall issues
“High temperatures are regularly experienced by passengers in hot weather on the Underground, particularly during summer evening peak time. On stations such as King’s Cross, Waterloo, Victoria and Oxford Circus, the temperature can be 11 deg C above ambient temperature above ground. In some instances recorded temperatures have reached 40 deg C. Temperature is the main factor affecting passenger thermal comfort, although air movement is also significant. Survey work in summer 2003 commissioned by LUL [23] identified the average temperature range for thermal comfort as between 21 deg C and 26 deg C in trains and between 17 deg C and 25 deg C in stations. This compares with average observed temperatures over the same period of 28 deg C in trains and 26 deg C in stations.”
Warmer, wetter winters

- Increased flooding of the network, and strain on drainage systems.
- Damage to earthworks - failure of saturated embankments
- Track circuit problems
Slope failure at Carmuir Tunnel
More extreme events

- Increased likelihood of dewirement (the pantograph losing contact with the overhead wire)
- Increased possibility of train overturning and derailment
- Accidents or network disruption due to trees and building debris being deposited on the track.
Sea level rise - Dawlish

- Extreme conditions estimated
- Transferred from offshore point to nearshore locations
Sea level rise - Dawlish

<table>
<thead>
<tr>
<th>Year</th>
<th>Increase in Overtopping</th>
<th>Events Resulting in Both Lines Being Shut</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>0</td>
<td>1 in 6</td>
</tr>
<tr>
<td>2020</td>
<td>50%</td>
<td>1 in 3.5</td>
</tr>
<tr>
<td>2050</td>
<td>125%</td>
<td>1 in 2</td>
</tr>
<tr>
<td>2080</td>
<td>250%</td>
<td>1 in 1</td>
</tr>
</tbody>
</table>
Current work at Birmingham University

- The effect of climate change on railway operation
- FUTURENET
The effect of climate change on rail operation
Global temperature rise, degrees (°C)

- IPCC A1FI emissions
- A2 emissions
- B2 emissions
- B1 emissions

Start to diverge from mid-century

Delay (minutes) vs. Maximum Daily Temperature °C

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Number of delay minutes attributable to “buckle” events recorded in the ADB against the maximum daily temperature on the date recorded for each region.
Maximum, Mean and Standard deviation trends in delay minutes of all heat related incidents from the ADB against the maximum daily temperature on the date of discovery for all regions.
FUTURENET
Future resilient transport networks

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Funding

- FUTURENET is funded under the EPSRC “Adaptation and resilience to climate change” programme
- ARCC co-ordinates around 6 new projects and 6 from earlier calls
- Annual workshops / data sharing
- Collaboration between projects encouraged
- Stakeholder events
- Most use UKCP09
- Total FUTURENET value - £1.5million (25% of new funding)
The key questions

- What will be the nature of the UK transport system in 2050 both in terms of its physical characteristics and its usage?
- What will be the shape of the transport network in 2050 that will be most resilient to climate change?
The project objectives and deliverables

- The development of a number of possible UK transport scenarios for 2050. (WG1)
- The identification of a route corridor for the study together with an inventory of infrastructure assets for that route corridor. (WG2)
The project objectives and deliverables

- The development of conceptual models of weather / climate induced failure mechanisms of transport systems, together with meteorological and climatic trigger levels. (WG3)
- Travel behaviour survey including discussion of effect of infrastructure reliability on travel choice (WG4)
The project objectives and deliverables

- The development of a modelling methodology that will integrate the work of the earlier objectives, and allow the effect of climate change on the resilience of transport networks to be systematically studied. (WG4)
- The development of generic tools that can be applied to other transport corridors and the wide dissemination of the results amongst stakeholders. (WG5)
Time scales

- Kick off meeting – June 10th 2009
- Current activity
  - Appointment of staff
  - WG1 - stakeholder workshops
  - WG2 – gathering data for preferred routes
  - WG3 - develop conceptual framework
- Finish – March 2013
Corridor selection

- Selection criteria:
  - Road, rail and air travel modes
  - Significant passenger (leisure and business) and freight usage
  - Variations in climate; temperature, temperature, sheltered/exposed
  - A range in the projected change in climate
  - A range of geology
  - A range of flood risk
  - Areas of high winds
  - Well defined corridor/reduced travel options to reduce complexity of modelling
Great Britain
Passenger railway network
Outline map

Not all stations or routes shown

- Airport interchange
- Rail-air link with Heathrow Airport
- Ferry interchange

London terminals
- C Charing Cross
- E East C
- F Fenchurch Street
- K Kings Cross
- L Liverpool Street
- W Waterloo

www.projectmapping.co.uk

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### Meeting the criteria

<table>
<thead>
<tr>
<th></th>
<th>London to Glasgow</th>
<th>London to Edinburgh</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air traffic</strong></td>
<td>High</td>
<td>Highest</td>
</tr>
<tr>
<td><strong>Rail traffic</strong></td>
<td>V. busy station, but relatively low rail passenger numbers travelling to London.</td>
<td>A less busy station than Glasgow or Manchester, but larger passenger numbers travelling to London.</td>
</tr>
<tr>
<td><strong>Road traffic</strong></td>
<td>Busy roads around Glasgow and London to Manchester, less busy Manchester to Glasgow (&gt;150,000 in places).</td>
<td>Less busy (&lt;75,000 AADF).</td>
</tr>
<tr>
<td><strong>Temperature variation across corridor</strong></td>
<td>5 to 7°C.</td>
<td>5 to 7°C.</td>
</tr>
<tr>
<td><strong>Rainfall variation across corridor</strong></td>
<td>1400mm.</td>
<td>400mm.</td>
</tr>
<tr>
<td><strong>Projected change in annual mean temperature</strong></td>
<td>London +2.5°C, Glasgow +2.1°C</td>
<td>London +2.5°C, Edinburgh +2°C</td>
</tr>
<tr>
<td><strong>Change in winter and summer mean daily precipitation</strong></td>
<td>London DJF +15%, London JJA -21%, Glasgow DJF +12%, Glasgow JJA -15%</td>
<td>Edinburgh DJF +11%, Edinburgh JJA -13.5%</td>
</tr>
<tr>
<td><strong>Modelling complexity</strong></td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>
Selected corridor

- London to Glasgow along the west coast
  - high volume of road, rail and air traffic
  - large variation in climate by choosing south east to north west route
  - variety of climate change impacts
  - strategically important route
FUTURENET: Modelling context

1. Identify journeys, routes and modes
2. Identify principal route / diversionary route segments
3. Identify ‘normal’ end-to-end principal / diversionary route journey times
4. Identify ‘normal’ principal route / diversionary route capacities
5. Identify delay severity and probabilities on principal and diversionary route segments due to weather events (this will include identification of thresholds)
6. Generate weather time series consistent with climate change scenarios and apply to route segments, comparing with climate thresholds
7. Distribute traffic flow between principal and diversionary routes
8. Calculate new end-to-end journey time
9. Repeat (6) to (10) many time – Monte Carlo method
10. Calculate resilience.
FUTURENET: Modelling context

Transport Network Planning (5-year cycle)

FUTURENET Model (on 5-year cycle to match Network Planning cycle)