Future Resilient Transport Networks (FUTURENET)

An Overview of the FUTURENET Project with Particular Reference to Railway Aspects

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Abstract

FUTURENET is a multi-partner, multi-disciplinary research project, investigating the development of a methodology to assess the resilience of the United Kingdom (UK) transport network to climate change. It looks forward in time to changes in climate and weather anticipated in 2050, and considers the impact of these on the principal modes of transport (road, rail and air) operating on the UK’s London to Glasgow corridor. The project includes a number of sub-projects, designed to fill important gaps in knowledge relating to resilience, including: what transport scenarios would be most appropriate for 2050; what impact climate change will have on travel demand; how best to generate future weather patterns and apply them to the transport network, and; how best to combine knowledge of scenarios, demand and weather to create a methodology capable of assessing the resilience of the network? The methodology is being developed within the context of a complex transport system; to cope with that complexity, systems engineering techniques are used to provide a framework for data gathering, integration and modelling. The first part of the paper provides an overall description of the project. This is followed by a section describing in more detail railway aspects. The paper concludes with an outline discussion of future work.

1.0 Introduction

FUTURENET is a multi-partner, multi-disciplinary research project, investigating the development of a methodology to assess the resilience of the United Kingdom (UK) transport network, in the face of climate change. It looks forward in time to changes in climate and weather anticipated in 2050, and considers the impact of these on the principal modes of transport (road, rail and air). FUTURENET is funded by the Engineering and Physical Sciences Research Council (EPSRC) as part of its ‘Adaptation and Resilience to Climate Change’ (ARCC) programme. ARCC is part of the UK Government’s Climate Impact Programme (UKCIP), which aims to generate the knowledge required to mitigate climate change effects and help organisations to adapt.

There is a significant risk that in forty years time climate change will have a noticeable, adverse effect on the UK’s transport network. This will show itself in a number of ways including: higher average and peak temperatures, resulting in higher risks of railway track buckling; reduced average rainfall experienced in fewer, but higher intensity storms, leading to higher risk of landslips and flooding, and; related to storm intensity, higher peak wind speeds with higher risks of vehicle over-turning.

If the transport network is to operate satisfactorily in these more difficult conditions, new and enhanced infrastructure will be required. Infrastructure works have a long lead-time and service-life; therefore, strategic transport planners must begin to take action over the next few years, if the needs of 2050 are to be met. However, existing strategic planning processes do not adequately address climate change. A new, integrated methodology is required: one that provides an assessment of the resilience of the network in the light of anticipated weather conditions, and offers a foundation from which to identify the work required for future provision of a robust transport network. FUTURENET’s
principal aim is the development of this methodology. To facilitate this, the project includes a suite of sub-projects, designed to fill some of the important gaps in existing knowledge.

This paper provides a general description of the project, before focusing on railway aspects. It starts by highlighting the challenges that climate change will cause and the complex range of issues that must be considered together, to assess the resilience of the transport network. It then moves on to consider a suitable framework for the project and explains the decision to use a systems engineering approach to assist methodology development. The supporting research packages are described in outline, followed by a more detailed description of railway-related, early-stage research. The paper concludes with a brief discussion of points of interest that have emerged from the project so far.

2.0 Background

2.1 Climate Change and Transport

Much current discussion about transport and climate change focuses on the impact of transport on climate change (e.g. Chapman 2007). Many mitigation measures are focused on the transport sector (Walsh & Hall, 2007). However, FUTURENET recognizes that climate change also has an impact on transport. Recent ARCC workshops have identified this impact as having two dimensions: an engineering dimension, derived from the interaction between climate, weather events, infrastructure design and the physical network, and; a socio-economic dimension, derived from the interaction between weather, climate and patterns of transport demand (Jaroszewska et al, 2010). FUTURENET integrates both in the development of a methodology to assess the future resilience of the UK transport system. This interdisciplinary approach will help stakeholders take the strategic decisions necessary to at least maintain in 2050 existing levels of network resilience.

2.2 The Engineering Dimension

Transport is continuously subject to meteorological impacts, causing disruption, injuries and fatalities across all modes (Thornes, 1992). The effects of rain (Andrey et al, 2003), wind (Baker, 1993), high temperatures (Dobney et al, 2010), ice and snow (Chapman et al, 2001) are each individually well documented; however, the combined effects are not (Dijkstra and Dixon, 2010). Climate change will decrease some events (e.g. ice), but others will become more frequent (e.g. high temperatures). UKCIP and the Intergovernmental Panel on Climate Change (IPCC) have identified the need to allow for this when designing new, or adapting existing, transport infrastructure (UKCIP, 2001; IPCC, 2007). The potential impact of significant alterations in meteorological hazards must be holistically assessed, given the economic benefits of an efficient national transport network (Eddington, 2006), the costs associated with disruption, and the similarity between infrastructure development time scales and the timeframe for climate change.

2.3 The Socio-Economic Dimension

The UKCIP (2001) observes that, ‘Studies to assess climate change impacts suffer from serious weakness if, by default, they merely assume that the projected future climates will take place in a world with a society and economy similar to today’s’. However, the drivers for transport demand are not well understood, let alone their vulnerability to climate change. The first Foresight work on Transport (OST, 1995) identified a social science gap in understanding why people need to travel. Recent reviews (e.g. Larsen et al, 2008) show that limited progress has been made. Current models and methodologies do not sufficiently capture how transport is embedded in people’s social and economic relationships, and how these are likely to shift under changing climatic conditions.

2.4 Project Scope

When the original concept for FUTURENET was being developed, it assumed an outline structure for the resilience assessment methodology, which has been carried through into the project. This assumes a major, multi-modal, UK transport corridor, described in terms of: topology; geology; hydrology; principal and diversionary route segments for each mode; existing traffic flows, and; infrastructure. Weather events, generated by the UKCP09 climate projections (Murphy et al, 2009) are combined with future travel scenarios, applied to the corridor, and the impacts these have on infrastructure performance and traffic flows are used to assess network resilience
FUTURENET includes a suite of sub-projects, designed to fill knowledge gaps in the development of the methodology. The research topics include:

- Identification of a UK transport corridor on which to base development of the resilience assessment methodology;
- A scenario-based investigation of the influence climate change has on travel demand;
- A survey-based investigation of the influence climate change has on travel behaviour;
- The investigation and modelling of transport failure modes and associated failure triggers and thresholds, relating to a range of factors including infrastructure, travel and ground conditions;
- An investigation into the generation and application of future climate and weather events to the transport corridor, and;
- Development of the network resilience assessment methodology.

3.0 Coping with Complexity

The UK transport network and the environment in which it exists form a complex system: changes in one part of the system can have effects in other parts that are difficult to predict. It was realised at an early stage that FUTURENET needed some way of coping with this complexity in terms of: identifying and storing all the relevant data; integrating the data to create a working methodology, and; using the methodology to estimate resilience for a range of possible future conditions. System engineering techniques were developed in the 1950s in response to this sort of challenge, and based on experience gained on an earlier EPSRC-funded research project studying systems-based aspects of railway innovation (Bouch et al 2010), the decision was made to employ them on this project.

3.1 What is Systems Engineering (SE)?

SE provides a top-down methodology for the development of new products and their associated systems, and is often described using the ‘V – diagram’ in Figure 1 (INCOSE, 2010). The activities on the left-hand leg cover: identification of the operational concept (an outline description of what the system will do, but not how it will do it); identification of the originating requirements (what stakeholders want from the system); derivation of the system requirements (what the new system must do to satisfy the originating requirements); development of the system architecture (how the system will be structured to deliver the requirements), and; implementation (construction of the components, software or hardware, from which the system will be built). The stages on the right-hand leg cover the activities necessary to check the system that has been created meets the requirements originally specified.

![V Diagram](image-url)

*Figure 1: ‘V – Diagram’ showing the principal steps in the systems engineering design and manufacturing process*

3.2 Application of SE to FUTURENET

3.2.1 Background

In the early stages of the project, SE was not used explicitly in the generation of the research proposal, but was implicit in the logical process adopted and the structured outcome. The early work of UKCIP identified that climate change would have an adverse impact on the transport network’s
Challenge F: Even more trains even more on time

infrastructure and the ability of the network to perform as required. ARCC identified the need to allow for this in the strategic planning process. FUTURENET responded with a research proposal that identified the need for a system to assess the resilience of the network under changing weather conditions (the methodology), and provided an outline operational concept. Originating requirements were not stated, but the project was very clearly focused on addressing two key questions, namely:

- What will be the nature of the UK transport system in 2050 (taken as the mid-point of the UKGP09 scenarios), 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?

3.2.2 Modelling the Resilience Assessment Methodology using CORE®

The ability to integrate large amounts of system data is important to the successful development and operation of the methodology. A number of sophisticated computer-based tools have been developed that can help, including CORE®, produced by the Vitech Corporation in the U.S.A. CORE® is a large scale Entity-Relationship-Attribute database, where entities (the ‘things’ that constitute the system and include non-physical things like requirements, as well as hardware) are described by their attributes, and linked together by relationships, as shown below in the diagram of Figure 2. This arrangement creates a very powerful tool that can do several important things:

- Provide a logical framework for the storage and integration of the system data
- ‘Operate’ the methodology: in other words step through the methodology functions to provide an assessment of network resilience;
- Link requirements to methodology functions and provide a mechanism for tracing the impact on the system of any changes made during methodology development

![Figure 2: A Diagram Showing the Components of a CORE® Model](image)

3.2.3 Building the FUTURENET System Environment

Development of the resilience assessment methodology must take account of a wide range of factors. Among them are:

- Strategic planning processes used to ensure that the transport network is developed effectively to meet the UK’s future needs;
- European and national government policies relating to transport: these include policies on sustainability, green house gas emissions and economic growth and community development;
- Procedures employed in the operation and maintenance of the network, and;
- Technical and safety standards which have to be complied with.

The relevant policy, procedures and standards documents were identified using the top-down techniques developed on the previously mentioned EPSRC-funded railway innovation project. The
documents were reviewed to identify requirements relevant to the methodology, together with the constraints that would apply. These have been input to CORE® and will be linked to the resilience assessment functions as development of the methodology progresses.

3.2.4 Building the FUTURENET Resilience Assessment Methodology

The first step was to identify FUTURENET’s overall mission. This was not stated explicitly in the research proposal; however, the two key questions stated in section 3.2.1 above were used to derive the following Mission Statement:

‘To develop a methodology for assessing the resilience of the UK transport network in the face of predicted climate change’

The next step involved expansion of the outline operational concept from the research proposal, to give a clearer picture of what the methodology has to do. This lead to the following operational concept:

- Identify principal route segments for each mode
- Identify diversionary route segments for each principal route segment(s)
- Identify journeys (combination of principal routes and modes)
- Identify end-to-end journey times for normal conditions
- Identify diversionary route travel times for normal conditions
- Identify diversionary route capacities
- Identify weather events
- Identify probability and severity (%) of principal and diversionary route segment capacity reductions due to a range of possible weather events of varying severity (this will include identification of thresholds)
- Apply weather events to principal and diversionary route segments
- Distribute traffic flow between principal and diversionary routes
- Calculate new end-to-end journey time
- Calculate resilience

Work is underway to develop each of the steps in the operational concept, involving integration of existing tools and models with new ones, created using new knowledge generated from FUTURENET’s research sub-projects.

4.0 Research

4.1 The Transport Corridor

Modelling the whole transport network of the UK in sufficient detail to identify all climate vulnerabilities would be a task beyond the resources of this project. However, while no single route can encompass all situations, geologies, topographies, climate and infrastructure that a transport operator will come up against, a corridor could be identified that covers a wide range of typical situations enabling the development of a modelling methodology applicable to all of the UK.

The key criteria for selecting the corridor are: that it is long enough so that different transport modes (e.g. road, rail and air) are viable, and; that it should also be used for both passenger and freight, with a reasonable amount of usage for all modes. The corridor also needs to experience a broad range of typical UK weather and the range of climatic changes projected for 2050. This enables a range of climate impacts to be explored. It was also felt that the corridor should include London due to its political and economic importance to the UK and the high volume of traffic in this area.

Outputs from the UKCP09 Climate Projections were explored to identify corridors with significant climate variation along the length of the corridor. This process indicated that corridors that covered a significant distance north-south and/or east-west should be considered. Potential corridors to be examined in more detail were identified, looking in particular at the traffic volumes for both people and freight across the three modes.

After considering climate and road, rail and air usage data for a short list of options and discussion with key stakeholders the corridor selected was that covering London to Glasgow via the west coast.
This is a strategically important corridor which transverses a range of climate, geology, topography and has a high volume of traffic using each transport mode.

4.2 The Influence Climate Change has on Travel Demand in 2050

This element of the project is developing scenarios for travel behaviour and demand in 2050. In contrast to other strands of FUTURENET, it has a substantial qualitative element. This involves taking various quantitative projections (demographic, economic, climatic, etc) together with more speculative visions of value change, and attempting to translate these into plausible narratives of behaviour and demand. While the quantitative elements will be available for use in FUTURENET modelling, the scenarios can be used for wider public engagement in policy debates about strategic investment decisions to reduce vulnerability or enhance resilience.

A particular feature of the FUTURENET approach is the provision of an explicit evidence base for each scenario, together with an account of any value choices implied by the narrative: many existing scenario packages obscure these, failing to show their foundations in a robust dataset or concealing their normative assumptions about what would constitute adaptive behaviour under future social, economic or environmental conditions. This approach also challenges the implicit technological determinism that is frequently found in scenarios, seeing that the adoption of technologies for resilience will be shaped by social, economic and cultural factors as much as shaping them. The ability to deliver a resilient transport system in 2050 will, for example, be strongly influenced by the economic and cultural conditions of the next decade, which will determine what resources are available to support technological development and the choices made in where those resources are invested.

4.3 The Influence Climate Change has on Travel Behaviour;

A travel behaviour survey of users along the London-Glasgow transport corridor is being undertaken in order to understand user response to network performance modifications due to climate change. The main survey, of at least 2,000 individuals, is to be conducted in April/May 2011 (after two pilot surveys) across four sampled neighbourhoods in both Glasgow (North East; Linn; Garscadden/Scotstounhill; Anderston/City) and London (Barking & Dagenham; Barnet; Merton; The City of Westminster). The survey, using an internet panel, will cover both leisure and business travel (a subsequent smaller-scale survey will examine freight operators). The three main parts of the survey examine:

1. Uncertainty: previous user trips affected by extreme weather and natural events; exploring respondents’ normal reaction to uncertainty when travelling, and; propensity to risk.

2. Social contacts and impacts upon travel: define the users’ social network and indicate who they turn to in particular for advice on travel decisions (including if they were experiencing an uncertain situation while travelling).

3. A stated preference experiment of eight different choice situations along the corridor using the following attributes: method of travel; normal duration of the trip; frequency of service; ticket or fuel cost; toll cost, and; likely travel-time delay. In addition to choice between the transport modes of air, train, car and coach, respondents are given the possibility not to travel given the described conditions.

The questionnaire also includes personal/household demographics, background transport information and environmental attitudes. In terms of linkages to the overall FUTURENET project, there will be an exploration of respondent perceptions of what constitutes failure, apart from the delay itself. Choice model outputs (from the stated preference experiment) will produce coefficients explaining the weight of each attribute level in the determination of the probability of choice, and it will be possible to calculate elasticities and willingness to pay values for (reduced) delays. It should also be possible to see (if statistically significant) at which level of the delay respondents turn either to another mode, or to the option of not travelling.
4.4 Modelling of Transport Failure Modes and Associated Triggers / Thresholds

The FUTURENET project involves two types of modelling: detailed physical models for the effect of meteorology on specific types of infrastructure (e.g. landslips, flooding), and large-scale statistical models for the effect of meteorology on traffic velocities on links along the route. Through this the probability of a link being completely severed under certain meteorological conditions can be found (using both the detailed and large scale models), as well as the effect on volumes under meteorology that doesn’t cause complete failure (using the large-scale model).

The large scale model will need to determine both the threshold beyond which a link will fail, and the relationship between meteorology and velocity below this threshold. Failure data has been obtained from the Highway Agency’s HATRIS database (with potential use of the STATS19 police accident records) for road transport, and Network Rail’s alterations database (ADB) for rail transport. Data sources for air travel have yet to be determined, although access to airports is to a large extent determined by the reliability of road and rail transport. Meteorological data will be obtained from surface meteorological stations as well as the NIMROD rainfall radar network, which will allow relationships to be built on a daily or hourly temporal resolution. Confounding transport-related patterns such as daily, weekly and seasonal patterns in traffic volumes will also be taken into account.

The relationships will be applied to the route using a geographical information system (GIS) running visual basic. The route will consist of both primary and diversionary paths, each split into links. Both single and multi-modal journeys along the route will be modelled, with time series of concurrent meteorology being run over the network. The model will determine whether a link along the route will fail or be reduced in velocity, and whether this will also affect the diversionary routes. From this a weather-affected journey time can be calculated, which can then be compared to that under normal conditions.

The GIS ground model has been built up in ArcGIS® (Esri) using DigMapGB50 (British Geological Survey) to provide 1:50 k scale vector geology and NEXTMAP® (Intermap Technologies) to provide digital elevation on a 5 m raster. The model has been populated with the spatial distribution of the susceptibility of the ground to geo-hazards, such as landslide and flooding, based upon GEOSURE (Harrison & Forster 2006). Specific datasets such as, the Landslides Database have also been interrogated to include spatial information relating to observed geo-hazard events into the ground model. The ground model incorporated in ArcGIS provides the platform to study the geological domains in which each geo-hazard occurs. By interrogating the observed events, failure thresholds can be associated with a set of characteristic parameters and used as a basis to define domains with geo-hazard failure potential. The ground model can then be interrogated to identify where these domains coincide with the transport corridor and the infrastructure links that will be affected. In this way, a geological dimension to the resilience of the transportation infrastructure can be assessed.

4.5 Generation / Application of Climate and Weather Events to the Transport Corridor

The ability to determine low-probability, high-impact events is of great importance to transport when considering such hazards as rail buckling or landslips, and is best catered for by the UKCP09 probabilistic climate projections and weather generator (WG). The UKCP09 climate projections use thousands of model variants to account for uncertainties in our understanding of the climate system. These are presented as probability density functions (PDFs) for decadal time-steps (2020s, 2030s, 2040s etc) at low, medium and high emissions for annual and seasonal temperature and precipitation averages. These can be converted into synthetic time series of daily and hourly weather at a 5km grid scale using the WG to create plausible data for rainfall, temperature, sunshine hours and potential evapo-transpiration (PET). These capture both the extreme short-duration events that can trigger transport failure, as well as the longer-term antecedent conditions.

However, a major drawback of this method is that the projections are not spatially coherent, meaning that they do not give a picture of the weather for the UK as a whole, limiting the ability to analyse multiple link failures during a given journey. The WG also excludes projections for wind, an important meteorological variable for transport (although this could be calculated through PET). An alternative method is to use the 11 member Hadley RCM (regional climate model). This has the advantage of creating a daily time-series of realistic weather across the UK at a 25km grid scale. It would therefore
be possible to determine the likelihood of several links of different modes failing during a journey. This approach has the distinct disadvantage that the projections are given at the daily rather than hourly resolution. Additionally, being based on only 11 model runs, it fails to account for the full range of potential climates (although recent updates have improved this situation). The FUTURENET team are investigating the possibility of using both tools in combination to create spatially coherent daily time series for the entire route.

4.6 The Network Resilience Assessment Methodology

The logical steps of the operational concept highlight the need for identification of weather events that drive the physical processes which, in turn, impact on the network and its users. The approach attempts to reduce the modelling effort by focusing on a number of plausible narratives of weather event sequences (scenarios) that are known (or suspected) to lead to specific events that have a negative impact on the resilience of the infrastructure network. These scenarios form the main drivers of the Futurenet approach. Using this as a starting point, it is possible to simplify the logic of the physical modelling approach by a cascading structure. Thus, assessment of the forecasted impact of physical processes on the condition of the network leads to a determination of how this is felt by the user, and this can consequently lead to an assessment of network resilience (Figure 3).

Figure 3: Conceptual diagram illustrating the main components of the cascading structure of the network resilience assessment methodology.

The ‘climate forecast’ is intended to be based on downscaled UKCP09 probabilities for certain weather event sequence scenarios (Jones et al., 2009), or could be based on the recorded historical weather using UKCP09 scaling factors (relevant to the tri-decadal centres of 2030, 2050, 2080). Either approach is potentially capable of providing probabilistic inputs into the model. The weather event sequences are manifested in different environments (e.g. fluvial, pluvial, ground) and define the processes of a range of physical models (grouped under the heading physical model typology). The physical models (e.g. ponding, overland flow, groundwater fluctuations, thermal straining, wind pressure) are influenced by conditioning parameters driven by the infrastructure asset, ground and topographic conditions. The ‘infrastructure condition’ represents an additional layer of complexity determined for any time in the future that is relevant to the modelling of the physical processes (this can be used, for example, to model the infrastructure asset condition by simulating conditions ‘as good as the present’, ‘better than the present’, ‘worse than the present’). The ‘ground condition’ incorporates landforms, internal hydrology and materials. The ‘topographic condition’ provides a mechanism to identify the intensity of processes (e.g. convergence of flow, relative position of infrastructural element in the landscape). This approach delivers, via the groups of different physical models, a range of event outcomes that can be expressed in probability terms.
The ‘outcomes’ are physical process manifestations and these will be related to the consequences for a user of the infrastructure network (e.g. skid risk, visibility, temperature stress, ride quality). This will be achieved in a limit state context to order the thresholds affecting the users (ranging from a serviceability limit state to an ultimate (failure) limit state). To maintain the generic nature of the model a single user consequence concept is employed. This ‘unit user’ component also interacts with the model by informing thresholds and thereby the probabilities of specific event occurrences as shown above.

A further step is required to upscale from the unit user to the aggregated effects of multiple users (driven by the user behaviour/choice modelling). This lies outside the realms of the physical model and is dependent upon work done elsewhere in the project. This turns the probabilities of a single event impacting on a single user into joint probabilities of weather event sequences interacting with the complexities of user behaviours and choice. This component links the physical model with the assessment of resilience.

5.0 Railway Aspects

This section of the paper describes research findings relating to the railway mode. In the case of travel demand and failure modes, the findings relate to passenger services. Data for freight services will be gathered later on in the project.

5.1 The Railway Corridor

Departing from London Euston, the first 96 kilometres (km) are at least four-track railway. Between 96km and 336km (Preston station) the line is a mixture of two and four tracks. From Preston to Glasgow the line is predominantly two-track. The whole route has recently been renewed and upgraded as part of the West Coast Route Modernisation scheme. The line is electrified throughout with overhead line electrification (OHLE) at 25kV and the principal train service on the route is operated with electric traction at a maximum speed of 200 kilometres per hour (kph).

South of Crewe (253km north of London) there are two options for diverting trains off the main line. For main line blockages occurring between 96km and 134km (Rugby), trains can be sent via the Northampton Loop. For main line blockages between 134km and 213km (Stafford), trains can be sent via Birmingham. In both cases, no special traction arrangements would be required. North of Crewe options are much more limited: for blockages between Preston and Carlisle, the Settle - Carlisle line is available, but arrangements would have to be made to provide diesel traction, because the line is not electrified.

Strategic development of the corridor and of the network as a whole, takes place against the background of a series of Government-administered Control Periods, each of five years duration. Prior to the beginning of each Control Period, the Department for Transport and Network Rail agree a statement of railway outputs to be delivered over the next five years, together with the level of financial support that will be provided. Performance of the railway during the Control Period is judged against its ability to deliver the agreed outputs within the budget. During the course of a Control Period, planning for the next one will be underway; therefore, the lead time for delivery of new infrastructure can be up to ten years. However, timescales can be longer for large projects where there are significant town and country planning issues to be considered.

5.2 Railway Travel Demand

The travel behaviour survey will be carried out in May 2011; therefore, it is not possible to explore the behavioural results relating to railway travel in this paper. It is interesting to note in terms of overall railway travel demand, however, that in the decade up to 1997 UK rail passenger travel increased by 40%. The UK Government’s current policy aim (DfT, 2007) is to double the level of passenger traffic in the period up to 2014, while at the same time creating a railway that is safer, more reliable and more efficient than now. It must be able to cater for a more diverse, affluent and demanding population; and it must reduce its carbon footprint and improve its overall environmental performance. The actions taken to achieve these goals will have an impact on demand, which will be studied within the context of the scenario development described above.
5.3 Failure Modes, Triggers and Thresholds

The UK’s railways have a well-defined set of plans for coping with adverse weather conditions. Railway Group standards provide high level guidance on the action to be taken, while Network Rail’s own technical standards and procedures provide detailed instructions. In the light of this, what constitutes failure of the train service: how does it fail, what are the triggers, and are there any clear thresholds between acceptable service levels and failure?

In the case of flooding, if water is flowing along or across the track, the Rule Book (RSSB, 2003) requires services to be suspended through the affected area until engineers have visited site and confirmed the track is in a satisfactory condition. If it is, trains can run again, but must travel at low speed, while the track is monitored visually. If water is standing on the track, trains can run, but emergency speed restrictions apply, with speeds determined by the depth of the water above or below the rail head. The situation can be made more complicated by the existence of more severe ‘local’ instructions, applied to a specific area or type of train: for example, some trains have traction packages that are more easily damaged by flood water; therefore, train operating companies impose stricter limits on permissible flood depth than the Rule Book.

In the case of wind, services are modified in response to the strength and frequency of wind gusts. For gusts greater than 50mph an emergency speed is imposed. For gusts greater than 60mph, the permissible speed is reduced further, while for gusts greater than 70mph, the service is suspended. Again, local instructions may apply.

Where the depth of snow on track does not exceed 200 millimetres above top of rail level trains can run as normal. If the depth is between 200 millimetres and 300 millimetres the train service must be suspended, except for trains fitted with mini snow ploughs, which can run as normal. For depths between 300 millimetres and 450 millimetres trains fitted with mini snow ploughs can only run with the authority of the local manager. For depths greater than 450 millimetres and less than 1800 millimetres, trains can only run after the line has been cleared by independent snow plough.

Track buckling normally becomes an issue when the air temperature starts to exceed 35 degrees centigrade, which implies a rail temperature of approximately 50 degrees centigrade. In that situation there is a range of emergency speed restrictions that can be applied to reduce load on the track and reduce the risk of buckling.

Network Rail’s response to severe weather is based on 5-day weather forecasts that it receives from the forecasting company Meteo. If the forecast suggests severe weather a telephone conference is held with the relevant train operators to agree an amended timetable, based on previously prepared contingency plans. The amended timetable could involve things like: cutting every second train out of a service, and; routing trains via alternative lines.

If the weather problem occurs without advance warning, changes are made to the timetable by the operations Control Room, in response to the circumstances on the ground. So for example, if a train is running very late, the Control Room may decide to stop it short of its final destination and send it back to its start point.

Where severe snow is forecast Network Rail may decide to operate a ‘key route strategy’. This concentrates available resources on key junctions, while leaving others unattended. The effect is to run a limited service on key routes, but with the risk of running very little elsewhere. This approach is adopted very much as a last resort, because of the risk of severe damage to the train service.

It is clear from the above that railway services can operate in a range of states due to weather conditions. These include:

- Good weather - service operating to timetable
- Bad weather, but the infrastructure and trains can cope with it – service operating to timetable
- Severe weather, but mitigation procedures (snow clearance, point heating) work satisfactorily – service operating to timetable
- Severe weather requiring introduction of contingency plans – reduction of timetabled services (reduction could range from relatively minor to severe)
- Very severe weather outside the scope of contingency plans – service suspended.
What is not clear is the point at which the service can be said to have failed. It seems obvious to assume that this might be when the service has to be suspended; however, if a severely reduced timetable reduces the number of passengers travelling, this might also be regarded as a failure.

5.4 Application of Climate and Weather Events

Dobney et al (2010) provides a foundation of work for the FUTURENET project with an assessment of the potential impact of increases in high temperatures on buckle-related delays. This work relates delays recorded in the alteration database (ADB) to daily maximum temperatures recorded at meteorological sites in the UK. Regression equations were found, as well as threshold temperatures after which delays become more likely. This was conducted over four composite regions of the UK. FUTURENET will translate this work onto the finer resolution of the rail corridor. Work has been carried out on linking NIMROD rainfall radar data to road disruption from the HATRIS database. Although presented at a finer resolution than the climate projections, the rainfall can be averaged over 5km or 25km grids for compatibility. This is currently being implemented for the ADB along the rail route.

6.0 Further Work

The FUTURENET project has another two years to run, during which time work on methodology development and the associated research sub-projects will continue. With regard to systems aspects, the focus will be on the identification and review of relevant policy documents and technical standards to elicit the requirements for the methodology. The sub-projects will contribute to the development of the operational concept functions, which will be input to CORE® and linked with their respective requirements: in particular, detailed work will be carried out to identify and/or develop tools and models relevant to each of the functions. Output from the travel behaviour survey will be combined with the work on travel scenarios to produce a set of future travel demand scenarios. The relationship between weather conditions and failure of the network will be explored further, and output from the travel survey will be used to identify what level of service degradation is consistent with the network failure from the passengers’ point-of-view. The weather generator will be developed further and applied to the London-to-Glasgow corridor, to provide patterns of weather against which transport system performance can be assessed. Finally, the integrated methodology created in CORE® will be used to assess the resilience of the corridor under a range of climate and demand conditions.

Bibliography


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