AVOIDING PERFECT STORMS: ITS FOR WEATHER EVENTS

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1 INTRODUCTION

1.1 Background

In recent years we have experienced adverse weather conditions which have caused major problems for transport services. During this time we have seen a number of extreme storms and floods which have caused significant disruptions to road traffic and ferry services. These occurrences of extreme weather conditions have had considerable impact on the Scottish economy with thousands of hours lost each year, not to mention the significant number of lives that have been lost as well. The Scottish Government has recognised this in the recent 'Scottish Road Network Climate Change Study' [Transport Scotland (2008)] in order to adapt the future design and operation of the Scottish road network to the predicted effects of climate change. Since weather events can have significant impacts on the transport network it is important to be able to monitor and predict weather conditions in order that timely information can be made available to network operators and travellers. This will result in safer environments, smoother traffic flow and reduced delay.

1.2 Outline of Paper

This paper will consider the environmental and climate change challenges facing transport operators and review how applications of Intelligent Transport Systems (ITS) can be used to monitor and manage weather events, reduce risk and disseminate appropriate travel information. While we cannot change the weather, we can reduce the disruption it can cause to travellers and provide better support for transport operators. The paper will consider the following aspects in relation to the effects of adverse weather conditions and their impact on transport operations:

- Climate change and changing weather patterns;
- Methods and technologies for monitoring weather conditions;
- Managing weather related events which affect transport services; and
- Dissemination of information to transport network users.

International practices for monitoring, managing and disseminating information relating to weather events will be reviewed. This will include network monitoring, weather event management and the provision of relevant and timely information to travellers. In conclusion the aim is to learn from other experiences which can be transferred to a Scottish or UK context and to consider future directions for ITS developments in this area.

2 Climate Change and Extreme Weather

2.1 Changing Weather Patterns

The general consensus in the media is that our weather, and in particular the frequency of severe weather conditions, is getting worse. It is also evident that the type of extreme weather affecting different regions of the world does vary considerably. The main focus in North America, since the Rural ITS programme was introduced in the 1990's, has been on winter driving conditions. More recently, Hurricane Katrina, which hit New Orleans in August 2005, has triggered research into the impact of hurricanes on transport services and particularly evacuation plans and strategies. Government authorities, throughout the world, are warning that climate change is the greatest environmental challenge facing the world today. The fear is that rising global temperatures will bring changes in weather patterns, rising sea levels and increased frequency and intensity of extreme weather conditions. These effects are already being felt in the UK where weather patterns have changed over recent years.

2.2 Impacts of Climate Change

The Earth's climate is not static and has changed many times due to natural causes. The UK Department of Energy and Climate Change (www.decc.gov.uk) reports that the Earth's temperature has warmed by 0.74°C over the last century and approximately 0.4°C of this warming has occurred since the 1970s. For the UK, climate change means hotter, drier summers (more heat waves), milder wetter winters, higher sea levels and an increased flood risk in coastal areas and river valleys. The outlook for this century is even bleaker with the recent Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report (AR4) [IPCC (2007)] predicting that mean global temperatures are likely to rise between 1.1 and 6.4°C above 1990 levels by the end of this century, depending on our emissions. This will result in a further rise in global sea levels of between 20 and 60 cm by the end of this century, continued melting of ice caps, glaciers and sea ice, changes in rainfall patterns and intensification of tropical cyclones, resulting in strong winds and torrential rain.

2.3 Weather Events

The main types of weather affecting transport networks in the UK are precipitation (rain and snow) and wind. In recent years we have experienced more milder, wetter winters which have resulted in the occurrence of more localised flooding, drainage run-off problems, embankment erosion and landslides which have had considerable impact on transport networks. We have also experienced more frequent storms than in recent decades and these are becoming more extreme with the resulting impacts on road safety and bridge operations. It had been thought that the occurrence of cold weather events would become less of an issue but during this past winter we have seen a return to a more traditional UK winter with sub-zero temperatures and more snowfalls. The impact of heavy snowfalls are much more apparent now given that many sections of our transport network are operating at or near capacity and any extreme weather events can cause significant or major disruptions, as was the case on 2nd February 2009, when London was effectively inaccessible by road or rail. The UK Climate Impacts Programme report, UKCP09, shows that there has been a trend towards wetter winters and drier summers from 1931 to 2006 [Jenkins et. al. (2009)]. They also show that the number of severe storms per decade has increased over the last 50 years, but the figures for the 1990's are no worse than occurred during the 1920's. Barnett et.al. (2006), in their review of patterns of climate change across Scotland, have shown that, since 1961, there has been a significant reduction in the number of days per year when an air frost occurs and a downward trend in the average number of days per year with snowfall. Although these latter cases show overall downward trends there are still very significant year on year variations, as was the case this winter.

2.4 Transport and Climate Change

Clearly, climate change is now becoming an important aspect of each governments' sustainable development policy. The UK Climate Impacts Programme (UKCIP) was set up to help organisations to consider and adapt to climate change. In December 2007, a workshop, Developing a Transport Strategy for Climate Change Adaptation, was held in London to help the UK government better understand how the transport system could adapt to climate change. The consensus from the speakers highlighted the fact that climate change is a reality and if we continue designing infrastructure as we are it is unlikely to be "fit for purpose" given the predicted changes in weather patterns [SDRN/DfT (2008)].

The Eddington transport study [DfT (2006)] examined the long-term links between transport and the UK's economic productivity, growth and stability within the Government's broader commitment to sustainable development and the environment. Eddington identified three strategic economic priorities for long term transport policy: international gateways; cities and their catchments; and, national transport networks. Transport links are vital to both urban and rural areas in the country and have now become even more vulnerable due to these extreme weather events. The existing transport networks, both in urban areas and in some cases on the rural network, are in many cases operating at or near capacity. We have seen that weather events can have a considerable effect on transport operations and capacity. In the case of the national transport networks, road and rail, the impact that snow, rain or wind can have can also be substantial in terms of removing part or all of a network link, requiring travellers to make significant diversions around the particular problem location. This can be partial or full closure as a result of severe gales, flooding, landslides or heavy snowfall. Transport network users are then faced with long delays or may even have to postpone or cancel their travel. In recent years there have been a number of high profile cases, such as at Glen Ogle on the A85 in August 2004 where 57 motorists were trapped between two landslides, and the death of 5 members of one family in the Western Isles during a storm in January 2005.

Given the climate change issue and the increasing traffic levels on our roads it is inevitable that we can expect disruption to occur more frequently. Therefore it will be necessary to reconsider policies, plans and methods to reduce the impact of such events. Our transport infrastructure is clearly important, both socially and economically, and it is important that we adapt and implement measures that can reduce the overall impact of extreme weather conditions. Therefore, in addition to revisions to our infrastructure designs, there is also potential in the application of Intelligent Transport Systems (ITS) technologies which can provide significant benefits for dealing with adverse weather events and the provision of timely information to transport network users.

3 MONITORING WEATHER CONDITIONS

3.1 Weather Forecasting

In the UK we are well known for our interest in the daily weather forecasts that are broadcast on TV, radio and printed in national newspapers. Weather forecasting in the UK is mainly the responsibility of the Met Office who supplies other providers, such as broadcasting companies, with their data and forecasters. Weather information comes from a number of sources including: satellites, radar, weather balloons, personal observations, and measurements of barometric pressure, which are then all processed by meteorologists using advanced computer systems. In the UK the Met Office also provide a specialised service called OpenRoad which gives key information to road transport and infrastructure decision makers particularly in relation to winter maintenance requirements [Met Office (2008)]. In addition to the regular weather forecasting information provided there has been an increasing demand from the public for more specific road condition information. This has resulted in the development of more remote weather stations that gather data from sensors embedded in the road and by roadside weather sensors. This information can then be passed onto the transport operators and road users.

3.2 Road Weather Information Systems

Smithson (2005) indicates that surface weather is very different from upper atmosphere weather because of ground interaction and therefore the information provided by a traditional forecast may often be inadequate for effective road related decision making. He draws a distinction between weather forecasting and road weather forecasting, the latter relating to the micro-climate at the road's surface. This is created by air, humidity, precipitation, pavement orientation, surface and subsurface temperatures and traffic all combining at the pavement surface to create an environment that can be much different to that occurring a few feet above the ground.

During the last 15 years there have been significant developments in the installation of road weather information systems (RWIS), particularly in Scandinavia and North America. RWIS sensors are also utilised by the Met Office in the UK for their OpenRoad service. The three main components of an RWIS system are: the environmental sensor stations (ESS) used to collect data; the models, algorithms and processing of the data; and the dissemination of data to users. ESSs consist of hardware, software and communications interfaces which are required to gather information and then transmit this data to the traffic control centre. Most early RWIS installations were used primarily for monitoring winter weather conditions but these have now been further developed to monitor a variety of road weather conditions. The types of information that can be collected by these sensors includes both weather (air temperature, amount and type of precipitation, visibility, dew point, relative humidity, wind speed and direction) and road surface data (pavement temperature, sub-surface temperature, surface condition, level of de-icing chemical on road, and freezing point of road surface). Early RWIS systems provided just raw data but these are now being supported by Maintenance Decision Support Systems (MDSS) to help maintenance operators make appropriate decisions in relation to winter maintenance and in some cases for traffic managers setting variable speed limits.

3.3 The Future of Road Weather Systems

In 2004 the U.S. Department of Transportation (U.S. DOT) and the National Oceanic and Atmospheric Administration (NOAA) joined forces to develop a national road weather information system called Clarus (www.clarusinitiative.org). The Clarus Initiative is an ongoing research and development programme which aims to integrate all statewide RWIS systems in order to provide more benefits to transportation managers, weather providers and travellers. Its ultimate aim is to "create a robust data assimilation, quality checking, and data dissemination system that can provide near real-time atmospheric and road pavement observations from the collective states' investments in road weather information systems, environmental sensor stations (ESS) as well as mobile observations from Automated Vehicle Location (AVL) equipped trucks and eventually passenger vehicles equipped with transceivers that will participate in the Vehicle Infrastructure Integration (VII) Initiative". The latter goal is to progress towards more intelligent vehicle/infrastructure developments, where vehicles can be used as probes to feedback road weather information to control centres that can process data and disseminate travel information to vehicles.

4 DISSEMINATION OF TRAVEL INFORMATION

4.1 Travel Information

Timely travel information can provide significant benefits to users. The availability of real-time travel information has become increasingly important and new technology is continually improving the speed with which this can be made available to users. In addition the proportion of travellers who are able to receive up-to-date information via new personal devices is increasing although the proportion of the travelling public using these devices is still relatively low. The effective dissemination of travel information is becoming more important and there is more demand for this type of information from transport network users. Many applications of Advanced Traveller Information Systems (ATIS) have been implemented over the last 20 years or more. In Scotland we have seen the progress made in the development of the CITRAC/NADICS systems which now cover most of the major routes in Scotland and the further development and combining of services under Traffic Scotland (www.trafficscotland.org).

Effective travel information can allow travellers to plan optimal routes or even multi-modal trip plans both before departing and more importantly enroute. Travel information can be either static or event information and available for both pre-trip planning and while travelling. Traditionally trip makers have, pre-trip, used static means for planning journeys, such as maps, timetables or routing software packages, and maps and road signs will enroute. The closest one could get to real-time information while travelling was from radio station broadcasts but messages are subject to delay depending on when the station can find time within the broadcasting schedule to transmit the relevant information. In many cases, especially on national radio stations, the location of the information may have little relevance to most listeners. In recent years more real-time information has become available in the vehicle via the FM radio signal Radio Data System-Traffic Message Channel (RDS-TMC) technology, Variable Message Signs (VMS) and now more so using GPS enabled satellite navigation systems and WAP enabled mobile devices.

Real-time information can be obtained from various sources such as sensors and surveillance equipment on the road, or from police and highway maintenance personnel, probe vehicles, and the travelling public. The real-time information that is of interest to travellers normally includes road travel conditions associated with travel delay, such as congestion and locations of queues and incidents; potential alternative routes that can be used to avoid incidents, particularly in the event of a temporary road closures resulting from weather events such as snow, ice or wind. One of the key decisions facing transport network operators is whether to provide only the incident related information or in addition to provide information regarding alternative routes or travel options. Liability issues pertaining to the provision of traffic and travel information have still not been fully addressed.

4.2 Pre-trip Travel Information

Pre-trip travel information allows travellers to plan journey departure time, mode or route. Traditionally pre-trip information has been obtained from maps, motoring agencies or routing software packages. These have now largely been overtaken by the internet. Information can normally be accessed at home or work and can assist decision making in terms of choosing a route or an alternative route, change of mode, delaying departure time or not to travel at all. This can help travellers avoid delay and also provide relief from congestion if the transport network is experiencing delays. The main sources of pre-trip information include telephone, internet, mobile phones or personal digital assistants (PDAs), radio or TV broadcasts.

4.3 Enroute Travel Information

After departure, travellers have largely been dependent on maps and signposts for guidance and radio broadcasts for unexpected event information including updated weather reports. Event messages can be received within the vehicle by normal radio broadcasts or by RDS-TMC broadcasts using the FM frequency, in-vehicle satellite navigation or via personal mobile devices. In addition VMS at the roadside can be a valuable source of en-route travel messages. These are however limited to fixed locations with limited text and must be on the driver’s route if any event information is going to be communicated to travellers. There is now more demand for dynamic real-time in-vehicle services and these are being more widely offered particularly with high-end sat-nav systems and multimedia mobile phones with full web access, such as the iPhone.

4.4 North America's National '511' Services

In recent years we have seen the development of internet websites, such as Traveline Scotland, which provide useful travel information to assist in journey planning. Generally, these services provide static information and are not set up to provide real-time event information. Traffic Scotland does provide event information on its website with information on current incidents but most travellers can only access this pre-trip and not while enroute.

In July 2001 the Federal Communications Commission in the USA designated '511' as the single information telephone number to be made available to states and local jurisdictions across the country. The most famous N11 code in the USA is 911 for emergency services (equivalent of 999 in UK). Other numbers include 211 (community services), 311 (municipal government services) and 411 (directory assistance). The 511 service is a quick access universal dialling number for callers to obtain travel and weather information and can provide highway condition information, including planned closures or lane restrictions and weather related restrictions, in addition to traffic congestion information. In many cases it has brought together existing travel information services within metropolitan areas or statewide systems. 511 systems use touchtone telephone technology and voice recognition menus. They can also provide information relating to special events, alternative travel routes and carpark occupancy status.

In order to improve the coordination and development of 511 services across the USA a 511 Deployment Coalition was set up which includes the American Association of State Highway and Transportation Officials (AASHTO), the American Public Transportation Association (APTA) and the Intelligent Transportation Society of America (ITS America), with support from the U.S. Department of Transportation. As of 2008, there were forty-three 511 services available in 33 states across the USA with more coming on stream in 2009. 511 has had limited uptake in Canada after the service was introduced in 2005. So far only one province, Nova Scotia, and one territory, Yukon, have adopted 511 systems.

Most 511 services are developed by the state, province or metropolitan area and make use of information already being collected for managing transport services, including weather information. This information is then processed and made available to callers around the clock but must be accessed by travellers.

4.5 Mobile Phone Alerts

Mobile phone alerts allow drivers to avoid traffic congestion by receiving information on problems via their phones. With this service it means that they no longer need to be dependent on the next radio broadcast which may be up to 30 minutes later. This can help travellers to change departure time and routing decisions. Transport updates using mobile phone alerts and updates are becoming more readily available in the UK, for example AA Roadwatch. Caledonian McBraynes, have also recently introduced a texting service for ferry updates in addition to online and phone information. Text updates can be received by texting the text code 60030 and by using the relevant service number, for example calmac 25, for Ullapool to Stornoway, with texts costing 25p. The only problem is you have to memorise the relevant service number when contacting them whilst enroute if you don't have access to the internet.

4.6 Future Directions for Travel/Weather Information

Static and location specific VMS information have provided travellers with useful information for many years. In recent times there has been a significant demand for both in-vehicle sat-nav and personal mobile devices. Travellers are now looking for more up-to-date information and they are demanding more real-time traffic and weather updates, with many people also requiring alternative routing information. The trend had been towards in-vehicle devices but the platform of choice is now mobile devices, such as iPhones and other similar 3G devices. These are off course no longer restricted to the vehicle but are truly personal and mobile and can be applicable to any transport mode service. Although there has not been a huge uptake of high technology personal devices these will continue to decrease in price and as more travel information is made available there will be an increasing take up of these devices and services. However, although there has been much interest in the developing technologies, people have not been as willing to pay for travel information and in many cases these services have either been bundled with the purchase price of the devices or are provided free-of-charge by transport authorities.

In order for travel information to be effective it must be timely, accurate and be relevant to the users needs. In addition the information must provide value to the user when followed, otherwise the creditability of future messages will be in doubt. There is also a move away from more general information towards more personal en-route trip-specific travel information. The North American 511 model has provided a co-ordinated, more up-to-date service which is now being extended to provide multi-modal travel and weather information. There are already commercial opportunities for information and as personal devices become more widespread it seems that there can only be more opportunities within the private sector in relation to traffic and weather information services, possibly even a single national service provider.

6 CONCLUSIONS

The wide consensus is that human actions are the main cause of global warming and climate change. In recent years we have seen changes in our weather patterns, particularly the frequency of extreme weather conditions, such as storms, flooding and landslides. There have been a number of developments in relation to road weather information systems throughout the world since the 1970s. Recently there have been a number of further developments in this area within the realm of ITS. This paper has considered a number of aspects relating to the future developments in the collection, processing and dissemination of travel and weather information, particularly in relation to the apparent adverse weather conditions we have experienced in recent years.

There is clearly a difference between upper atmosphere weather conditions and road surface conditions with the latter having its own unique micro-climate. The information provided by a traditional forecast may often be inadequate for effective surface transportation-related decisions such as winter maintenance requirements. Therefore in recent years we have seen significant developments in RWIS systems including environmental sensing sensors (ESS) to monitor these road surface conditions. Current thinking is that in future we will make more use of vehicles themselves as mobile probes which will greatly enhance road surface condition data collection.

It is clear that the technological means for disseminating travel and weather data is developing very quickly and clearly moving towards mobile platforms. Fairly recently, the platform of choice was largely seen as the vehicle itself but given the popularity of mobile phones this has can now become the individual regardless of which mode of transport they are using. Also the significant uptake of 3G devices that are capable of receiving mobile internet will also have a major impact on the development of travel and weather related services.

As we look towards the future we can anticipate a significant uptake of technologies and services which are able to provide real-time traffic and weather information. Travellers will demand more personal journey specific data. At the same time there will be a need to collect, process and provide more accurate information on road conditions and transport service operations. There will also be interest in how transport users respond to this information and the benefits that may accrue, but human factor issues will also have to be considered.

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