

Automating the management of incidents in northern Europe's largest road tunnel project: **Norra Länken**

30th November 2014 saw the opening of Northern Europe's largest tunnel project – Norra länken (The Northern Link), which is part of European motorway route E4 and E20 and the Stockholm ring road.



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The effective management of traffic in and around the new tunnel as well as the wider network is critical to support the objectives of reducing congestion, improving safety and City air quality, and enhancing the quality of life for the people and businesses of Stockholm. It is imperative that in a complex and confined environment such as the Norra länken tunnel where safety is paramount, that in the event of certain incidents that actions are taken immediately such as sprinklers responding to a fire, emergency lighting is switched on, ventilation changed, emergency telephones used are answered, emergency services alerted, etc. Tunnel systems are well versed in automatically implementing these actions and alerting the operator that the actions have already been taken.

But this is only a small part of the story. Vehicles will need to be managed on the approaches to restrict access, incident support units will need to be managed to clear the incident, speeds on the approaching motorways will need to be reduced, variable message signs will need to be set, local traffic signal timings may need to be adjusted, the Media and other stakeholders informed, senior managers kept updated to support major incident decision

making and other transport operators made aware of changes in expected travel patterns. At the slightly wider area, other traffic will need to be informed to potentially change their plans through use of the Internet, smartphone applications and in-vehicle systems, as well as other roadside signs, radio and television broadcasts; major transport hubs such as train stations and airports may need to be informed to advise their travellers.

And all this needs to happen very quickly if the response is to be effective; it also needs to be consistent, both the next time and in other parts of the network, so that drivers, operators and stakeholders trust and react appropriately to the information they are presented with.

In order to deal sensibly with this volume of information and the extent of actions required needs any support system to be smart in its decision making and enable the whole process to be effectively handled by a single operator. The automation of as many actions as possible is critical to the success of any incident management solution. It shall also be easily configurable so that the automation of actions can be delivered as operational experience and learning is proven and procedures refined.

Sweden is equipped with a National Traffic management System (NTS) that delivers a fully integrated management service for all roads throughout the Country, and the building of this new major Norra länken link is no exception. NTS has been managing traffic around the construction site for 7 years, but took over the full operation of the tunnel since it was open to traffic as a fully integrated management service.

Innovation

A modern traffic management system has a number of different requirements and for these to be met a framework architecture will include a number of components:

- Automation – by taking decisions in parallel and in sequence, business and operational procedures can be delivered quickly, reliably and consistently
- Multiple systems – the overall system should be built from separate specialised components
- Distribution – systems, databases and devices should all be deployed at the most appropriate locations
- Integration – multiple systems are integrated via common communications standards, by a common user interface and by a

- common network model
- Virtualisation – delivering benefits for cost, maintenance and reliability
- Redundancy – supported at multiple levels ensures high availability
- Graphical Displays – clear and concise displays making use of modern GIS software
- Expert Knowledge Base – expert systems are a necessity as they can embody the core business logic for decision support, automation and act as a supervisor for managing subsystems and devices
- Complexity and Commonality – incidents require a coordinated response from many agencies often having different command structures, operating procedures and terminology.
- Simplicity – however sophisticated the system, it should appear simple to its users

The NTS architecture is designed around these principles, combining over 60 local [sub]systems, 10,000 devices across 100 equipment types, coordinated through four regional control centres, into a single integrated virtualised platform. Unlike most networks that manage local, regional and national networks independently, NTS delivers a fully

integrated service across all parts of the network, such that a single operator is able to manage the network in a holistic manner

Integration

The new tunnel has been equipped with an array of advanced technical monitoring and control equipment, incident detection and information dissemination systems. The comprehensive nature of the NTS system means that existing staff within the Trafik Stockholm control centre were able to take full responsibility for the management of the new Norra länken tunnel infrastructure. Operators didn't need to learn about all the new systems in the Norra länken tunnel because these systems were simply integrated into NTS and existing operational procedures. The use of common standards and interfaces has minimised the effort required to integrate all aspects of the new tunnel systems.

Automation

NTS comprises the G2 expert system to drive fast and effective decision support services, making real time decisions based on all collected data

and automating defined actions. All information dissemination is tailored and directed through specific channels as part of comprehensive traffic-engineered response plans, which can be further tailored by the operator to meet specific needs. Response plans execute management and control facilities at the local, regional and national levels across the network. NTS's user configurable tool implements process and flow-control steps (in parallel and series, automatically and with operator validation).

NTS plans can contain algorithms and parameter driven functions, allowing these plans to have a wider applicability (e.g. in terms of location) than typical predefined plans in most current systems. Response action plans are created as either specific to a location or generic, where they can be deployed across the network and automatically adapt to the location where they are being executed. When these generic plans are executed all required information is dynamically loaded into the plan, including information based on location, specific CCTV camera to control, roadside assistance vehicles to deploy, message signs and signals to set, message content, diversion routes, telephone numbers and emergency service personnel to liaise



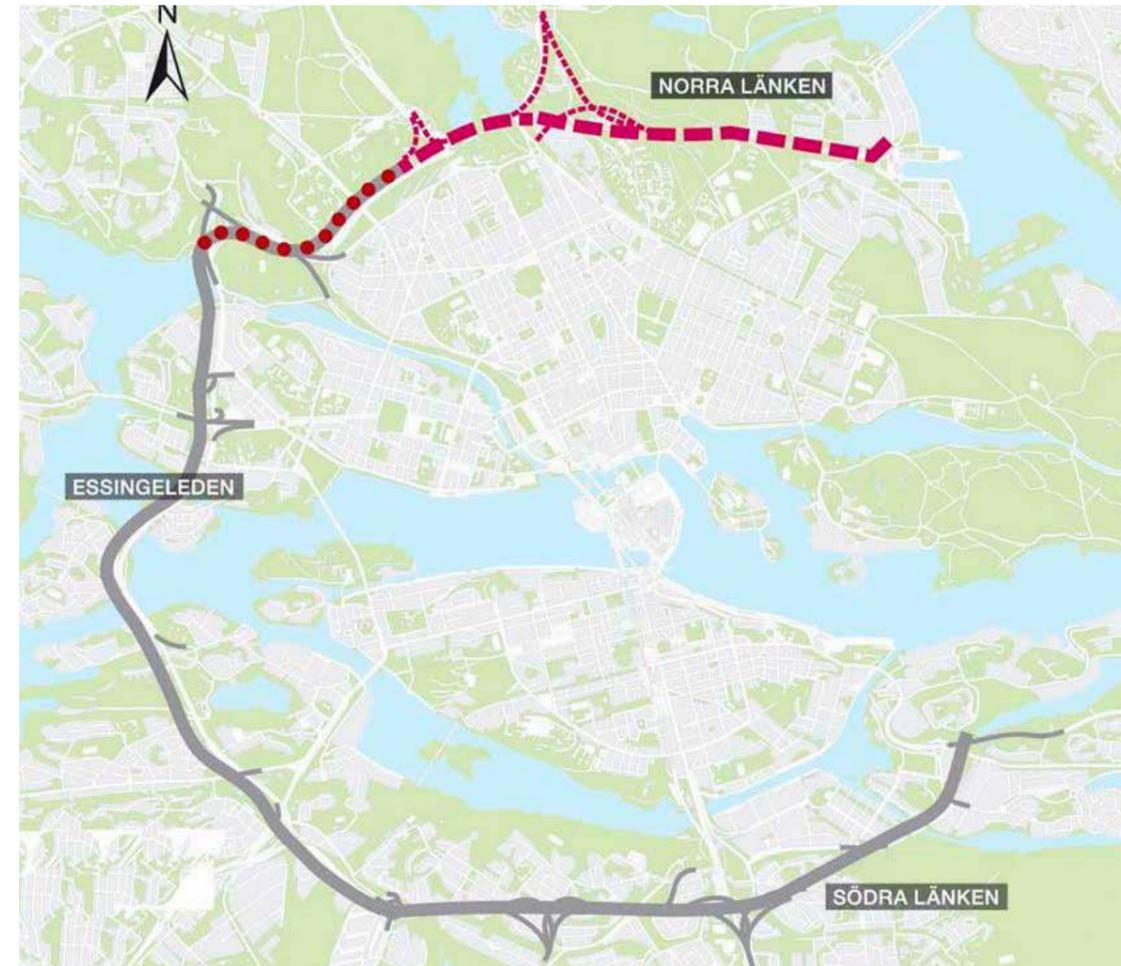


massive construction programme in the northern part of Stockholm and is an important piece of the puzzle to solve the region's traffic, safety and environmental problems. Costing some €1 billion, Norra länken is one of Northern Europe's largest road tunnel projects and stretches from Karlberg to Värtan in Stockholm. It is important for solving the traffic problems in the region, supports the establishment of two new city districts in a rapidly growing city region, and creates a new trunk road for traffic and goods from the ports to the Baltic countries, Finland and Russia. Norra länken will simplify driving for traffic going to Värtahamnen and Frihamnen, Sweden's most important ports. The tunnel moves heavy and dangerous goods vehicles in a more controlled network under the city, resulting in a cleaner and safer surface environment, reducing noise levels and congestion

Most of Norra länken is in tunnels, all of which are one-way and are 13 km long in total; 9 km are in rock and 4 km are concrete tunnels. The link road has three lanes in each direction; two continuous traffic lanes and one for slip roads and exits. The new route travels under the National City Park and other popular recreational areas. New pedestrian and cycle routes have been built as well as close links to rail and metro interchanges.

Norra länken comprises seven complex underground junctions and to provide motorists with landmarks for improved orientation, the route has coloured lights in the roof of the tunnel and artwork along the walls and in the background where the tunnel sections separate - each junction has its own identity to help motorists find their way.

Trafikverket has introduced a range of measures to minimise



environmental impact ranging from using coloured concrete to blend in with the environment to re-using excavated earth to fill under the road. Excavating this 1,200,000 cubic metres of rock and 400,000 cubic metres of earth will be enough to fill Stockholm's Globe Arena twice over! At ground level there are hardly any signs of the road 30 metres underneath. A waterworks station has been installed to clean surface water and washing/rinsing water. Just over one million cubic metres of excavation material has been raised from the three construction tunnels that were built earlier, and this has been re-used in the construction of Norra länken.

The new network has been equipped with advanced technical equipment, including lighting, ventilation systems, controllable traffic signal systems, emergency telephones, fire extinguishers, smoke and heat detectors, sprinklers, access control devices, variable message signs and different types of telecommunications equipment. Traffic is monitored by cameras and incident detection equipment.

For optimal operation, the fans are controlled by an advanced measurement system that registers levels of pollution, visibility and air velocity. Pumping stations and cleaning plants handle rain from torrential downpours as well as washing water, but also to safely handle any spills of dangerous liquids or polluted water from firefighting measures or other incidents. The tunnels are equipped with antenna systems and devices for retransmitting radio and mobile telephone signals. There are evacuation routes, rescue rooms, fire locks, help stations and loud speakers for emergencies; telephones provide direct communication with the Trafik Stockholm control room. All power is delivered with appropriate redundancy

Enhancement

The core NTS system was enhanced to deliver the enhanced functionality over 1 year ago, enabling Trafikverket to fully configure and comprehensively test the system to prove correct operation for

this extensive and complex new infrastructure. Delivering the software upgrade early in the construction programme allowed Trafikverket to more easily adjust the opening date; the tunnel was previously planned to open in 2015, but with effective risk management, the construction proceeded ahead of schedule and with all systems in-place the opening was able to be brought forward to 30th November 2014.

Trafikverket have defined a standard interface for the implementation of all SCADA-based tunnel control systems throughout the country. By defining the interface in this way, the integration of the new SCADA system for Norra länken into NTS was undertaken with minimal software change; indeed, the required software change to NTS was undertaken in only 4 weeks.

The final sections of the tunnel under Hagastaden will open in 2015 with the opening of the southbound link between Norrtull and Tomtebodan and in the northbound direction the following year. The new Värtabanan rail tunnel opens in 2019. ♦

» with, etc. This enables improved management of response definitions and share best practice across the network. All response plans have been agreed by all key stakeholders such as the police, fire service, other highway authorities, etc. as part of their operational procedures.

Using such an expert system allows a single operator to be able to effectively and safely manage major incidents on the network, control access to critical sections (such as Norra länken), switch-on environmental and safety devices, inform all emergency services, transport operators, the media and other stakeholders about the incident, and keep all drivers informed through roadside signs, in-vehicle systems, traffic websites, television and radio broadcasts. During an extended incident, the operator may also be required to undertake other tasks such as update planned events in the system, review a previous incident response plan or draft a monthly management report.

By supporting the operator in this way delivers the following benefits:

- Immediate event response started following event verification
- Reliable and consistent decision making
- Reduced operator workload (minimising overall operator numbers)
- Multi-tasking as responsibilities are easier to learn and manage
- The operator can focus on managing the network problem and not the system
- Mundane and routine tasks can be easily automated
- Increase in complexity of service responsibilities does not necessarily require more operators
- Consistency of incident response implementation across the whole network
- Faster generation by traffic engineers and deployed in the system
- Ease of modification
- Ease of operator training

About the tunnel

Built by Trafikverket (Swedish Transport Administration) and the City of Stockholm, Norra länken is a