NATIONAL TRANSPORT MANAGEMENT IN SWEDEN

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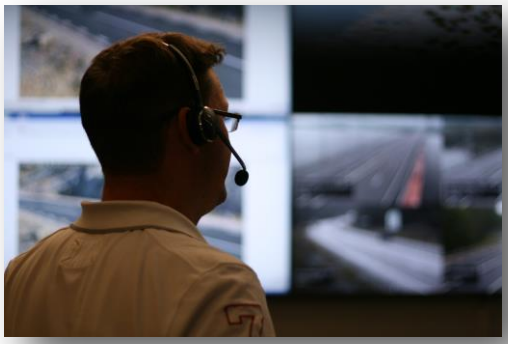
INTRODUCTION

Today in Sweden, the National Traffic management System delivers an integrated service for the whole of the Swedish road network, managing at the local, regional and national levels. It provides a comprehensive decision support facility, bringing information from multiple systems together into a single platform and tool, automating many services, to enable operators to focus on critical decision making. It communicates with multiple systems and stakeholders, including highway operators and maintainers, public transport service providers, the emergency services, the media and third-party information system suppliers. This multi-layered and expert system has evolved over many years to become one of the World's most advanced systems (winning the International Road Federation 2013 Global Award for ITS and Traffic Management) but how has it got where it is and where does it need to go from here?

This paper describes how the National Traffic management System in Sweden was delivered from a Contractor's and Client Authority and Operator perspective, particularly highlighting how a collaborative style of working and relationship with all stakeholders has contributed to the success of the system in meeting its objectives. The paper describes the current situation of the system and details some real examples of how incidents are managed at multiple levels on urban and inter-urban highways from its 4 main control centres. It outlines the key decisions that are being considered to further develop the system to meet operational needs across the transport network to meet the objectives of Trafikverket and making life easier and better for all of Sweden's 9 million inhabitants.



THEORY OF EVOLUTION

The system in Sweden has evolved over the last 10 years from single subsystem management to the comprehensive management of over 50 subsystems and 10,000 devices for the integrated management of traffic throughout the network, which has grown from a regional system in Stockholm to a national system that delivers services through 4 control centres covering all 4 quadrants of the Country.

The subsystems and their connected roadside devices include over 100 different equipment types, each with particular operational requirements, old and new technologies. They include SCADA systems for the control of tunnels, weather and climate control, CCTV and road condition cameras, traffic and radar incident detection, urban traffic signalling, lighting, variable message signing and lane control signalling, radio and traffic information such as RDS TMC and Datex 2, road assistance and maintenance vehicles, emergency telephones, the list goes on. The process of subsystem integration has been simplified through the use of an industry standard IP network using standard and bespoke interfaces – e.g. Microsoft.NET remoting, web services, DCOM, XML, ASN.1 and ODBC.

By integrating these subsystems into a single platform we are able to unify the way they are managed from the control centre. We are able to minimise the number of items on the control desk to a single workstation with one mouse and keyboard to optimise operator performance. Creating a single view of the network enables an operator to effectively manage major incidents throughout their lifecycle. The system provides the operator with high levels of decision support, taking many routine decisions automatically, guiding through a strict process of actions running in series and multiple parallel work flows, prompting the operator to take certain actions at certain times and when conditions occur, all allowing the operator the time and ability to take the critical decisions and actions when they are needed. The diagram below shows the type of information that feeds into the Traffic Management Centre (TMC) and what information comes out of the TMC and where it appears.

INTEGRATED MANAGEMENT

Regional and City traffic authorities and Trafikverket operate in partnership using NTS to deliver a unified service across all parts of the network so the road user is provided with a seamless service across all roads. NTS takes decisions decided by experts. Because the system is able to manage at multiple levels, and all incident response plans are pre-defined and fully tested by traffic experts, a single operator is able to effectively manage all types of incident.

Not only has the system integrated multiple systems, devices and equipment, but has required the integration of four different ways of working into one, pulling together different working tasks and priorities into a single management process. Integrating the management of all Sweden's road network from rural roads to large city conurbations has required the implementation of effective intelligence supported decision making to traffic network operators to ensure their actions and those of the system are quick, informed, consistent and coordinated across the whole national network, encompassing urban and interurban traffic management strategies. This multi-layered system balances different types of goals across the whole network to achieve overall objectives to radically improve traffic management services that contribute to optimising the performance of the road network, improving safety and reducing carbon emissions.

EVOLUTION

Trafikverket has been using an integrated system for traffic management since 2001 when the Stockholm Central Technical System (CTS) was commissioned. In 2011 the system went from a regional to a national system as it was deployed to three other TCC's and became NTS – National Traffic management System. This process required a significant engineering change to the system and massively increased its functionality and capability to meet ever increasing demands to meet very tough targets and objectives.

The system in Sweden is continually improving. These improvements are at different levels of maturity, ranging from simple 'operator wish list' enhancements that are relatively simple to implement but where the benefit may be significant to more complex enhancements such as the integration of a major new subsystem for the management of a new road or tunnel. By listening carefully to all that have an interest in the operation of the system, we are able to fully understand the cost and benefit of each improvement and balance priorities to deliver the largest benefits for the lowest cost - they are all driven by a desire to make life easier, better and safer for drivers and operational stakeholders alike.

Trafikverket has a comprehensive plan of system improvements that will be deployed over the coming years. This plan is continually being juggled to cope with changing budgets and priorities. These include short term improvements such as enhanced map symbols and new reporting tools, to new subsystems for motorway and tunnel control, and enabling traffic signal control throughout all 4 control centres.

Sweden, like many countries, is undertaking major investment in transport infrastructure. The architecture of the system has been designed to easily integrate new major new roads, tunnels and bridges into the overall system, not only delivering a more effective management system but also eliminating the need for new control centre facilities, systems and additional operational

staff. A good example is the new E4 Stockholm Bypass. This new road will be 6 lanes of 21km in length, with 18km being built under ground, and will carry over 140,000 vehicles per day. By integrating the new road into the existing system all operations will be brought under the existing management system and control room staff to optimise network performance and ensure its safety.

COLLABORATIVE WORKING

Nicander has supported Trafikverket and the NTS system since 2008. This period has involved an extensive programme of software enhancement and system expansion. The success of the project has been underpinned by a strong and collaborative relationship with not only the Trafikverket but also operators and other key stakeholders. This has not been an easy process as the public authority and private company are obviously two fundamentally different organisations, with different cultures and corporate objectives, one English and the other Swedish. Key features of this relationship include:

- Understanding client objectives and goals enables us to fully understand requirements and appreciate project priorities.
- Close programming of future work with client enables project objectives to be met, particularly within the context of major road building programmes opening early.
- System evolution, building on existing systems and investment, has eliminated the typical risks of s big bang approach and has enabled all parties to learn how the system functions in reality and to ensure operational processes are optimised.
- Close liaison with operators has enabled us to fully understand system functionality and identify potential areas of improvement.
- Remote support from UK is effective, but installing new software releases on site and being close to client and operators enables more effective knowledge transfer (both ways), including training in new and changed functionality, as well as an improved working relationship.
- Collaborative style of working in a team environment has created an environment where risks are more clearly identified, owned and shared, and trust firmly established.
- Direct liaison with client project team personnel has enabled more effective information flow and a faster resolution of problems.
- Use of the English language – 86% of people in Sweden speak English.

EFFECTIVE INCIDENT MANAGEMENT

The NTS system in Sweden has been designed with full lifecycle support and operational costs in mind. Its solution architecture regularly delivers 99.9% availability of services, but by creating an effective operator decision support system that unifies the management of over 100 technologies and over 40 systems with one keyboard, one mouse and one virtual screen to manage all parts of the network, means that operator numbers are kept to a minimum and with each operator performing multiple roles (many automated by the system) within each shift means that teams can be optimised to deliver effective services 247.

The 4 Regional Control Centres deliver a multi-layered service at local, regional and national levels. They are fully coordinated enabling any operator in any TMC to manage the network in any other TMC. The solution enables a single approach to operation throughout all 4 centres,

helping to prioritise tasks across all parts of the network from rural roads to big cities. Each operator role is fully defined by login credentials but over time as operators have become multi-skilled across many roles their definitions are becoming more common and today we can see each operator has one of three main roles. The more senior are Traffic Managers, who are responsible for the management of all key incidents. The next role is a Traffic Information operator who is responsible for distributing key information associated with events on the network such as roadworks etc. The third role is the Drift Operator who is responsible for responding to technical alerts from the subsystems. Stockholm is the largest management centre and is about double the size of Gothenburg handling a significant number of urban and inter-urban incidents. Malmo is slightly smaller than Gothenburg and the smallest centre is in the North of the country handling mainly rural issues and much snow in Winter.

During the day, Stockholm has 2 x Traffic Managers, 2 x Traffic Information operators and 1 x Drift operator (i.e. 5 daytime). During the night these numbers fall to 1 of each (i.e. 3 overnight). The other three centres have more of a combined operator role as the number of incidents is fewer in number. Gothenburg has 4 operators during the day and 2 during the night. Malmo has 3 operators during the day and 2 overnight. In the Northern centre there are 2 operators during the day and 1 overnight. Trafikverket also employ 2 operators during the day to drive their external facing systems such as their traffic information website, third party RDS TMC and traffic information app suppliers. Outside of normal working hours any one of the operators across the network also responds to general public enquiries.

The facilities and services provided by the system are continually evolving to improve their coverage and scope of response to events on the network, listening very closely to all stakeholders (traffic operators, senior Trafikverket management, the Emergency Services, public transport, bus and other operators, the Media) that have interests in the operation of the system to ensure a balanced approach to network management.

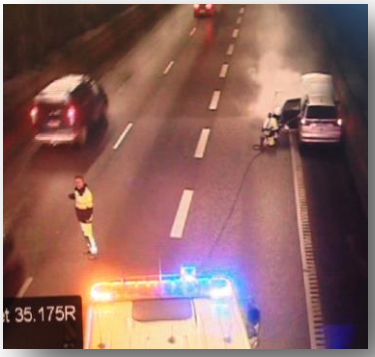
E4 Incident – May 6th

There was a major accident between a lorry and a car at 7.00 am on Sweden's busiest road, the E4/E20 at Essingeleden. All southbound lanes were closed directly after the collision. After 30 minutes one lane (out of four) was opened and after 1 hour and 45 minutes all four lanes were opened. Massive queues occurred in both directions on the E4 and all roads towards Stockholm from the north were congested throughout the morning. The Södra Länken tunnel closed all entries for over 1 hour for safety reasons. Disruption on southbound routes lasted for 12 hours.

This major incident was effectively managed by only one operator at the TMC. NTS analysed the problem defined in the system and used its expert system to propose the best action plan to respond to the accident, helping the operator to take the most appropriate actions in a logical and agreed process to effectively resolve and close the incident. NTS presented all alert and camera information to the operator when the accident happened and proposed the best camera to verify the incident. The system helped the operator to distribute streaming video, information and alerts to the TCC

co-operating parties including the police, fire rescue, emergency assistance vehicles, the media, along with senior management at Trafikverket. NTS coordinated response planning which included changing the Stockholm city traffic signal timing plans and managing traffic on the motorways and strategic roads through lane signals and variable message signs. Within the control room, NTS managed the video wall to display the right information to stakeholders including television and radio operators. NTS issued traffic information through the Trafikverket website and via SMS, fax and email. They were kept updated with the latest news throughout the entire incident.

Tunnel Fire – March 3rd



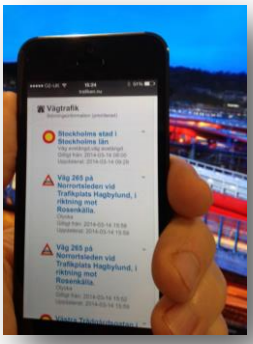
A vehicle caught fire in the Södra Länken tunnel, which is one of the most complex in Europe with 7 entrances and 4 underground major intersections. Any closure requires a complex sequence of actions is undertaken quickly, reliably and in a consistent manner in accordance with strict business and operational rules that balance safety, congestion and environmental impact. One operator was able to safely close the tunnel in just two minutes from verification. The operator received a phone call from a motorist in the tunnel as well as a number of system alerts; the operator created an incident report, verified the vehicle fire using CCTV and executed an action plan. NTS implemented over 200 specific commands, closing tunnel entrances and exchanged commands between 11 different systems (including VMS, fire ventilation, barriers to close tunnel, radio messages, SMS and traffic information and emergency services notified). The fire was quickly dealt with to prevent damage to the tunnel and no persons were injured, and to minimise the impact of tunnel closure on the surrounding network. The response to such an incident could not have been dealt with as swiftly without an integrated system.

Keeping Stakeholders Informed – March 13th

Senior managers and stakeholders in Sweden receive immediate SMS alerts on key events on the network relevant to their responsibilities. On the 13th of March senior stakeholders were informed of:

- An incident with two cars involved on the E4 motorway, restricting use of the network, that the emergency services are in place and of their plans to make safe the situation and manage the incident to minimise impact on congestion. 2 lanes are closed and long queues have formed, the incident will last for 30 minutes.
- A car fire in the Årsta Tunnel. The tunnel was closed completely, the Emergency services have extinguished the fire and there were no injuries. He is told that they are unsure when the tunnel can open, so will receive continual updates on the situation so is completely aware if he needs to step in to support the management of the incident.
- A vehicle crash has occurred on the E18, there are limited delays and the incident will be resolved within 10 minutes.

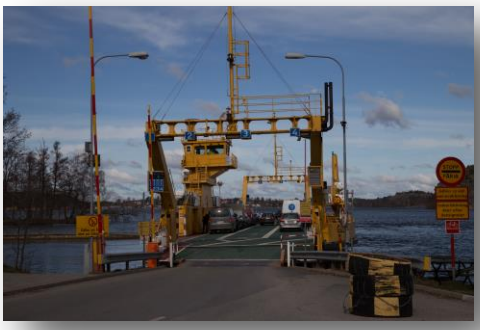
- Problems with the Slagsta ferry, which is delayed in both directions and will impact traffic on the surrounding roads. All stakeholders are involved and traffic management plans have been implemented to advise motorists of the delays.
- Traffic incident on the E4 at Rotebroleden involving several vehicles. Lanes are blocked in both directions and the time prognosis is unclear.
- Bus collision in Stockholm City on the 229 at Gubbängen. The route is suspended and the vehicle assistance informed to recover the vehicle.
- Update on incident at the Klara Tunnel: Entrance to Klara Tunnel from Brick Hill / Central Bridge and Rödbo street is closed due to an emergency repair and clearing work. Work is expected to last at least all day possibly all weekend. Updates will be ongoing.



Stakeholders are presented with key contact details relevant to each incident if they need more information and are continually provided with updates to inform of changing conditions, so are able to make effective management decisions based on the latest up-to-date information. They are provided with all relevant post analysis information on all key incidents to learn from experience and fine tune plans to improve performance for future incidents. By using the same background thinking and common analysis across the whole network, stakeholders are confident that operators and road users are provided with reliable and consistent incident response in rural and urban environments throughout the country.

A DAY IN THE LIFE OF AN OPERATOR

An operator starts her shift at 6.30 am. After logging in to the system she is presented with all key relevant events and what is planned. She first starts to deal with a few overnight roadworks. NTS has a connection (via NTIS to FIFA), the tool used by the traffic engineers for confirming and authorising roadworks on national Swedish road; the system's interface conforms to national standards defined by the Authority, which easily enables the system to integrate from each of its 4 regional control centres. This interface enables the automation of many processes to ensure single data entry in one system is automatically transferred to the other to minimise operator workload and risk of error.



One of Trafikverket's ferries (free to use for the public) has a problem and its manager telephone the control room advising that only one out of two ferries will be in service today. The operator uses the event report function in the system to define the problem with the ferry and the system quickly proposes a suitable plan of action to inform stakeholders, the public and authorities that we might have delays and queues today. The operator

is content with the system's resolution and executes the action plan which advises all parties using their chosen media for communication. The system holds over 7,500 contact details within the system to enable each action plan to immediately collate all contact details required to inform them quickly and reliably. The operator does not need to look for who they need to contact, the system handles that task for them and automatically send out the emails, SMS, Word documents, PDFs, faxes as required.

An alarm appears in the event list and is shown on the map on the screen to reflect congestion that is occurring in one of the tunnels. The system creates an appropriate event report and the operator uses the CCTV camera images presented by the system to verify the problem. The event report is completed and instigates the immediate closure of some its entrances and make safe the situation. The system disseminates a range of information to motorists through roadside signs in and around the tunnel and well as the surrounding area. It is expected that the problem will be quickly resolved so the response plan is confined to this area of the network.

The operator receives a summary of road conditions from each of the regional contractors detailing issues of snow, frost, gritted, wet, dry, etc. through a web interface directly to the TMC. The system collates all necessary information from which the operator produces a regional summary report that is issued to stakeholders and managers so they can understand the condition of the network.

During the morning peak period, an accident occurs on one of the most heavily trafficked roads on the network. The operator is presented with a alarms from the radar detection system and an event report is automatically created, verified by the operator who implements an action plan with appropriate motorway lane closures. The system manages the implementation of the plan and communicates with several subsystems including the motorway control system (MTM2), variable message signing systems, roadside assistance vehicles, email and text messaging, to manage the network and inform drivers and stakeholders appropriately.

A member of the public detects a pothole on a rural road and telephones customer service who forwards the call to the traffic operator; they complete the event report and implement the plan to quickly identify and contact the right contractor so that they can fix the problem. The system handles rural and city roads alike.

A stopped vehicle is detected in one of the tunnels and the operator is advised of the problem and follows the standard reporting process but as this involves a vehicle fire, the operator directly

distributes a video feed to the central fire department control centre. The traffic operator and the fire operator work together to resolve the problem and the entire tunnel system is closed in less than 100 seconds. The operator manages the network to support all rescue work activities of the Fire Department.

A new set of roadworks are planned for 10pm tonight. The operator starts the action plan so that VMS, media and other people of interest can have information about it. The plan is then in idle mode and are awaiting another operator who will handle the road work at 10 pm. Events continue to occur on the network, with the same operator managing a faulty traffic signal on a busy Stockholm junction at the same time as the vehicle fire. The ferry is now OK and the tunnels are fully operational. The operator has kept all stakeholders and road users informed throughout the lifecycle of each event. The operator enjoys the variety of work, sleeps well, and is ready for her next shift.

One of the critical benefits for NTS operators in Sweden is the pre-defined action plan scenarios that have been generated by traffic engineers that define how to response a specific event such that the primary task of the operator is to support the definition of the problem situation held within the system (Event Report) and to simply confirm which Response (as recommended by the system) to implement rather than the complex details of how to respond. Operators are provided with the flexibility to modify any plan as suggested by the system, but the operators have grown significantly confident in the quality, reliability and consistency of event response that the majority of response plans are implemented as defined by the system. They are generic and specific in nature. Each generic plan will collate its variable data (time, location, input conditions, etc) from system data when the plan is defined and run. Specific plans may be generated for those parts of the network that are unique eg tunnels, bridges, complex junctions.

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 scenario response plan implementation across the whole network
- Faster generation by traffic engineers and deployed in the system
- Ease of modification
- Ease of operator training