The Lake Lothing (Lowestoft) Third Crossing Order 201[*]

Document 7.5: Design Report

Appendix 10

Author: Suffolk County Council

Project:	Lake Lothing Third Crossing			
Document title:	Technical Note – Network Operations Strategy			
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	Name	Company		
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1 Background

Lake Lothing Third Crossing is planned for a central location between the current two Lake Lothing crossings in Lowestoft; Mutford Bridge in the west, and the A47 Bascule Bridge in the east at the entrance to the inner harbour. The local highway network is formed of the Highways England-controlled strategic road network (SRN) and county council-maintained local roads. The highway network in Lowestoft is significantly affected by congestion which is further exacerbated when either the A47 Bascule Bridge or the Mutford Bridge is raised to allow access for vessels into or through the Port of Lowestoft. The height of the A47 Bascule Bridge requires it to open for any vessel, which also adds to delays, and reliability of the opening mechanism is a concern.

The distance between the two existing crossings can make journeys unnecessarily long and inconvenient for people walking and cycling, discouraging these modes of transport.

Lowestoft has a growing role in the energy sector as the Port of Lowestoft is to be used as an operations, management and construction base for offshore windfarm projects. These developments, taken alongside planned future housing growth, are likely to lead to significant future traffic growth and the appropriate infrastructure needs to be in place to support this.

The key benefits of the Scheme are anticipated to be:

- to open up opportunities for regeneration and development in Lowestoft;
- to provide the capacity needed to accommodate planned growth;
- to reduce community severance between north and south Lowestoft;
- to reduce congestion and delay on the existing bridges over Lake Lothing;
- to reduce congestion in the town centre and improve accessibility;
- to encourage more people to walk and cycle, and reduce conflict between cycles, pedestrians and other traffic;
- to improve bus journey times and reliability; and
- to reduce accidents.

In addition, other benefits include:

- national and local journey time savings;
- a reduction in traffic volume, and hence congestion across the network;

- increased connectivity between the northern and southern communities of Lowestoft in the central area of Lake Lothing providing greater accessibility to the Great Yarmouth and Lowestoft Enterprise Zone;
- increased community wellbeing and public health benefits through greater opportunities for walking and cycling, with routes that link to wider networks;
- an iconic bridge design, developed with a 'marine tech' concept which references both Lowestoft's past as well as its growing role in the energy sector;
- provision of a high quality public realm, additional public space and landscaping,
- areas of habitat creation and enhancement for reptiles; and,
- resilience of the Scheme to climate change.

2 Technical Note Objectives

This document will outline a strategy for the traffic situation in Lowestoft once the Scheme is implemented. This strategy consists of:

- A review of the existing operational regime.
- Analysis of the changes resulting from the Scheme.
- Development of an optimal process for the new operational regime.
- Identification of the technology and compliance strategies appropriate for supporting this regime.
- Demonstration of alignment between the Scheme and Highways England strategic objectives.

3 Network Operations Review Findings

A Network Operations Review undertaken (Appendix B) as part of this strategy, identified current and forecasted congestion as the prime issue facing Lowestoft's road network. The review found that intervention at a strategic level will be particularly beneficial, assisting the movement of people and goods throughout the town by influencing routing at key decision points in response to network conditions and the status of the various crossings.

The use of existing and proposed intelligent transport systems (ITS) will be essential to enabling strategic management. Lowestoft currently has eight Variable Message Signs (VMS) and a network of CCTV in key locations around the town. In addition, the Urban Traffic Management (UTMC) and Control Common Database (CDB) in Ipswich acts as a central repository for data originating from traffic management systems and enables pre-determined plans to be automatically implemented in response to prevailing traffic conditions. A number of traffic signal sites in Lowestoft along the trunk roads form part of the Split Cycle and Offset Optimisation Technique (SCOOT) urban traffic control (UTC), with a migration programme for other sites across the town currently in progress.

In future, strategic management based on ongoing network conditions could be refined using data from external providers (e.g. INRIX, Google) or council-owned and operated systems (e.g. Bluetooth, radar, loops) and linked back to UTMC CDB. Further VMS would also prove beneficial.

4 Reclassification of roads

A reclassification of several strategically vital roads within Lowestoft is currently proposed alongside the pre-application stage of the Scheme. The proposed reclassification is depicted in Figure 4.1 (and Appendix B); of primary importance is the designation of the current A1117/B1531 Waveney Drive/ C970 Peto Way/Riverside Road route (incorporating the Scheme) as the A12 primary trunk route through Lowestoft; and the consequent reclassification of the A47 as a local road serving Lowestoft town centre.

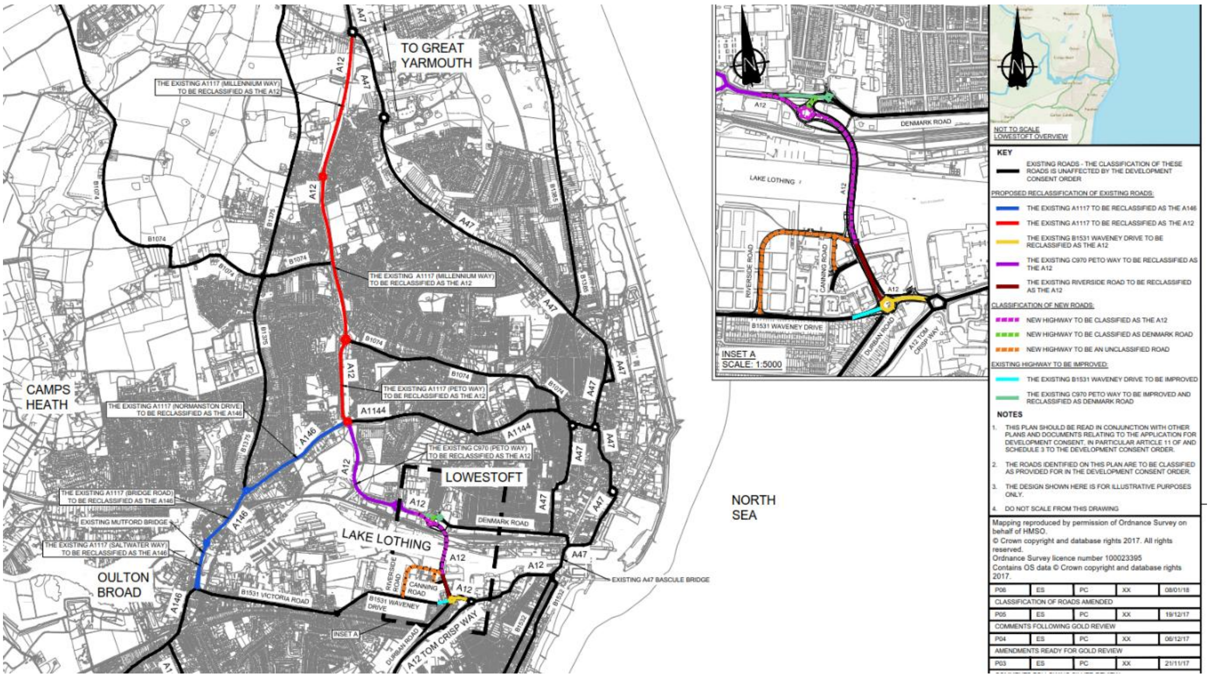

Figure 4.1 - Proposed reclassification of roads, Lowestoft

5 Network operation

The Scheme will need to ensure efficiency in operation and communications with the current operating regime of the A47 Bascule Bridge, Mutford Bridge, and Oulton Broad level crossing.

5.1 A47 Bascule Bridge

The existing A47 Bascule Bridge opens on request for all vessels at the following times:

Monday - Friday	0300	0500	0700	0945	1115	1430	1600	-	1900	2100	2400
Weekends and Bank Holidays	0300	0500	0700	0945	1115	1430	1600	1800	1900	2100	2400

Notice of 20 minutes is required from vessels arriving or departing at these times. No lifts are scheduled for weekday AM and PM peak times (between 0700 – 0945 and 1600 – 1900).

The A47 Bascule Bridge opens on demand outside these hours for commercial shipping over 50 gross register tonnage (GRT). Commercial shipping is discouraged from passage: 0815 – 0900, 1230 – 1300, and 1700 – 1745. Notice of one hour is required for these openings.

Small craft and yachts may use an on-demand bridge opening for commercial shipping provided that prior arrangement has been made with Lowestoft Harbour Control, subject to vessels proceeding in the same direction as the commercial vessel. Other vessels wishing to pass through the bridge from the opposite direction will have to wait for the next on-request craft opening time.

The existing A47 Bascule Bridge operates as follows:

- system user logs in;
- starts the pumps (takes about 30 seconds before traffic/lifting sequence can commence);
- initiates traffic wig wags then waits for bridge to clear of traffic and pedestrians (timings vary);
- closes traffic and pedestrian barriers. Note that traffic barriers cannot be closed until pedestrian gates are closed. Pedestrian barriers are closed individually; traffic barriers can be closed in pairs (timings vary);
- Initiates bridge opening sequence: Nose and tail bolts retract/bridge raises/tail bolts engage (takes about 1 minute 30 seconds);
- sets traffic lights to green for vessel(s) then wait for them to transit, (timings can vary from about 30 seconds to 5 minutes, the latter for larger less manoeuvrable vessels);
- commences closing sequence, which is the reverse of the opening sequence (this takes approx. 1minutes 30seconds); and
- once the bridge is locked in position, opens barriers, (usually simultaneously), for traffic and pedestrians.

Full sequence from starting wig wags to re-opening road is usually anywhere between five and ten minutes.

At present, the A47 Bascule Bridge is opened an average of 14 times per day. The bridge has a clearance of 2m above the lake.

5.2 Mutford Bridge

Mutford Bridge opens on request for small vessels at the following times:
April to October: 0800 - 1800;
Nov to March 0800 - 1100.
Lifting restrictions are in place at peak times (prior to 0900, 1200 - 1300, and 1700 - 1800).

Pre-booking is currently advised rather than required; the bridge may open on immediate request for vessels that have not given notice, but they try to coordinate opening times to ensure several vessels can pass through in a single lift. Lifts are also coordinated with the A47 Bascule Bridge's scheduled lift times, with a 30 minute gap assumed for journey time between the two bridges.

Opening can be disrupted by stationary traffic on the bridge stretching back from the Oulton Broad level crossing. Full sequence from starting wig wags to re-opening road is usually between two and four minutes, but can be more. At present Mutford Bridge typically opens two to four times per day. The bridge has a clearance of 2m above the lake.

5.3 Oulton Broad level crossing

The level crossing at Oulton Broad typically takes three minutes to close and re-open during each cycle. The cycle is instigated automatically by trains passing on The East Suffolk line. Trains are scheduled to pass Monday – Friday at the following times:

Lowestoft - Norwich	0547	0639	0740	0753	0855	0953	1102	1153	1302	1353
	1502	1553	1653	1753	1853	2000	2102	2153	2253	
Norwich - Lowestoft	0614	0659	0722	0834	0924	1042	1127	1242	1327	1442
	1527	1627	1735	1827	1942	2042	2142	2242	2317	

5.4 The Scheme

The reference design for the Scheme is expected to have an average opening cycle of 8:35 minutes, ranging from 5:50 to 11:20. The Scheme will have a clearance of approximately 12m above the lake, allowing a greater range of vessels to pass under it without the need for it to open.

It is typical of an opening bridge to feature a control tower from which the opening span and associated safety barriers/alerts are operated, as a physical presence on the bridge with visibility of all users ensures safety.

5.5 Harbour layout

Figure 5.1 - Harbour layout and travel times between bridges

Maximum speed in the harbour = 4 knots (7.4km/hour).

6 Key scenarios

There are four key scenarios to be considered in planning a strategy for network operations in Lowestoft accounting for the Scheme. These scenarios explore the key distinction between whether lifts are scheduled or ad hoc, which affects how much time Suffolk County Council's ITS department (SCC ITS) would have to implement appropriate traffic management tactics.

Also accounted for are the potentially disruptive variables of the Oulton Broad level crossing being closed, and any other general disruption on the local network.

6.1 Scenario one: Scheduled lifts

Scheduled lift times at the A47 Bascule Bridge are predictable; the bridge will lift at scheduled times on request with 20 minutes' notice required for notification.

In theory, under the current process, the A47 Bascule Bridge and Mutford Bridge operators are be able to inform each other, and SCC ITS, of whether a scheduled lift will take place, how many vessels will be involved, how tall these vessels are, and their ultimate destination. This information in turn would enable SCC ITS to understand how many other bridges must be opened and when, and which traffic management tactic to implement.

However, in practice, information regarding scheduled lifts is currently shared between the A47 Bascule Bridge and Mutford Bridge operators, but these control rooms do not currently communicate with SCC ITS.

6.2 Scenario two: Ad hoc lifts

Ad hoc lift times are unpredictable; large vessels approaching the A47 Bascule Bridge usually give only approximate notice of what time they require the bridge to be lifted, whilst no notice is in principle required for the Mutford Bridge to be lifted.

Under the current process, traffic management systems could only be employed once the bridge lifting operation has begun. Once this lift has begun, however, the operator could inform the Mutford Bridge operator and SCC ITS that the lift has started taking place, the number of vessels involved, vessels height, and their ultimate destination to help inform whether other bridges would need to be lifted and when.

Currently, approximately one minute passes between the control room user initiating the bridge opening sequence and the bridge closing to vehicles and pedestrians.

6.3 Scenario three: Oulton Broad level crossing closed

The Oulton Broad level crossing operates 38 times per day Monday - Friday, including at peak times, with a typical duration of three minutes per cycle. The congestion caused by this level crossing is considerable; diverting traffic towards the Mutford Bridge when the level crossing is due to come down will likely exacerbate the congestion in the local area.

The crossing could be accounted for in one of two ways:

1) Either an automated signal could be sent to the UTMC CDB when the level crossing cycle begins (or ideally, 10 minutes before a cycle is due to begin);

2) The UTMC CDB automatically changes the traffic management tactic in response to scheduled crossing times.

6.4 Scenario four: Disruption on the network

Congestion caused by collisions, roadworks and other disruptions may make certain routes through Lowestoft unviable regardless of bridge and level crossing patterns.

Traffic monitoring technology is required to ensure road conditions are constantly monitored and accounted for when implementing a traffic management tactic in response to bridge and/or level crossing lifts.

Figure 6.1 demonstrates the process involved when a bridge is opened, incorporating the two crucial decision points of scheduled/ad hoc lift and existing network disruption/no existing network disruption ('conflict'/'no conflict'):

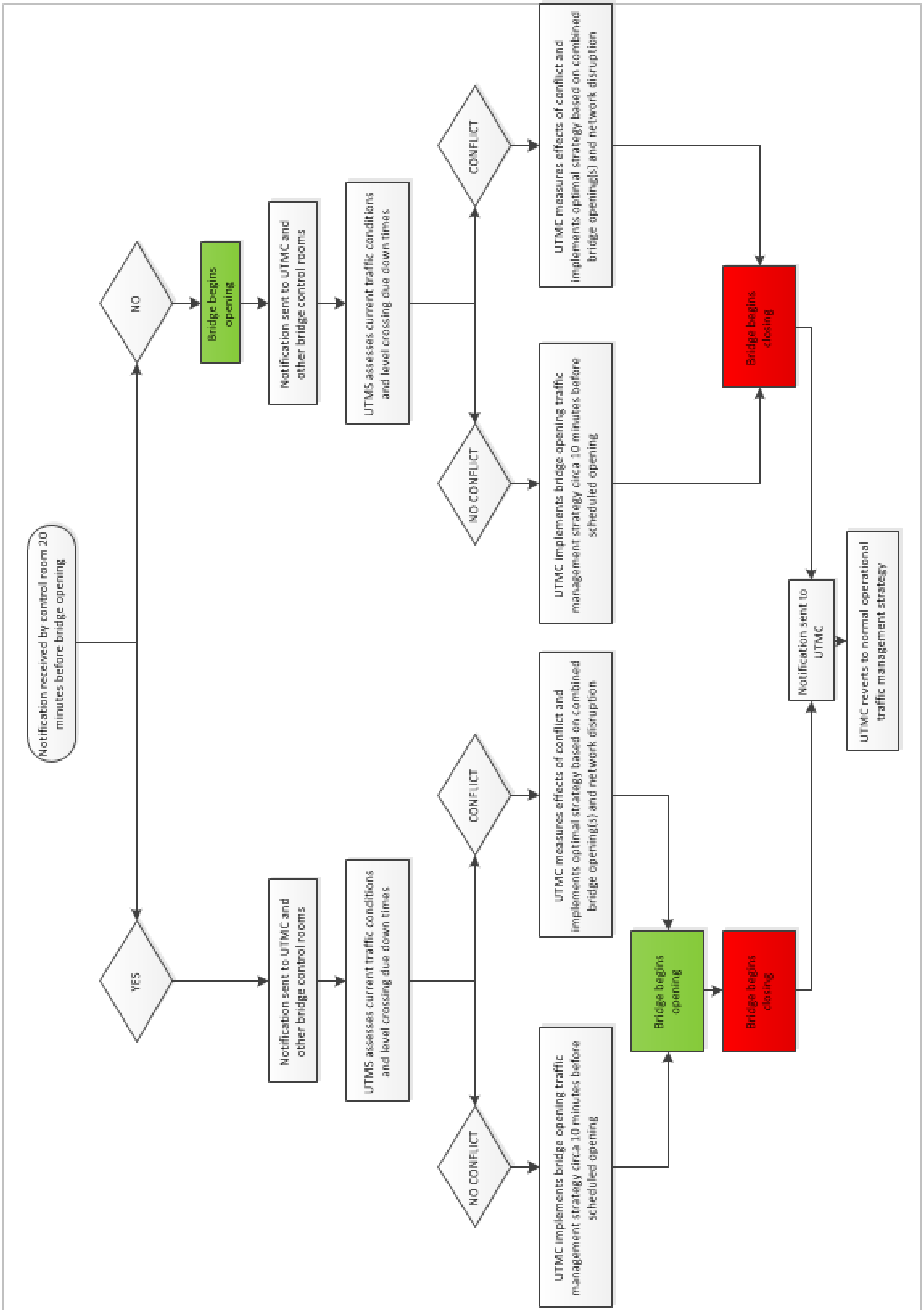

Figure 6.1 – bridge opening process

7 Scheme Operation - Network Impact and Alternative Routings

Figure 7.1 depicts distances, off-peak journey times, and forecast 2022 AADT (incorporating the existence of the Scheme) on major routes in Lowestoft, as well as current VMS locations. It also shows the current SCC ITS strategy for diverting through traffic over the Scheme, and town centre traffic over the A47 Bascule Bridge.

SCC ITS transport strategy will emphasise using the A12 and Scheme as the ‘normal’ route for through traffic, with the A47 Bascule Bridge managing traffic for the town centre. Origin/destination data shows that 42% of journeys in Lowestoft involve traffic originating or ending outside the town, and 58% of journeys in Lowestoft involve traffic originating or ending in the town centre.

Given the relatively even distribution of through traffic and traffic originating or ending in the town centre, and SCC ITS’s commitment to using the Scheme to accommodate the majority of freight traffic in Lowestoft, the Scheme is an appropriate choice to become the trunk road for through traffic across Lake Lothing.

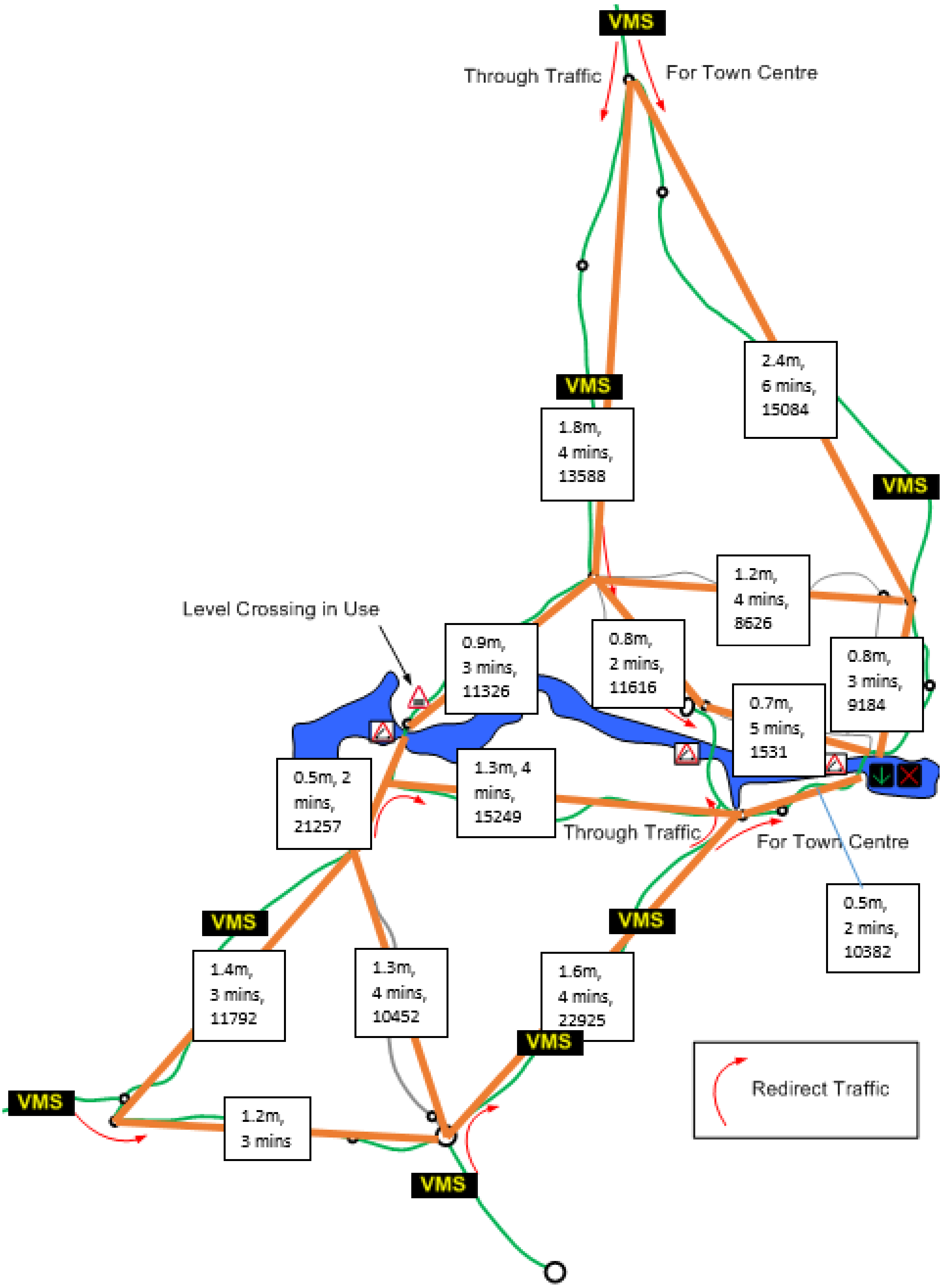

Figure 7.1 – Future Network Example of Diversion Strategy for Level Crossing Closure (with distances, off-peak journey times, and 2022 forecast AADT)

For ad hoc lifts, a certain number of cars will be heading for a lifting bridge beyond the point that VMS could divert them to a non-lifting bridge; therefore, a number of journeys will not be improved by traffic management tactics. Note that, given the short lift duration for the Mutford Bridge (assumed at 3:30 minutes), no journeys are estimated to be improved via ad hoc traffic management tactics.

Ad hoc lifts	Journeys saved/lift	Minutes saved/lift
A47 Bascule Bridge	5	46
Mutford Bridge	0	0
The Scheme	72	616

Table 7.1 - Ad hoc lift time savings, VMS

For scheduled lifts, since important decision points are no more than nine minutes away from the nearest bridge under off-peak conditions, a 20 minute notice period would be sufficient for bridge lift tactics to divert all affected traffic away from lifting bridges.

Scheduled lifts	Journeys saved/lift	Minutes saved/lift
A47 Bascule Bridge	55	412
Mutford Bridge	40	138
The Scheme	184	1577

Table 7.2 - Scheduled lift time savings, VMS

8 Technology

The UTMC CDB located in Ipswich gives SCC ITS the facility to operate ITS installed within Lowestoft to implement appropriate traffic management strategies based on network conditions, including but not limited to bridge openings.

8.1 Traffic signals

A number of traffic signal sites in Lowestoft along the A12 route are linked to the UTMC CDB system, and/or coordinated via SCOOT UTC. The process of integrating other key traffic signals in Lowestoft to the UTC is ongoing.

8.2 VMS

There are eight VMS currently in operation in Lowestoft, depicted in Figure 5.1. These are standard 3-line VMS; VMS on the A12 are subject to Highways England message standards. VMSs are currently used primarily to display campaign messages, but are intended to display route diversion information in the event of bridge openings or major incidents.

VMS are currently located at the major decision points in Lowestoft and therefore no extra major signs are necessary; however consideration may be given to smaller signs at the entry to each bridge to display important tactical or strategic messages (e.g. to encourage drivers to turn off engines whilst waiting at a lifting bridge) should this be required following implementation of the Scheme. The ITS Innovations Research Report[1] (Appendix D) states that mobile VMS have been used on London's Tower Bridge to lower emissions and boost air

[1] Lake Lothing Third Crossing: ITS Innovations Research Report, July 2017

quality by encouraging drivers to switch off their engines during bridge openings. An air pollution monitoring station has been installed to measure the impact of the project.[2]

With regard to the Scheme, the benefit of this innovation is dependent on how long drivers will have to wait before continuing to cross the bridge. The Scheme aims to reduce this wait by providing the third crossing, and using VMS signs to direct road users towards available alternative crossings. However, an objective of SCC's second Local Transport Plan (2006-11)[3] is to improve air quality, so it is possible the council may wish to consider implementing this following an assessment on the usefulness of this innovation after Scheme completion.

Urban VMS to direct drivers to parking availability in the town could also be considered in the future, as they can help to ease congestion caused by drivers looking for somewhere to park.

8.3 Tidal flow

The A47 at the A47 Bascule Bridge utilises a 'tidal flow' system; one lane northbound, one lane southbound, and one lane which varies (northbound in the morning peak, southbound after 11.30am). The tidal flow system has the potential to be incorporated into a wider network strategy, facilitating extra capacity in either direction in response to network conditions and bridge lifting times.

8.4 Intelligent bus services

SCC currently operates the Icarus Real-time Passenger Information (RTPI) system that tracks the movement of buses through the network and provides information to passengers on their progress and likely arrival time. Displays are located in Lowestoft bus station. Work is currently being done to link the RTPI system to the ITS servers to make bus priority available as an option.

The Lake Lothing Third Crossing: ITS Innovations Research Report[4] (Appendix B) mentions the new 'Smartbus' that is trialling in London which includes real time tracking software and integrates with the Citymapper app as well as transport network data made open by Transport for London. It is also capable of counting passenger numbers and features a smart display to show travellers where they currently are along the bus route and which stop is coming next.

Citymapper has built a tool which uses historic data to identify new and improved bus routes. In the future it may look to monitor real time traffic information to change the routes between bus stops if there is heavy congestion in a particular area[5].

Improving the bus service in Lowestoft is part of the ITS Strategy and a council objective. It is therefore a viable ITS innovation that could be pursued by SCC following the completion of the Scheme and could further improve congestion conditions.

8.5 Traffic monitoring technology

As the impacts of the operation of the bridges and level crossing, as well as any incidents that occur on the network, are dependent on the level of congestion present on the network, which in turn determines the most appropriate tactic to implement, additional network monitoring would be beneficial. This could be achieved using data from external providers, such as INRIX

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[2] http://www.its-ukreview.org/drivers-urged-to-switch-off-engines-at-tower-bridge/ (accessed 18/07/2017)

[3] Suffolk County Council, Local Transport Plan, 2006-11

[4] Lake Lothing Third Crossing: ITS Innovations Research Report, July 2017

[5] http://www.its-ukreview.org/intelligent-bus-service-tested-in-london/ (accessed 18/07/2017)

or Google, or through the implementation of Council owned and operated systems, such as radar, loops, Bluetooth detectors, etc. This data can be input directly into the UTMC CDB and thresholds and rules set to allow the system to make best use of it in tactic selection. Permanent, directional, classified traffic counters would provide consistent and reliable traffic flow data and help with the calibration of data from the traffic signal detection systems. Historical sites at the two existing bridges should be reinstated and a third included to monitor traffic over the Scheme.

8.6 UTMC automation

SCC is in the process of developing a link between the lifting operation commencing for the A47 Bascule Bridge and the UTMC CDB, such that the lifting of the bridge triggers the appropriate traffic management tactic. Such a system should be simple to replicate with the Scheme if required.

For scheduled lifts, it is possible to programme in the lift times into the UTMC CDB then be triggered either to confirm or cancel the implementation of a tactic in advance of a scheduled bridge lift. For both scheduled and ad hoc lifts, information regarding approximate lift duration would also be of benefit for the UTMC system to contain.

A user interface in the ABP and Mutford Bridge control rooms containing important data regarding lifts (scheduled time, expected duration) with a connection to the UTMC system would be highly beneficial. It should be explored with ABP and Sentinel Leisure Trust (who currently operate the Mutford Bridge) the extent to which they would be willing to implement such a system.

9 Compliance

Any innovations will need to achieve road user compliance from an operational and safety perspective to be effective.

9.1 Operational compliance

A key problem from an operational compliance perspective is ensuring road users act rationally and collectively - moving towards open roads and away from closed roads (due to a bridge opening or traffic incident). Road users may have engrained habits and may not readily adopt new habits even where these have benefits both to the individual and the road network. Achieving changes in habits will require clear and sustained communications that demonstrate the benefits to road users.

Operational compliance challenges can be summarised as:

- Optimising road capacity: with bridges regularly opening and closing above Lake Lothing, it is imperative that road users divert towards available crossings, minimising unnecessary congestion and delays.
- Increasing non-motorised user (NMU) usage: encouraging NMU traffic is an explicit Scheme objective. There is an opportunity through the Scheme to encourage greater bicycle usage in Lowestoft, as the network can act as a disincentive for NMU usage in some aspects, for example difficulty for NMUs in crossing Lake Lothing.

Operational compliance can be optimised through a variety of means:

- Engineering:
    - Effective ITS is important for optimising road capacity. Drivers can be advised via VMS of clear, credible, visible information diverting drivers towards optimal routes. Drivers could be compelled via SCOOT/UTMC CDB-linked traffic lights towards optimal routes. ITS engineering for operational compliance is underpinned by effective information-gathering and communication systems, as well as effective tactics to be employed during various scenarios.
    - NMU usage can be made more attractive via appropriate road engineering and design. Provision of safe, quick, and direct lanes for pedestrians and cyclists; controlled and signalised crossings; and appropriately designed (well-lit, well-landscaped) routes are critical in ensuring relevant objectives for increasing NMU usage are met.

- Education/encouragement:
    - For optimising road capacity, consideration should be given on how best to communicate scheduled lift times to road users. In addition, a public information campaign on the road network following the implementation of the Scheme and on how the VMS directions benefit road users should be undertaken.
    - Cycling safety campaigns should be used to both encourage safe and enjoyable cycling amongst the local population, and to encourage safe driving behaviours amongst motorised users. These would be local initiatives separate to the Scheme.

9.2 Safety compliance

Safety compliance involves inducing appropriate behaviour from road users to minimise the risk of collisions and casualties. Protecting motorcyclists and NMUs is particularly important for the Scheme: to assist in reducing collisions involving motorcyclists and cyclists in Lowestoft. Encouraging NMU traffic, reducing conflicts between NMUs and other road users, and reducing collisions are all county-wide and Scheme objectives.

Safety compliance can be optimised through a variety of means:

- Engineering: road and junction layout is crucial for optimising safety compliance. Controlled, signalised junctions with regular crossing points are ideal for protecting NMUs in particular. Clear and visible road signs are also important. Speed bumps can be used to engineer low vehicle speeds in areas with high NMU usage.

- Education: education campaigns can be promoted for both motorists and NMUs to encourage safe and mutually-respectful road behaviours. Training and courses can be offered to safety compliance offenders. ITS (via CCTV, speed cameras, etc.) may be effective in identifying road users for whom training would be appropriate.

- Enforcement: persistent or serious offenders may be best handled via police enforcement. Offences such as using mobile phones whilst on the road, failing to wear seatbelts, speeding, and drink/drug driving present a serious danger to other road users and must be eradicated as far as possible from Lowestoft's roads. As with education, ITS (eg CCTV, ANPR speed cameras) can have a significant part to play in detecting serious and repeat offenders.

10 Alignment with Highways England strategic objectives

Lowestoft faces multiple challenges in aligning with the strategic objectives defined in Highways England's Strategic Business Plan[6]:

- Supporting economic growth – Lowestoft is heavily dependent on the A12/A47 for connectivity with the rest of England; lack of capacity on the A12/A47 may be hindering potential for local growth.
- More free-flowing network – congestion caused by pinch points at the A47 Bascule Bridge and at at-grade junctions and roundabouts between Lowestoft and Great Yarmouth.
- Safe and serviceable network – high collision rate on the A47 between Lowestoft and Great Yarmouth, and accident hotspots on the A12 south of the A47 Bascule Bridge (Pier Terrace/London Road South).
- Improved environment – A12/A47 heavily used with noise and air quality (AQ) consequences.
- More accessible and integrated network – A47 between Lowestoft and Great Yarmouth generates severance issues due to insufficient facilities; community severance an issue between north and south Lowestoft.

The Scheme will help Lowestoft to achieve these objectives by increasing road capacity, trunking of the Scheme (and de-trunking of the A47 Bascule Bridge), inducing a gradual shift from car users to NMUs, and the greater efficiency induced by provision of ITS throughout the town:

- Supporting economic growth – the Scheme will become the new A12/A47 route; this will increase capacity on the route by adding a major new road to the network and ensuring the A12/A47 is closed less often (via bridge lifts) than the current route. This is expected to lead to more journeys being made and more businesses being accessed within Lowestoft.
- More free-flowing network – the extra capacity provided by the Scheme, and greater coordination enabled by appropriate ITS, will alleviate congestion in the local network; congestion may be further alleviated by inducements for road users to switch from cars to non-motorised vehicles.
- Safe and serviceable network – congestion-related collisions to be reduced as a consequence of congestion-reducing effects of the Scheme; increased protection to be given to NMUs.
- Improved environment – VMS may be used to encourage idling traffic at bridge lifts to switch off engines whilst waiting.
- More accessible and integrated network – the Scheme reduces north/south severance in Lowestoft by offering a central route by which road users (particularly bus users and NMUs) can traverse Lake Lothing; UTMC and associated ITS will also ensure the network operates in a more integrated and efficient manner.

[6] Highways England Strategic Business Plan 2015-2020, p.9

11 Conclusions and Recommendations

Conclusions

- The traffic tactics employed during bridge lifts in Lowestoft will have to account for two basic separate scenarios: scheduled lifts and ad hoc lifts. These tactics need to be sensitive to the level crossing at Oulton Broad and other disruption on the network.
- The implementation of appropriate traffic management tactics under bridge lift conditions could be expected to achieve the following results:

Ad hoc lifts	Journeys saved/lift	Minutes saved/lift
A47 Bascule Bridge	5	46
Mutford Bridge	0	0
The Scheme	72	616

Table 7.3 - Ad hoc lift time savings, VMS

Scheduled lifts	Journeys saved/lift	Minutes saved/lift
A47 Bascule Bridge	55	412
Mutford Bridge	40	138
The Scheme	184	1577

Table 7.4 - Scheduled lift time savings, VMS

- Existing technology in Lowestoft (UTMC CDB, VMS, SCOOT UTC, CCTV) provides a strong foundation to implement an effective network strategy for Lowestoft; consideration should be given to both extending this existing network and to introducing new elements (urban VMS, Bluetooth traffic monitoring) to enhance the integration of the traffic network and further ameliorate the problems (congestion, safety, severance, regeneration and growth) identified by SCC in Lowestoft.
- The Scheme aligns with both SCC's stated objectives and with Highways England's overall strategic objectives.

Recommendations for the next phase of work

1) Incorporate results of Lowestoft harbour maritime survey to gain a deeper insight into current and expected bridge lifting patterns in Lake Lothing.
2) Explore various bridge operation scenarios and devise traffic management tactics with level crossing and congestion factors incorporated.
3) Develop a Memorandum of Understanding (MoU) with affected parties including: ABP, Sentinel Leisure Trust, and Network Rail to establish bridge operation procedures (ABP and SLT) and terms of cooperation with SCC e.g. recording lift details.

Appendix A – References

References	
[1]	http://www.eadt.co.uk/news/suffolk-lowestoft-unwanted-bridge-in-lowestoft-gets-2-million-backing-1-2273132 (accessed 04/10/2017)
[2]	http://www.peteraldous.com/content/peter-aldous-leads-debate-third-crossing-over-lake-lothing (accessed 04/10/2017)
[3]	http://www.heart.co.uk/eastanglia/news/local/lowestoft-to-get-3rd-crossing/ (accessed 04/10/2017)
[4]	http://www.edp24.co.uk/business/final-preparations-at-lowestoft-third-crossing-site-ahead-of-public-consultation-1-5129497 (accessed 04/10/2017)
[5]	Lake Lothing Third Crossing: ITS Innovations Report (July 2017)
[6]	http://www.its-ukreview.org/drivers-urged-to-switch-off-engines-at-tower-bridge/ (18/07/2017)
[7]	Suffolk County Council, Local Transport Plan, 2006-11 (March 2006)
[8]	http://www.its-ukreview.org/intelligent-bus-service-tested-in-london/ (18/07/2017)
[9]	Highways England Strategic Business Plan 2015-2020 (December 2015)

Appendix B – Reclassification of roads

Appendix C – Network Operations Review

Project:	Lake Lothing Third Crossing (LL3X)			
Document title:	Technical Note – Network Operations Review			
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Checker:	Paul Marsh	Mouchel	Date:	03/02/2017
Authoriser:	Joanna Lyon	Mouchel	Date:	

Background

Lake Lothing in Lowestoft is currently traversed by two bridges, separated by a distance of 3km – an eastern Bascule Bridge (bordering the town centre), and the western Mutford Lock (just south of a level rail crossing). A third bridge to cross Lake Lothing has been agreed upon, its location described as a 'central' option between the two existing bridges.

This document will review the existing traffic situation in Lowestoft, with a particular focus on the areas around the two bridges. This review will consist of an:

- Overview of the strategic and specific objectives on the client (Suffolk County Council).
- Review of the applicable literature.
- Analysis of the current operation of Lowestoft's transport network.
- Brief identification of the key stakeholders in this project and issues with respect to both the operation of the network and their perception of how ITS interventions may assist.

Furthermore, it will explore potential options for future network operations strategies and the technologies required to implement them with the aim of maximising network efficiency both during and post construction of the new crossing.

Technical Note Objectives

The technical note examines, at a high level, the current and potential future challenges that affect the performance of the road network in Lowestoft. Examining these, it explores options for addressing the issues at both a tactical and strategic level. Tactical management occurs at a localised level in response to an event or incident, such as at a junction. Strategic management considers the movement of traffic across the town as a whole with the view to influencing its routing or progress through the network with a view to preventing delays or escalation of existing events.

The note then considers the technology (typically Intelligent Transport Systems) already available for use, identifies gaps in the provision and then proposes how the individual systems can be integrated into a powerful transport management tool.

Specific Objectives

The purpose of the Lake Lothing Third Crossing (LL3X) project is to stimulate regeneration, sustain economic growth and enhance Lowestoft as a place to live and work in, and as a place to visit. The project will:

- Open up opportunities for regeneration and development in Lowestoft
- Provide the capacity needed to accommodate planned growth
- Reduce community severance between north and south Lowestoft
- Reduce congestion and delay on the existing bridges over Lake Lothing
- Reduce congestion in the town centre and improve accessibility
- Encourage more people to walk and cycle, and reduce conflict between cycles, pedestrians and other traffic
- Improve bus journey times and reliability
- Reduce accidents

Current Network Issues

Lowestoft has a relatively dense transport network within the main urban area serving private car users, commercial vehicles, cyclists, public transport vehicles and pedestrians. In addition, the town has rail links with stations at Lowestoft and Oulton Broad North. The lift bridges can cause delays in the order of 15 minutes for each lift and the level crossing adjacent to Oulton Broad North station can delay traffic for between two and seven minutes per opening with the potential for multiple openings in the peak hours. These can be compounded when the timings of the Mutford Lock Crossing and train station occur sequentially, or when the eastern bascule bridge has multiple lift requests in short succession.

Studies have shown that approximately 80% of those who work in the town also live there, which results in short commuting journeys being made, a third of which being less than a mile and two-thirds being less than three miles. More strategic journeys through the town service Ipswich to the south and Great Yarmouth to the north via the busy A12, which runs close to the town centre and is of a lower standard of build in this area. Alternative routing outside the town is relatively limited, though traffic through the town can make use of the A146.

As previously detailed, the distance between the bridges makes diverting to the alternative crossing, if a user’s original route is blocked, unpalatable. This is especially true when there may also be delays at the other bridge or en-route.

The Suffolk Local Transport Plan 2011 – 2031 details the key road network and public transport issues for Waveney as:

- Lack of bus connections to/from Lowestoft, market towns and rural areas
- Access to development sites south of Lake Lothing in Lowestoft
- Impact of traffic in north Lowestoft
- Impact of lorries in Beccles
- Impact of lorries in Bungay town centre
- Poor frequency of service on the East Suffolk line
- Poor transport connections at rail stations on the East Suffolk line
- Traffic congestion at Oulton Broad North rail station
- Lack of pedestrian/cycle bridges over Lake Lothing
- Pinch points for north/south traffic in Lowestoft

- Sea level change and coastal erosion

Anticipated Benefits of Third Crossing

The main area of proposed regeneration is also where the transport network suffers significant problems, due to the limited crossing opportunities and congestion at the existing bridges. The anticipated growth in trips to and from the regeneration area will be significantly addressed by the proposed bridge, as it will provide more direct access to these areas. In addition, the new crossing will provide:

- Improved access to the A12.
- The choice of a "central" corridor for the third crossing meaning that traffic can travel easily between the Northern Spine Road (Peto Way) and the Southern Link Road (Tom Crisp Way) without using either of the existing bridges, helping to reduce congestion and reduce community severance.
- A bascule (lifting) bridge, which will be constructed to allow the passage of shipping within the inner harbour. When closed, the bridge will have a clearance of at least 12m. This will enable smaller boats to pass under the bridge. This, and its location west of some of the docks, means that it will have to open less frequently than the existing Bascule Bridge at the harbour entrance.
- A greater choice of route options when delays occur due to the operation of the other crossings or the level crossing at Oulton Broad North.

Residual Issues Post-implementation of Third Crossing

Whilst the proposed third crossing will address a large number of the issues related to accessibility, a number of issues may remain that affect the performance of the network. The Lowestoft Harbour Crossings and Associated Problem Junctions produced by AECOM seeks to recommend resolutions to a number of identified pinch points on the network in the general vicinity of the current crossings. This includes some realignment and the introduction of prohibitions to prevent traffic movements that are considered to cause conflict with the expeditious movement of vehicles.

These will assist in removing some of the bottlenecks, but are unlikely to address the significant impact of the operation of the bridges or the level crossing. The decision of road users to vary their route based on delays experienced at one location will still be based on available information, which the new crossing does not provide. It does, however, reduce the distance that a user would have to travel to find an alternative route, thus making it more appealing to those who make the choice to reroute.

Network Operations Options

The proactive management of the Lowestoft network offers opportunities to attain a greater level of benefit from the investment proposed for the new crossing and supporting network improvements. Network operations can occur at two levels:

- Tactical – interventions that have a direct impact on the network directly adjacent to their application, such as changing of traffic signal timings or a change in the lane allocation on the tidal flow system.
- Strategic – interventions with wider reaching effects across the network, such as dynamic rerouting of network users or the provision of advanced warning of disruption.

These interventions, typically referred to as strategies, will be developed through consultation with stakeholders and based upon measured and modelled data to inform a choice of options and approaches to meet both the political and physical environment to which they are being applied.

Tactical Management Options

The Lowestoft network, in its present form doesn't lend itself to many tactical interventions beyond those detailed in the AECOM report as the bottlenecks will remain in the form of the existing Lake Lothing crossings and the railway level crossing. As previously detailed, many short journeys are made in the town, so small changes may have a significant impact. The current work to migrate / upgrade standalone signalised junctions to an adaptive system (see Use of Intelligence Transport Systems Section) will provide the majority of these benefits for a number of users. These may be further enhanced if they are coordinated with the crossings to change the timings to encourage some rerouting and prevent blocking at junctions in adjacent areas.

These upgrades would also facilitate priority being given to buses at signalised junctions if they are running behind schedule to help bring them back on-time. In some European countries, HGVs are given a 'green wave' when air quality is low in order to reduce the amount of time they spend idling at lights and the additional pollution caused by them having to accelerate up to speed again. This could also be used to provide a corridor for emergency service vehicles attending an incident or to assist them leaving their stations / depots.

During the construction of the new crossing, the management of traffic around the two tie-in points will be key to ensuring that disruption is minimised. It is common for contractors to implement temporary traffic management systems and these are often not optimised for the prevailing conditions. This should be considered during the contractor appointment stage and form part of the requirements of their works.

Post crossing implementation, it is understood that significant re-routing of traffic will occur changing the stress points on the network. Signal timings and priorities will need to be revisited.

Strategic Management

At a strategic level, options exist to assist with the movement of people and goods through the town, mostly by influencing routing at key decision points in response to network conditions and the status of the various crossings. Whilst the majority of journeys are local and under 3 miles, changing the route taken by the longer distance traffic is likely to be beneficial for all users by preventing escalation and recovery time at pinch points, whilst preventing the more strategic from encountering congestion unnecessarily.

An example with the existing network is shown in Figure 6.1.

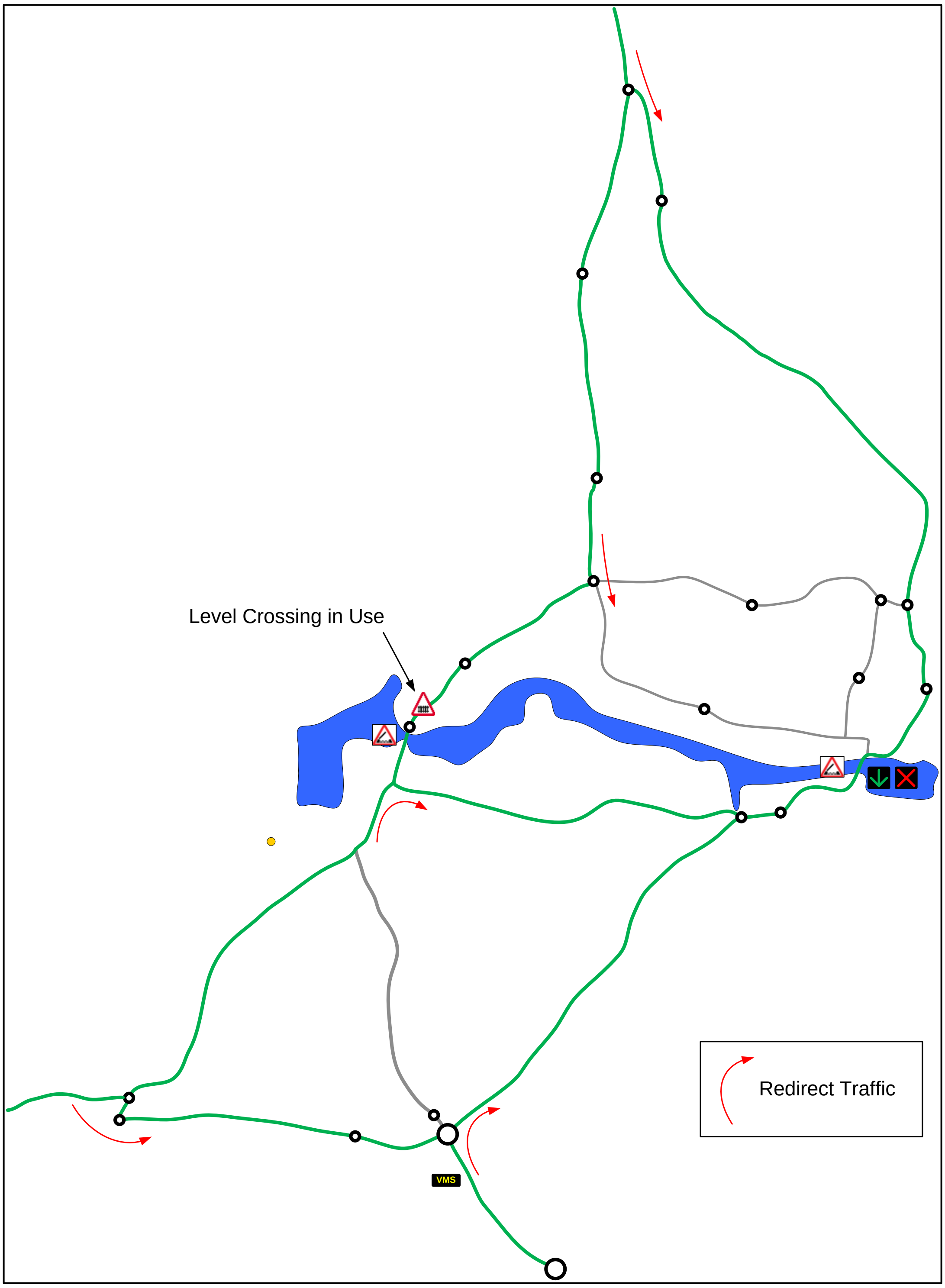

Figure 6.1 – Existing Network Example of Diversion Strategy for Level Crossing Closure

During the construction of the third crossing the use of diversions is likely to be required particularly on the routes affected as the tie in points to the existing network are constructed. The application of route strategies as per the pre-construction phase can equally be applied during the works.

Post construction, the options for strategic network management become greater and it is possible to direct people to the best route based on their intended direction, rather than just proving alternative routing. For example, traffic approaching from the north or south can be directed either through the town if they are passing through the town or to the town centre if Lowestoft is their destination of choice. This is illustrated in Figure 6.2.

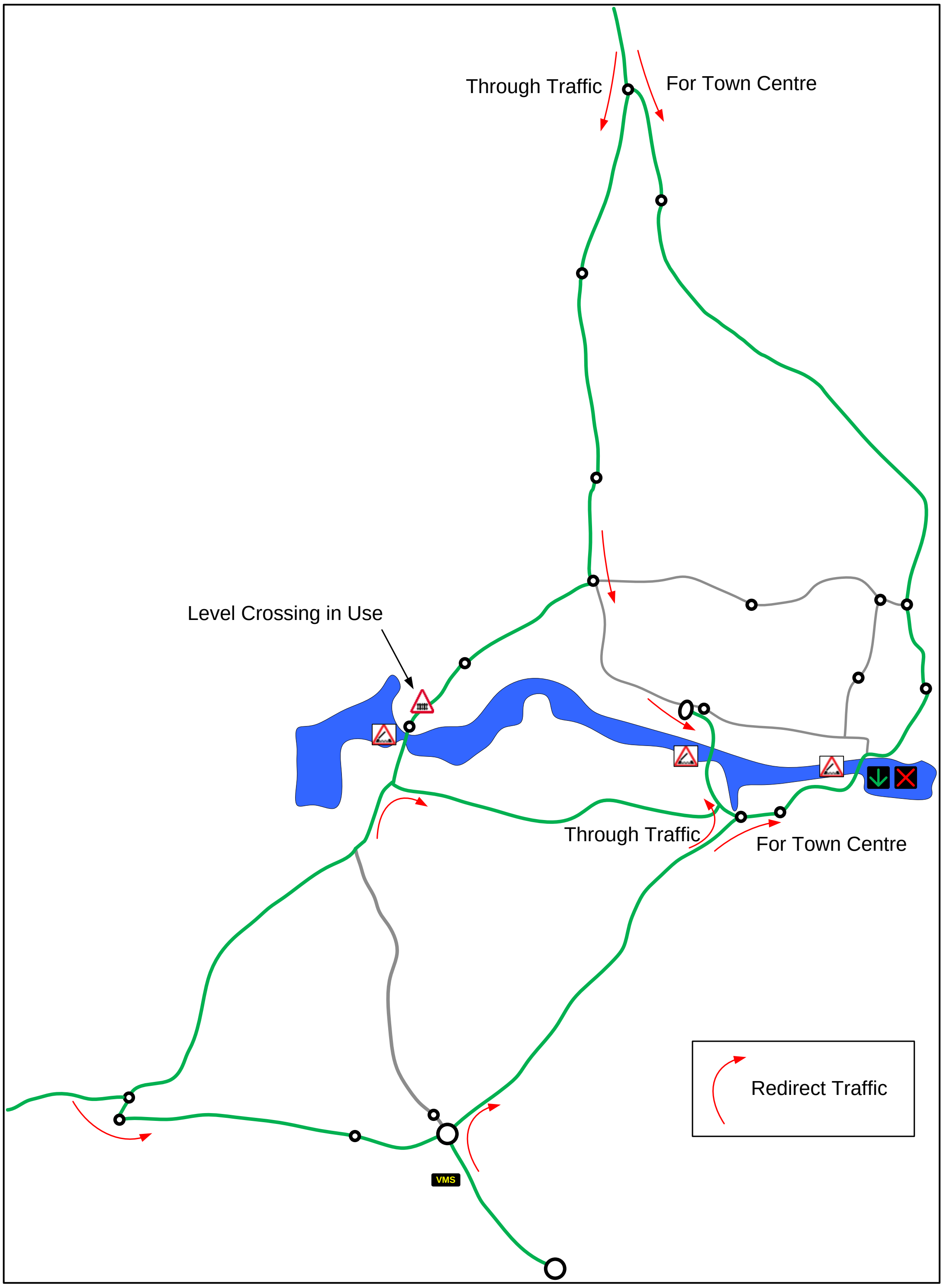

Figure 6.2 – Future Network Example of Diversion Strategy for Level Crossing Closure

More localised traffic movements may also be able to benefit from rerouting where delays are likely to be significant, as often occurs at the railway level crossing. With the new crossing providing a shorter alternative route, it becomes more feasible and attractive for road users to alter their journey.

The actual routes to be signed and the conditions under which diversions are recommended will need to be verified using traffic modelling and refined using data obtained post implementation.

Operational Scenario – Post Crossing Implementation

A vessel seeking to exit Lake Lothing requests for the bascule bridge to be lifted, providing the requisite notice. The bridge operator primes the bridge system and sends notice to the traffic management system that a bridge lift will be occurring. The system provides notice to road users likely to be affected by the operation of the bridge at the appropriate decision points. Traffic signal timings are altered, as required, for the new routings and provide more priority for those routes. Information is provided to the bus passenger information system to allow any delay to services to be conveyed to their customers (buses may be re-routed if compatible with their service). When the bridge is ready to close another instruction is sent to the traffic management system and, at the appropriate time, the notifications to road users are removed and the traffic signals return to standard operation.

Coordination and Collaboration

As detailed in the Use of Intelligence Transport Systems section, most of these proposals can be achieved through the appropriate deployment and integration of technology. However, underpinning the successful management of the network will be to foster and maintain good relationships with the bridge operators and Network Rail. These will be important in order to gain agreement for the linking of technology systems, sharing operational details and the maintenance of both.

Use of Intelligent Transport Systems

Intelligent Transport Systems (ITS) play a key role in providing the ability to dynamically manage a transport network in response to prevailing conditions. This section summarises the types of technology that exist within Lowestoft currently and considers how they may be used more effectively, as well as what additional technologies may help to get the most from the town's transport infrastructure both during and after the proposed crossing's implementation.

Existing ITS

The existing ITS tools identified as being currently used include:

Traffic Signals

Lowestoft has both standalone and adaptive Urban Traffic Control (UTC) based signalised junctions. The standalone signal controllers are a mixture of fixed time, vehicle actuated (VA) and Microprocessor Optimised Vehicle Actuation (MOVA). The standalone sites are being upgraded on a case by case basis to Split Cycle and Offset Optimisation Technique (SCOOT) UTC to allow better coordination of network regions formed by a number of signalised junctions. UTC typically requires sensors to be installed in or above the road, which are then used to calculate demand and alter the operation of the junction and neighbouring junctions appropriately.

CCTV

The town has a number of CCTV cameras to allow monitoring of centre and the road network. These are useful for general observation of traffic conditions, identifying / confirming incidents and providing reassurance to transport users of their safety.

Variable Message Signs

On the A12 on the approach to the roundabout adjacent to the South Lowestoft Fire Station, there is a multi-line Variable Message Sign (VMS), though no detail could be found at the time of writing as to who owns and operates this sign or if it has a specific purpose.

Tidal Flow System

The bascule bridge on the eastern corridor has a tidal flow system, using overhead signals to indicate to users if one or two lanes are available for the direction they are travelling. This provides additional capacity at peak times, as well as stacking capacity when the bridge is opened.

Bridge Control Systems

The bridge control systems perform a number of functions, including displaying signals to warn approaching motorists (pedestrians as well at the bascule bridge) that the bridge is preparing to lift, operating the barriers across the roadway, and lifting and lowering the bridge.

Level Crossing Management System

The rail crossing system comprises of signals to indicate to road users and pedestrians that the crossing is preparing to be used or is being used, along with the barriers and their lower and raising actuators. This system is operated by Network Rail in response to trains arriving at and departing Oulton Broad North station.

Real-time Passenger Information System

Suffolk County Council operate the Icarus Real-time Passenger Information (RTPI) system that tracks the movement of buses through the network and provides information to passengers on their progress and likely arrival time. Displays are located in Lowestoft bus station.

Urban Traffic Management and Control Common Database

It is believed that Lowestoft has an Urban Traffic Management and Control (UTMC) Common Database (CDB), which is a central repository for data originating from traffic management systems attached to it such that it can be shared between the systems. The CDB may incorporate a 'strategy supervisor', allowing rules to be set up to monitor for particular conditions and invoke a pre-determined plan, such as changing signal timing or putting a notification on a variable message sign.

Communications Network

A report produced by Faber Maunsell (now AECOM) in 2006 detailed a MESH wireless communications network being deployed within Lowestoft. The use case at the time was to link the bridge operation to local signals and the RTPI system. It is not known if this system is still in use and, if it is, whether it is still maintained to provide optimal performance.

Summary of Existing ITS

Lowestoft's current ITS operations are rudimentary - some fixed cameras at key locations, the tidal flow system, and some interaction (which they are looking to progress) between the bridge and surrounding traffic signals. SCC are going to take operational control of the traffic signal network in Lowestoft around 1st April; Highways England will retain a right to interject if the trunk roads are suffering.

Future ITS

At present, Lowestoft has a wide range of technologies that can be used to provide the underpinnings of a comprehensive network management system. However, to provide the full functionality required and the level of network intelligence to make informed choices about the most appropriate strategies to implement some additional ITS are needed. These are discussed below.

Network Monitoring

As the impacts of the operation of the bridges and level crossing, as well as any incidents that occur on the network, are dependent on the level of congestion present on the network, which in turn determines the most appropriate strategy to implement, additional network monitoring would be beneficial. This could be achieved using data from external providers, such as INRIX or Google, or through the implementation of Council owned and operated systems, such as radar, loops, Bluetooth detectors, etc. This data can be input directly into the UTMC CDB and thresholds and rules set to allow the system to make best use of it in strategy selection.

Variable Message Signs

In conveying information about route choice to road users the use of variable message signs provides a direct interface that allows informed decisions to be made regarding strategic decision points on the network. These can take a number of forms, including LED panels that allow considerable flexibility in the messages they convey, however, plate signs with variable elements that rotate to display destination / direction information can be more effective for redirecting traffic. It is likely that in the case of the Lowestoft network, both types may be required to provide comprehensive solution.

Integration

Critical to the overall solution will be the integration of all the technology systems to provide fast, efficient and appropriate responses to the prevailing conditions. This will likely require additional communications solutions to be implemented to provide connectivity from end devices to the central control system. The UTMC CDB may require additional adapters and configuration in order to provide the functionality and correct response to data inputs.

Conclusions and Recommendations

Conclusions

The Lowestoft network currently suffers from congestion due to the level of traffic it experiences and the disruption caused by the pinch points. Given the projected future growth in journeys, it will benefit considerably from the introduction of the proposed third crossing, however, to maximise the gains network management strategies will be required to balance demand by road users when disruption is caused by the operation of the bridges and level crossing. These strategies will need to be informed by traffic modelling and will evolve as the bridge implementation completes and regeneration begins to occur. In implementing the strategies, the use of ITS will be key and will build upon the tools the town and County already have at their disposal to form an integrated and automated network management system.

In terms of benefits, whilst much of the focus is on making best use of the network, i.e. delay minimisation and throughput, there will also be softer benefits such as an improved driving environment leading to a reduction in frustration. This has a number of potential effects, namely an improvement in safety for all users, including cyclists and pedestrians, as well as better compliance with speed limits and other signed restrictions.

Recommendations

In moving forward the following recommendations are made:

- Origin-destination modelling is undertaken for the whole of Lowestoft to identify the main traffic movements and the key decision points at which rerouting of traffic could occur.
- A comprehensive ITS inventory is undertaken to provide the intelligence of what transport technology tools exist within Lowestoft and are available from Suffolk County Council to determine how they can best be used and what additional ITS would be required to implement the strategies.
- Stakeholders will continue to have an important role as the scheme is developed and should continue to be engaged, such that they can buy into the concept of and participate in dynamic network management. Representatives from the key statutory stakeholders (the DfT, Network Rail, Highways England and Association of British Ports (ABP)) and project partners (i.e. Waveney District Council, Suffolk and Waveney Chamber of Commerce and the New Anglia LEP), and Peter Aldous, the Member of Parliament for Waveney will be invited by the promoter (Suffolk County Council) to form a stakeholder group for the scheme, based on the existing Steering Group.

Appendix D –ITS Innovations Report

REPORT N^{O} XXX-XX

LAKE LOTHING THIRD CROSSING

ITS INNOVATIONS RESEARCH REPORT

CONFIDENTIAL

JULY 2017

LAKE LOTHING THIRD CROSSING

ITS INNOVATIONS RESEARCH REPORT

Suffolk County Council

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TABLE OF CONTENTS

TABLES

FIGURES

1 INTRODUCTION

1.1 DESCRIPTION OF SCHEME

Lake Lothing in Lowestoft is currently traversed by two bridges, separated by a distance of 3km – the eastern A47 Bascule Bridge (bordering the town centre), and the western Mutford Bridge (just south of a level rail crossing). A third bridge to cross Lake Lothing has been agreed upon, its location described as a 'central' option between the two existing bridges. This is shown in Figure 1-1 below.

The purpose of the Lake Lothing Third Crossing scheme is to improve safety, stimulate regeneration, sustain economic growth and enhance Lowestoft as a place to live and work in, and as a place to visit[7]

Figure 2-1: Proposed design of Lake Lothing Third Crossing

1.2 SCHEME OBJECTIVES

The purpose of the Lake Lothing Third Crossing project is to stimulate regeneration, sustain economic growth and enhance Lowestoft as a place to live and work in, and as a place to visit. The stated objectives of the project are:

- Open up opportunities for regeneration and development in Lowestoft
- Provide the capacity needed to accommodate planned growth
- Reduce community severance between north and south Lowestoft
- Reduce congestion and delay on the existing bridges over Lake Lothing
- Reduce congestion and improve accessibility both in the north town centre and south Kirkley shopping and business area
- Increase the attractiveness of the key tourism area around the A47 Bascule Bridge Station Square and Royal Plain areas. Encourage more people to walk and cycle, and reduce conflict between cycles, pedestrians and other traffic
- Improve bus journey times and reliability
- Reduce accidents
- Extend the operational life of the A47 Bascule Bridge

[7] Lake Lothing Outline Business Case, 2.7

1.3 DOCUMENT PURPOSE

The purpose of this document is to research and demonstrate innovative intelligent transportation systems (ITS) that could be applied to improve the current or future operation of the Lake Lothing Third Crossing scheme.

This document also provides a high level analysis on the ITS innovations identified to indicate which innovations are best suited to the scheme.

1.4 DOCUMENT STRUCTURE

The structure of this document is summarised in **Error! Reference source not found.**.

Table 5-1: Document structure

CHAPTER	TITLE	DESCRIPTION
1	Introduction	Description of scheme, document purpose and document structure
2	Existing and proposed ITS	Existing ITS on the scheme, proposed ITS for the scheme
3	ITS Innovations Research	ITS Innovations for operation, safety, maintenance, environment and non-motorised users (NMUs)
4	Conclusions	Conclusions of report

2 EXISTING AND PROPOSED INFRASTRUCTURE

2.1 EXISTING INFRASTRUCTURE ON THE LAKE LOTHING SCHEME

Currently Suffolk County Council is invested in Urban Traffic Management and Control (UTMC) adaptable technology and strategies. This initiative better integrates ITS applications and uses modern communications technologies.

The table below lists all the technologies currently used as part of the Lake Lothing scheme. For further details see Intelligent Transportation Systems Strategy for Suffolk County.[8]

Table 6:1 – Existing infrastructure on the Scheme area

INFRASTRUCTURE	DESCRIPTION	LOCATION	BENEFITS
UTC/SCOOT	An adaptive system that responds automatically to fluctuations in traffic flow through the use of on-street detectors embedded in the road. It detects vehicles at the start of each approach to every controlled intersection and models the progression of the traffic from the detector through the stop-line, taking due account of the state of the signals and any consequent queues.	North and South Links through the A47 Bascule Bridge	Optimises the signals to minimise network delays. On the Scheme Traffic data input from local detectors on the approach to the bridge can be utilised to allocate an appropriate or increased green time needed to clear the traffic efficiently.
CCTV	Cameras are used to provide real time information for traffic management, congestion reports and incident management. Images can be made available on the internet to the public and the media and are monitored by control rooms and operator staff.	Various locations in Lowestoft	Provides congestion and incident detection and management. CCTV can be used with more modern technology such as local council apps that let you view the condition of the road live and make effective decisions to avoid the area adding to the congestion.
Strategic VMS	Provides traffic information for a variety of situations including emergencies, construction, and road closures. The VMS can	At the junctions for alternative routes between North and South Lowestoft	This technology can be placed on the approach to Lowestoft to warn drivers of the presence of traffic and

[8] Intelligent Transportation Systems Strategy for Suffolk County, March 2008

INFRASTRUCTURE	DESCRIPTION	LOCATION	BENEFITS
	also be used in cities to communicate events and activities, parking availability, and travel warnings in several languages. The modern displays are built with long life LED technology that is easily visible in all types of weather and through the use of a solar sensor, the brightness can be adjusted for both clear day and night viewing. The display system can operate as a stand-alone system or be integrated with other traffic control and management systems providing data for traffic detection, monitoring and surveillance.		advise alternative routes. Within the city centre the technology will be used to advice on upcoming busy periods including but not limited to social events. The message will help drivers prepare their journey better if they are made aware of construction maintenance or disruptions due to frequent openings of the bridges.
Tidal Flow System on the A47 Bascule Bridge and approaches	TFS is used in areas where the designers anticipated an increase in traffic from a particular direction at certain times of the day. TFS as a system relies heavily on the interaction of several other technology including but not limited to VMS and variable speed signs. Lane control signals are displayed above the road to indicate the availability of the various lanes	A47 Bascule Bridge	To maximise available lane capacity for changing traffic patterns. This technology is currently present at Lowestoft but has not been utilised since inception.
Air Quality and Monitoring Control	Modern Urban Ambient air quality system frequently used in road side technology can be configured to measure nitrogen dioxide, ozone and particulate matter, which are the most commonly measured pollutants in the urban environment.	Sensitive areas	To collect data on air quality and enable displaying warning messages on VMS and implement mitigating traffic management strategies. The government and local authorities are becoming aware of the effect pollution is

INFRASTRUCTURE	DESCRIPTION	LOCATION	BENEFITS
	As with other road technology when the data collected can be accessed remotely and where the pollution levels are creeping in to illegal levels as defined by EU rules other UTC technology can be used to divert traffic through less polluted areas.		having on its citizens recently shown by the ban on all diesel cars by 2040. This technology will help the local council decide to implement congestion tackling practices similar to the Congestion charge in London. As behaviour changes the local council may deem it necessary to discourage people from using cars in Lowestoft.
Traffic Data Collection	There are several ways Traffic data collection can take place including face to face interviews, and the development of automatic data collection systems.	Congested points in town	To monitor and improve the effectiveness of ITS and other strategies

2.2 PROPOSED INFRASTRUCTURE ON THE LAKE LOTHING SCHEME

The local authority has proposed the introduction of the following technology in order to help realise the full potential of the Scheme and deliver the congestion relief it promises.

The table below lists all the technologies currently proposed as part of the Lake Lothing scheme. For further details see Intelligent Transportation Systems Strategy for Suffolk County.[9]

Table 2:2 – Proposed infrastructure on the Scheme

INFRASTRUCTURE	DESCRIPTION	BENEFITS
Car park VMS	Car park VMS uses variable message signs to inform the drivers of parking availability	To direct vehicles to the available car parks so as to reduce traffic in town and to promote usage of less popular car parks
Advanced Direction signs	These are signs displayed away from the premises to which they relate and which are intended to direct traffic to those premises, which will be predominantly tourism or industrial enterprises.	To ensure more effective and timely journeys through early warnings and increased information to drivers
Bus Priority Measures	Bus priority measures include: segregation; traffic management; traffic signal control; and bus stop improvements.	To reduce journey times and improve the reliability of bus services. Effective bus priority measures can achieve a mode shift from cars, and

[9] Intelligent Transportation Systems Strategy for Suffolk County, March 2008

INFRASTRUCTURE	DESCRIPTION	BENEFITS
		in so doing, reduce delays for both bus users and car-drivers
Traffic Data Sharing	Traffic data is shared to a number of different organisations for analysis and to help inform the public so that road users can make informed decisions related to their journeys.	To develop a clear picture of traffic patterns and in turn create a solution for existing and future driving habits, as well as providing near real-time information to drivers to avoid worsening traffic problems

All the above proposed solutions are significant to the development of a congestion relief strategy for Lowestoft, however it is important that the local authority not limit its solution and that consideration is given to the recommended strategies and tools mentioned in the next section.

3 ITS INNOVATIONS RESEARCH

The table below separates the researched innovations into various subsections depending on what scheme-related issue the innovation is most likely to improve. These subsections are operation, safety, maintenance, environment and non-motorised users (NMUs).

It also provides high-level analysis to indicate whether further consideration should be given to their application for the Scheme.

Table 3-1: ITS innovations research and analysis

REF	TITLE OF INNOVATION	DESCRIPTION OF INNOVATION	POTENTIAL BENEFIT TO THE SCHEME
1.	Intelligent bus service	A new ‘Smartbus’ is trialling in London which includes real time tracking software and integrates with the Citymapper app as well as transport network data made open by Transport for London. It is also capable of counting passenger numbers and features a smart display to show travellers where they currently are along the bus route and which stop is coming next. The company has built a tool which uses historic data to identify new and improved bus routes. In the future it may look to monitor real time traffic information to change the routes between bus stops if there is heavy congestion in a particular area[10]	Improving the bus service in Lowestoft is part of the ITS Strategy and a council objective. It is therefore a viable ITS innovation that could be pursed following the completion of the scheme and could further improve congestion conditions. **Benefit summary:** • Improved congestion
2.	Rail signalling upgrades	Siemens commissioned its new Zone Controller system for the first time in the UK. The system is now the controlling signalling system at London Bridge, with additional deployments planned as part of later stages of the programme. Siemens Zone Controller units (ZCUs) benefits, include: Higher quality system at a lower installed cost, a reduction in labour required for assembly and installation,	This innovation could potentially benefit the Lowestoft area, and therefore the Scheme. Further investigation into a number of factors including whether the signalling upgrade will reduce the amount of time the Oulton Broad North level crossing is down for; enable the signalling system to communicate automatically with SCC/UTMC; and/or give more advanced

[10] http://www.its-ukreview.org/intelligent-bus-service-tested-in-london/ (accessed 18/07/2017)

REF	TITLE OF INNOVATION	DESCRIPTION OF INNOVATION	POTENTIAL BENEFIT TO THE SCHEME
		and easy lifting and handling with universal handle brackets (piping is supported by handles)[11]	notice of level crossing down times to SCC/UTMC system, is required **Benefit summary:** • Improved congestion
3.	Car-to-X communication	Car-to-X communication is capable of avoiding accidents and optimizing traffic flows. "Future traffic control centers could also inform other road users of the accident so that navigation systems can immediately calculate an alternative route and keep traffic moving", says Schonlau, Head of the Active Safety and Lighting Functions Department at IAV. This can optimise the way in which vehicle-2-X communication, traffic management systems, centralized map services and satellite navigation interact and will make it possible to alter an entire city's traffic flows in a matter of seconds[12]	The application of this innovation would provide significant benefit to the Scheme as it would help to relieve congestion by directing road users towards accessible route options whilst the bridge(s) were opening and closing. This innovation is in keeping with the proposed long-term ITS solutions for the scheme, and consequently will be given further consideration. **Benefit summary:** • Improved congestion
4.	SIL accreditation	The Sandfield Bridge over the Gloucester & Sharpness canal is the first in Europe to meet Safety Integrity Level, SIL2 accreditation requirements for its ITS system that converted the bridge to remote control operation. The ITS system design incorporated traffic signals, barriers, laser scanners, CCTV, intercom, VoIP, help points and the development of an app to automatically trigger the opening of the bridge. Barriers and traffic signals on either end of the bridge control vehicular and pedestrian traffic while light signals on the bridge approaches control approaching waterway traffic[13]	Further investigation should be undertaken to decide whether a SIL accreditation would be applicable and beneficial for the Lake Lothing scheme. Additionally, the scheme could benefit from using the Sandfield Bridge as a good example of how ITS was applied to a bridge scheme. **Benefit summary:** • Improved safety

[11] http://www.its-ukreview.org/siemens-delivers-rail-signalling-upgrades/ (accessed 18/07/2017)

[12] https://www.iav.com/en/automotion-magazines/automotion-03-2014-en/building-bridges-intelligent-transport-systems (accessed 18/07/2017)

[13] http://www.its-ukreview.org/member-achieves-sil2-rating-on-swing-bridge-scheme/ (accessed 18/07/2017)

REF	TITLE OF INNOVATION	DESCRIPTION OF INNOVATION	POTENTIAL BENEFIT TO THE SCHEME
5.	Drones for bridge inspection	Using drones to review the condition of a bridge has been shown to reduce potential health and safety risks as well as dramatically cutting costs and inconvenience to members of the public. Drones are fitted with recording equipment to allow the workforce on the ground to review the condition of the bridge once filming is completed. To ensure the drone is operated safely, a second camera is used to film it in action with an assistant reviewing the safety parameters around the drone in real time. The drones are also fitted with a GPS system to prevent them straying into 'no fly zones', such as airport space, without permission[14]	Following the completion of the Scheme, drones could be used for maintenance which would likely cut costs and reduce health and safety risks to inspectors who would have to use access equipment when working at height. **Benefit summary:** • Improved safety • Proven cost benefits
6.	RedBite Asset management Tool	The technology makes use of Radio Frequency Identification (RFID) technology, Quick Response Codes and GPS tags. Once a product has been tagged the data is securely transmitted to a webpage where all information relating to that piece of equipment or asset is recorded for future use. Alerts can also be sent out when faults are reported on any particular piece of equipment[15]	It is possible that the Scheme may be too small to benefit significantly from this innovation. However, further investigation into its use could be considered. **Benefit summary:** • Likely cost benefits
7.	Self-maintaining ITS	The development of intelligent transport systems which can maintain themselves is among the aims of a new strategic partnership set up by the Transport Systems Catapult and research and technology organisation TWI. The Catapult will utilise the 'Internet of Things' alongside monitoring technology provided by TWI in order to develop self-sustaining transport infrastructure and technology[16]	Whilst in the very early stages of trialling, self-maintaining ITS is a possible innovation for all schemes, and consequently could be given further consideration in the case of the Scheme. **Benefit summary:** • Likely cost benefits

[14] http://www.its-ukreview.org/west-sussex-introduces-drones-for-bridge-inspection/ (accessed 18/07/2017)

[15] http://www.its-ukreview.org/technology-trial-supports-asset-management/ (accessed 18/07/2017)

[16] http://www.its-ukreview.org/new-partnership-to-explore-self-maintaining-its/ (accessed 18/07/2017)

REF	TITLE OF INNOVATION	DESCRIPTION OF INNOVATION	POTENTIAL BENEFIT TO THE SCHEME
8.	VMS signs used to urge drivers to switch off engines	Mobile variable message signs (VMS) have been used on London's Tower Bridge to lower emissions and boost air quality by encouraging drivers to switch their engines off when there will be a long wait at the crossing whilst the bridge is opened. An air pollution monitoring station has been installed to measure the impact of the project[17]	The benefit of this innovation is dependent on how long drivers will have to wait before continuing to cross the bridge. The scheme aims to reduce this wait by providing the third crossing, and using VMS signs to direct road users towards the open bridge whilst another closes. However, an objective of Suffolk County Council's second Local Transport Plan (2006-11)[18] is to improve air quality, so it is possible the council may wish to consider implementing this following an assessment on the usefulness of this innovation after scheme completion. **Benefit summary:** • Improved air quality
9.	Cycle safety junction	The 'hold the left' junction at Cambridge Heath on Whitechapel Road is the first of many similar interchanges due to be rolled out across some of the capitals busiest roads. Traffic signals direct cyclists and turning motor vehicles to move in separate phases. Left-turning traffic is held at a red signal to allow cyclists to travel straight-ahead without risk of being hit. The cyclists are then held when vehicles are turning left. Future junction improvements will also implement a new 'two-stage right turn' feature to let cyclists make right turns in safety, while early-release traffic lights will give cyclists a short head start over other vehicles[19]	The current design plan for the Scheme includes roundabouts rather than junctions. As such, this innovation may not be fully applicable, however if the roundabout design includes traffic lights it may be advantageous to adapt this innovation and provide a similar cycle safety junction suitable for the current Scheme design. **Benefit summary:** • Improved safety

[17] http://www.its-ukreview.org/drivers-urged-to-switch-off-engines-at-tower-bridge/ (accessed 18/07/2017)

[18] Suffolk County Council, Local Transport Plan, 2006-11

[19] http://www.its-ukreview.org/london-launches-new-cycle-safety-junction/ (accessed 18/07/2017)

REF	TITLE OF INNOVATION	DESCRIPTION OF INNOVATION	POTENTIAL BENEFIT TO THE SCHEME
10.	FLIR systems allow smooth intersection traffic flow	ThermiCam thermal sensors from FLIR Systems have been deployed at a big signalized intersection leading from Utrecht to Amersfoort, the Netherlands. Based on heat energy coming from bicyclists and motorists, the cameras from FLIR can detect both types of road users and make a distinction between the two. The cameras pass down their detection information to the traffic lights and this way, a separate regulation for bicyclists and motorists is made possible, all the while both road users are sharing the same road space. The result of this installation is a smoother and more logical traffic flow at the intersection[20]	The current Scheme design includes a separate cycle path for the North roundabout, however this path is not parallel to the road and as a result is quite lengthy. Consequently, it is likely that cyclists will still make use of the main road. For this reason, it is recommended that this innovation be given further consideration for the scheme. **Benefit summary:** • Improved safety

[20] http://www.its-ukreview.org/flir-systems-allow-smooth-intersection-traffic-flow-in-utrecht/ (accessed 18/07/2017)

4 CONCLUSIONS

The below table uses a red, amber, green (RAG) status to conclude which of the ITS innovations from table 2.1 are recommended for further consideration, and to what extent they are recommended:

Green = Predicted to be the most beneficial and are highly recommended for further investigation.

Amber = Predicted to be beneficial and are recommended for further investigation.

Red = Not predicted to be beneficial and are not recommended for further investigation.

Table 4-1: ITS innovation conclusions

REF	INNOVATION TITLE	RAG STATUS	ADDITIONAL COMMENTS
1	Intelligent bus service		Recommended for further consideration following the completion of the Scheme
2	Rail signalling upgrades		Unknown whether this innovation would benefit this scheme. Further investigation is recommended but not essential
3	Car-to-X communication		Recommended for further consideration
4	SIL accreditation		Unknown whether this this accreditation is suitable and applicable. Further investigation is recommended but not essential
5	Drones for bridge inspection		Recommended for further consideration following the scheme's completion
6	RedBite Asset management Tool		Unknown whether this innovation would benefit this scheme. Further investigation is recommended but not essential
7	Self-maintaining ITS		Recommended for further consideration
8	VMS signs used to urge drivers to switch off engines		Unknown whether this innovation would significantly benefit this scheme. Further investigation is recommended but not essential
9	Cycle safety junction		Recommended for further consideration
10	FLIR systems allow smooth intersection traffic flow		Recommended for further consideration

SUMMARY

Six of the ten innovations have been categorised as green, and consequently are highly recommended for further investigation to determine whether they should be implemented as part of the Lake Lothing Third Crossing scheme.

The remaining four of the ten innovations have been categorised as amber, and consequently are also recommended for further investigation, however the benefits are currently unknown, or are considered less of a priority than the identified 'green' innovations.

None of the innovations have been categorised as red, demonstrating that none of the innovations were discounted from recommended further investigation, or believed to provide no benefit to the scheme.

GLOSSARY OF TERMS AND ABBREVIATIONS

REF	DESCRIPTION
CCTV	Closed Circuit Television
GPS	Global Positioning System
ITS	Intelligent Transport Systems
Km	Kilometres
LL3X	Lake Lothing Third Crossing
NMU	Non-Motorised User
RAG	Red, amber, green
RFID	Radio Frequency Identification
SIL	Safety Integrity Level
UTMC	Urban Traffic Management Control
VMS	Variable Message Sign
ZCU	Zone Controller Unit
CCTV	Closed Circuit Television
GPS	Global Positioning System