TRANSPORT

LCC03(ii)

Scheme Name:
North Hykeham Relief Road

Promoting Authority:
Lincolnshire County Council

Orders:
The Lincolnshire County Council (A1461 North Hykeham Relief Road) Compulsory Purchase Order 2024; and **The Lincolnshire County Council (A1461 North Hykeham Relief Road) (Classified Road) (Side Roads) Order 2024.**

Document Reference:
LCC 03(ii)

Subject:
Junction Modelling

Author:
Richard Bradley BEng MSc CEng MICE

Date:
June 2025

NORTH HYKEHAM RELIEF ROAD
JUNCTION MODELLING PROOF OF EVIDENCE

CONTENTS

Record of standards

Standard	Description
Junctions 9 ARCADY **[CD6.20]**	Software developed by TRL used to assess capacity and performance of priority-controlled roundabouts
LinSig User Guide **[CD6.19]**	LinSig guidance providing best practices for model development
LinSig v3.3	Software developed by JCT Consultancy for signal-controlled junction assessments
National Planning Policy Framework 2023 **[CD3.6]**	Provides national policy guidance

Abbreviations

Abbreviation	Definition
AM	Morning peak hour 08:00–09:00
ARCADY	Assessment of Roundabout Capacity And DelaY
DfT	Department for Transport
DoS	Degree of Saturation
ICD	Inscribed Circled Diameter
JCT	Joint Commission for Traffic
LCC	Lincolnshire County Council
LEB	Lincoln Eastern Bypass
LinSig	Linked Signals
MMQ	Mean Maximum Queue
NHRR	North Hykeham Relief Road
NPPF	National Planning Policy Framework
PCU	Passenger Car Unit
PM	Evening peak hour 17:00–18:00
RFC	Ratio of Flow to Capacity
WSP	Engineering and consultancy firm responsible for the strategic transport model and traffic flow information used for this traffic modelling

Terms and Definitions

Term	Definition
Degree of saturation	The LinSig ratio of traffic flow to capacity on a signal-controlled lane used as a standard measure operational performance
Flare length	The additional lane length provided at a junction entry to increase vehicle entry and storage capacity
Inscribed circled diameter	The diameter of the circle inscribed within the roundabout, used in geometric design
Mean maximum queues	The maximum queue within a typical cycle averaged over all the cycles within the modelled time period
Passenger car unit	A standardised unit of traffic flow; used to convert strategic transport model outputs for different vehicle types into equivalent passenger car units, equivalent to 5.75 metres length
Priority junction	A road junction where vehicles on one road must give way to vehicles on another
Priority-roundabout junction	A roundabout junction with priority junctions at the point of entry
Ratio of flow to capacity	The ARCADY ratio of traffic flow to capacity on priority-controlled roundabouts used as a standard measure operational performance
Roundabout junction	A road junction at which traffic moves in one direction round a central island to reach one of the roads converging on it
Signalised junction	A road junction managed using traffic signals to control vehicular movements
Signalised-roundabout junction	A roundabout junction with signalised junctions at the point of entry
Strategic transport model	A regional-level model used by WSP to forecast traffic demand and patterns

1. INTRODUCTION

1.1 Qualifications

1.1.1 My name is Richard Bradley, born in Boston (Lincolnshire) and spent my formative years in the Gainsborough and Retford area, where my family still live. I am a Director of Transport Planning at Ramboll and have 36 years of experience in transport planning and traffic engineering, with a strong focus on modelling and appraisal of transport schemes. I am a Chartered Civil Engineer, with a Master of Science Degree in Transport Planning and Traffic Engineering from the University of Salford and a Bachelor of Engineering Degree (Honours) in Civil Engineering from Trent Polytechnic.

1.2 Relevant Experience

1.2.1 I have extensive experience of all aspects of business case development for transport schemes, recognised in the North and Midlands as a modelling and appraisal expert. This includes a strong track record of delivering successful road improvements as a Technical Director, with examples now operational listed below.

1.2.2 Lincoln Eastern Bypass (LEB) Major Scheme Business Case, responsible for direct liaison with the Department for Transport (DfT) to scope and deliver an acceptable modelling and appraisal programme.

1.2.3 Doncaster White Rose Way Major Scheme Business Case, responsible for direct liaison with DfT to scope and deliver an acceptable modelling and appraisal programme.

1.2.4 Rochdale town centre masterplan, responsible for optioneering outline designs in the town centre and A58 ring-road prioritised to active modes, bus and then car, including proposed bus station and on-street Metrolink running, with various improvements taken from operational tests and appraisal into design, construction and monitoring and evaluation.

1.2.5 M3 Managed Motorway All Lanes Running Major Scheme Business Case, responsible for direct liaison with National Highways for all aspects of the stage 2 and stage 3 gateway reviews for this motorway scheme.

1.2.6 From 2021 to early 2025 I was Head of Strategy at Midlands Connect, the region's sub-national transport body. I led the data and forecasting team to deliver all aspects of the Midlands Strategic Transport Plan evidence base, including all data and modelling tools, the Midlands strategic transport model and appraisal suite, and many data and bespoke tools to support this forecasting system. I supported several local transport authorities in adapting regional forecasts for local schemes, including significant work with Lincolnshire County Council (LCC).

1.3 Traffic Modelling Overview

1.3.1 Traffic modelling has been used to test the operational performance of road improvements associated with the North Hykeham Relief Road (NHRR). This involved applying the strategic transport model output traffic flows provided by WSP to road improvements provided by the Ramboll highway design team. Standard measures of operational performance were used to check the road improvements operate at an acceptable level in the future. Future years of 2028 and 2043 were checked for the hours of 08:00-09:00 (AM) and 17:00–18:00 (PM).

1.3.2 The road improvements listed below were checked:

- priority-roundabout junction at A46/ A1434 Newark Road/ NHRR;
- signalised-roundabout junction at A46/ A1434 Newark Road/ NHRR;
- priority-roundabout junction at South Hykeham/ NHRR;
- priority-roundabout junction at Brant Road/ NHRR;
- priority-roundabout junction at Grantham Road/ NHRR; and
- priority-roundabout junction at A15 Sleaford Road/ LEB/ NHRR roundabout.

1.3.3 Traffic modelling of all priority-roundabout junctions was technically assured by WSP on behalf of the local transport authority, LCC. The roundabout at A46/ A1434 Newark Road/ NHRR did not provide sufficient capacity so an alternative signalised-roundabout junction was developed.

1.3.4 Technical assurance of the signalised-roundabout junction at A46/ A1434 Newark Road/ NHRR was undertaken by National Highways, as the A46 forms part of the Strategic Road Network. All traffic modelling was assured correct with proposed road improvements operating at acceptable levels.

2. TRAFFIC MODELLING

2.1 Road Improvements

2.1.1 Traffic modelling has been used to test the operational performance of road improvements associated with the NHRR. The road improvements listed below were checked:

- priority-roundabout junction at A46/ A1434 Newark Road/ NHRR;
- signalised-roundabout junction at A46/ A1434 Newark Road/ NHRR;

- priority-roundabout junction at South Hykeham/ NHRR;
- priority-roundabout junction at Brant Road/ NHRR;
- priority-roundabout junction at Grantham Road/ NHRR; and
- priority-roundabout junction at A15 Sleaford Road/ LEB/ NHRR roundabout.

2.2 Planning and Legislative Framework

2.2.1 Operational checks were undertaken within the National Planning Policy Framework 2023 context **[CD3.6]**, which applied at the time of the first planning consent. NPPF 2023 requires that developments ensure safe and suitable access for all users and mitigate significant impacts on the transport network. That has not changed with the production of the December 2024 version of the NPPF **[CD3.5]**.

2.3 Traffic Modelling Software and Guidance

2.3.1 Traffic modelling software and guidance used industry standard Junctions 9 ARCADY for priority-roundabout junctions and industry standard LinSig v3.3 for the signalised-roundabout junction.

2.4 Operational Performance Thresholds

2.4.1 For priority-roundabout junctions traffic modelling outputs for each arm of a junction primarily focus on:

- link capacity as the Ratio of Flow to Capacity (RFC); and
- queue lengths in Passenger Car Units (PCUs), with 1 PCU equivalent to 5.75 metres in length.

2.4.2 PCU is a standard measure for traffic modelling to express traffic flows in a standard unit. Vehicle type impacts traffic operations differently, for example one heavy goods vehicle is equivalent to more than one car, so flows are converted to PCUs for consistency when carrying out the operational performance checks. This approach is consistent with industry-standard modelling practices, as outlined in the Design Manual for Roads and Bridges (DMRB) **[CD6.1]** and supported by traffic modelling tools such as LinSig and ARCADY.

2.4.3 An RFC of 1.00 indicates that the arm in question is operating at its theoretical capacity and this figure could cause undesirable queuing on an approach lane. An RFC of 0.85 or less indicates that the arm is operating within capacity and any queuing is considered acceptable. The desirable maximum RFC defined by LCC is 0.75.

2.4.4 For signalised-roundabout junctions traffic modelling outputs for each lane of the junction primarily focus on:

- link capacity as the Degree of Saturation (DoS); and
- queue lengths as the Mean Maximum Queue (MMQ).

2.4.5 DoS is presented as a percentage and MMQ is measured in PCUs. MMQ represents the maximum queue within a typical cycle averaged over all the cycles within the modelled time period.

2.4.6 A DoS of 90% is the maximum acceptable for a lane to avoid performance issues. Queuing within the circulatory carriageway needs to be checked to ensure it fits within the junction's design and does not block upstream traffic flows.

2.5 Traffic Modelling Specification

2.5.1 The following traffic modelling specification was used to check all road improvements.

1. Assessment years:
    - opening year - 2028 with NHRR; and
    - design year - 2043 with NHRR.
2. Time periods assessed:
    - 08:00–09:00 (AM); and
    - 17:00–18:00 (PM).
3. Strategic transport model Core future scenario output traffic flows from WSP, converted to junction turning movements in PCUs.
4. Road improvement geometry provided by the Ramboll highway design team, including entry widths, approach road half-widths, flare length, entry radius, lane lengths and inscribed circle diameter detailed in design drawings.
5. Signal specifications agreed with National Highways:
    - coordinated signal timings between approaches and circulatory carriageway; and
    - hourly capacity saturation flows set at 1,800 PCUs for approaches and 1,900 PCUs for circulatory carriageway.
6. Operational performance metrics:
    - queue lengths for LinSig and ARCADY;
    - delay per vehicle for LinSig and ARCADY;
    - DoS for LinSig; and
    - RFC for ARCADY.

2.6 Operational Performance Check Process

2.6.1 The operational performance of road improvements was checked using outputs from the traffic modelling by demonstrating that NHRR junctions can accommodate forecast traffic growth within performance thresholds. The performance of existing and proposed layouts was checked for 2028 and 2043 Core scenarios to ensure compliance with LCC and National Highways standards.

2.6.2 Proposed junction layouts were assessed during several design iterations. This included coordination with:

1. Ramboll highway design team – to ensure consistency between model inputs and detail in design drawings;
2. WSP – who undertook the strategic transport modelling and technical assurance of the traffic modelling for all priority-roundabout junctions on behalf of the local transport authority LCC; and
3. National Highways who undertook the technical assurance of the traffic modelling for the signalised-roundabout junction at A46/ A1434 Newark Road/ NHRR, as the A46 forms part of the Strategic Road Network.

2.7 Supporting Documentation

2.7.1 All traffic modelling inputs and outputs were assured correct and submitted with supporting technical notes detailing:

- input assumptions;
- output summaries; and
- revisions made in response to comments from the reviewing authorities.

2.7.2 These documents formed part of the technical evidence for the planning submission.

3. OPERATIONAL PERFORMANCE CHECKS

3.1.1 All the proposed priority-roundabout junctions associated with the NHRR road improvements operate within the accepted RFC threshold of 0.75 in both 2028 and 2043 Core scenarios, except for the A46/ A1434 Newark Road/ NHRR roundabout on the Strategic Road Network.

3.1.2 The A46/ A1434 Newark Road/ NHRR roundabout exceeded capacity in both the 2028 opening year and 2043 design year scenarios. As such mitigation measures were explored and the introduction of traffic signals was identified as the most effective solution to improve capacity. This included a five-arm signalised-roundabout with signals on all the approaches apart from the Middle Lane approach, which remains priority controlled.

3.1.3 The initial LinSig model submitted with the planning application assumed a single lane with a flare at the Middle Lane entry. However, this initial layout did not provide access to the service area for vehicles turning right after the Middle Lane exit. Following a request from Rontec Limited (service area landowners), this right turn access was added.

3.1.4 The LinSig model was revised to include a one lane entry on Middle Lane and two exit lanes, so enabling right-turn access into the service area. The revised LinSig model was used to check the operational implications of this change using updated traffic flows provided by WSP.

3.1.5 The roundabout has been demonstrated to operate at an acceptable level with signals in place. The only non-signalised access point on Middle Lane has been looked at specifically to demonstrate how that operates with the junction improvements.

3.1.6 The LinSig model underwent a review by National Highways. Feedback was provided regarding assumptions and performance criteria, which led to National Highways agreed updates to signal specifications and signal timings. The revised model with the updated design was subsequently accepted by National Highways as a valid representation of the proposed junction's operation.

3.1.7 National Highways technical assurance concluded that:

1. DoS on each lane remained within the accepted threshold of 90% for the 2043 design year, which represents the peak forecast traffic flows; and
2. queues remained within acceptable levels without creating exit blocking on any arm of the signalised-roundabout.

4. SUMMARY AND CONCLUSION

4.1.1 The operational performance checks undertaken for road improvements associated with NHRR demonstrate that the proposed roundabouts would be able to accommodate Core scenario AM and PM peak period traffic flows in both the 2028 opening year and 2043 design year. All proposed priority-roundabout junctions operate within acceptable performance thresholds of RFCs less than 0.75. The proposed signalised-roundabout junction at A46/ A1434 Newark Road/ NHRR operates within performance thresholds, with all lanes being within the acceptable DoS threshold of 90%, with no evidence of exit blocking or excessive queuing.

4.1.2 Engagement with the highway authorities, including National Highways and WSP on behalf of LCC, has ensured all traffic modelling, assumptions, outputs and checks are acceptable and approved.

4.1.3 The NHRR is incorporated in the Central Lincolnshire Local Plan **[CD4.1]**, where it is recognised as a key infrastructure scheme needed to assist in providing highway capacity and support the development objectives of the plan.

4.1.4 Based on my extensive experience in transport planning and traffic engineering it is my professional judgement that the proposed NHRR road improvements have successfully completed all necessary stages for traffic modelling in this planning process. As such, there is a compelling and justifiable case to support and confirm the development of the NHRR improvements, aligning with strategic infrastructure needs and planning policies.