Modelling & Appraisal Challenges:

Pain-Point Analysis & Development Priorities

The Grand Challenge

Looking back and critiquing modelling and appraisal during the 2018-19 business year we have experienced broadly two types of modelling and appraisal challenge:

- one associated with an existing or future transport problem, where poor connectivity is restricting the economy and causing 'market failure'; and
- one where historically poor connectivity has been to such an extent that it has limited economic activity between adjacent areas, and restricted the economy in creating and shaping new markets.

For the former challenge we have noted a repeated cycle of failed investment business cases in the North, for example associated with the M60 around the north west of Manchester. But our biggest modelling and appraisal challenge for the North has been the shaping of new markets, which has become a key feature of our transformational analysis.

To tackle both market failures and market shaping it is, of course, important to define a compelling vision and objectives.

Our vision, or Grand Challenge, is to create a thriving North of England, where modern transport connections drive economic growth and support an excellent quality of life.

Key Milestone Objectives

Our Grand Challenge has less easy to define end points. To provide a way of measuring our success we have prepared the key milestone objectives listed below.

- **Managing Transport for the North's Investment Programme**, consisting of literally hundreds of strategic, pan-northern interventions, sequenced through to 2050 across the whole of the North of England.
- **Providing a fair system for evaluating investment**, allowing us to assess both market failures & market shaping, and in varying levels of detail captured in our brand around 'One North'.
- **Creating compelling and robust evidence** that shows how investment can rebalance the North's economy and allows us to explore alternative futures whilst still providing an accepted and robust appraisal process.

Prioritisation

To meet the Grand Challenge, and meet our Key Milestone Objectives, we have developed the Analytical Framework, providing overarching data and tools covering the whole of the North. To develop the Analytical Framework we have adopted a 'balanced portfolio' that:

- **strengthens** traditional approaches, which provides the quickest Return on Investment (RoI);
- **expands** traditional approaches with the introduction of new approaches; and
- **researches** new and contemporary approaches, which has the slowest RoI.

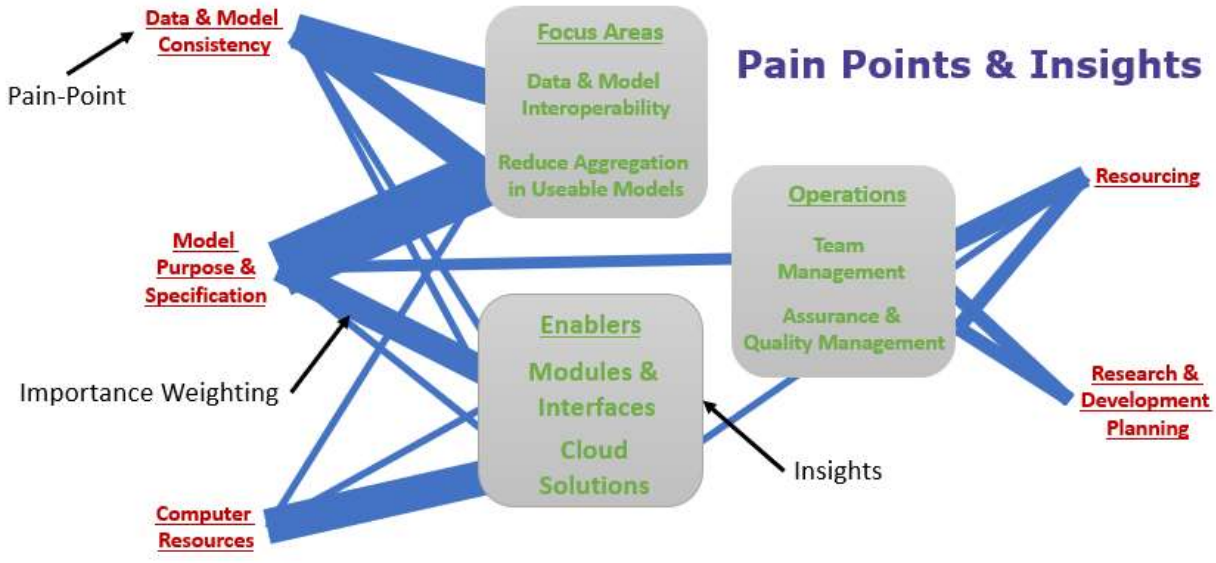
We have spread our development priorities within these three areas with the strongest early focus on strengthening traditional approaches to help deliver early value. This can be best achieved by taking a detailed look at our practitioner's current pain-points.

Tackling pain-points will require improvements within all three improvement areas but provides a stronger focus on strengthening traditional approaches. This will be most appreciated by our practitioners and is the quickest route to more robust, flexible and easy to use modelling and appraisal tools. This document therefore describes high-level pain-points to stimulate discussion and ensure that practitioner voices are more fully represented.

Pain-points are not merely operational issues but also limitations that have restricted the ability of practitioners to deliver against objectives. Due to the wide variety of circumstances facing different transport authorities this is particularly prevalent in developing a fair planning system whilst trying to find efficiencies. Practitioners have worked hard to find the best balance for this dichotomy, but this remains a significant challenge and may require more radical solutions.

TfN have undertaken their own assessment of current pain-points and identified two separate groups: one associated with data and modelling techniques; and one associated with resource and quality management.

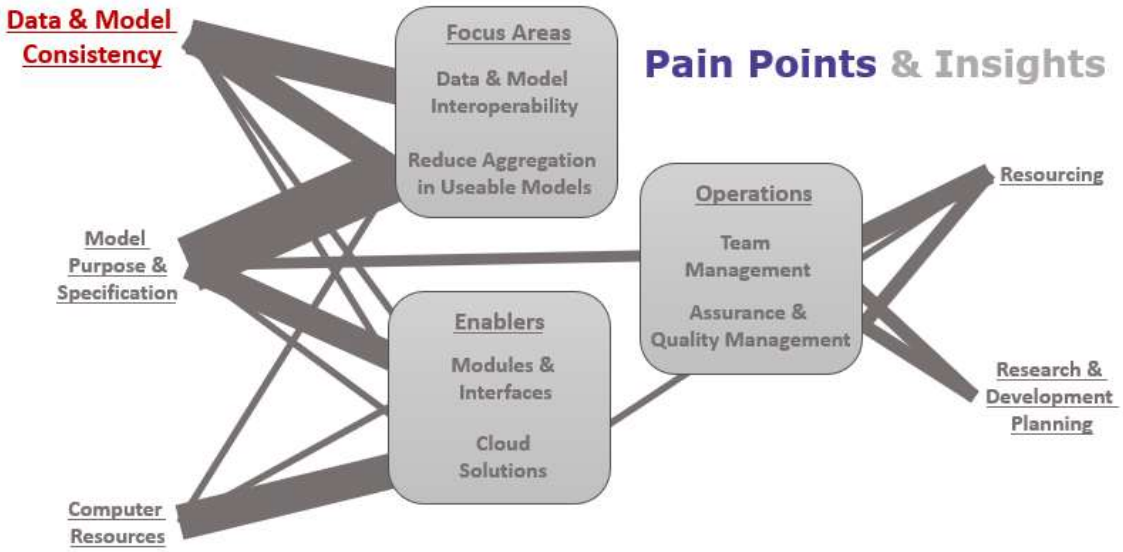
Pain-points associated with data and modelling techniques have been further split into three sub-groups: data and model consistency; model purpose and specification; and computer resources.



Data & Model Consistency Pain-Points

A key aspect of building our models has been making use of existing models developed for different reasons. This has led to several consistency problems as listed below.

- **Disparate zoning systems** – dealing with disparate zoning systems can introduce significant error and waste substantial effort.
- **Base model misalignment** – dealing with misaligned base models can introduce significant error and waste substantial effort.
- **Poor local representation** – aggregate models can substantially dilute the local representation within models and to such an extent that models report low levels of congestion but the user experiences substantially higher levels. Issues associated with aggregation take many forms and is a common thread in our pain-points and development priorities. For example, as we aggregate spatially and temporally we tend dampen the effects of capacity restraint and more adversely affect shorter distance trips that may be a high proportion of trips in urban areas and are most sensitive to agglomeration.
- **Poor data standards** – Dealing with errors in the basic definition of data within models can cause gross-error and can waste substantial effort.
- **Lack of local data** – many data and parameters are normalised from a wide variety of sources and presented as nationally representative. Some data and parameters are of unknown origin, definition or quality. This data can significantly misrepresent local areas.
- **Combining different models** – combining models from different projects to programme level, or from programme level to portfolio level, can introduce significant error and is computationally difficult to define.
- **Combining different appraisals** – combining appraisals from different projects to programme level, or from programme level to portfolio level, can introduce significant error and is computationally difficult to define.



Model Purpose & Specification Pain-Points

The model's intended use compared to currently available model specifications are often incompatible. This has limited how well models can answer questions and test hypothesis, and particularly inhibits exploring policy and future uncertainty. Aggregation in models remains a common denominator in many of our areas of concern.

- **Model runtimes limiting exploration** – excessive transport model runtimes are limiting 'transport planning' exploration. Many models are designed to better represent capacity and build robust economic cases. However, they may not be appropriate for exploration, and their use in that context can result in substantial effort with limited exploration in return.

- **Limited model functionality** – existing transport models can have restricted functionality that can limit exploration.

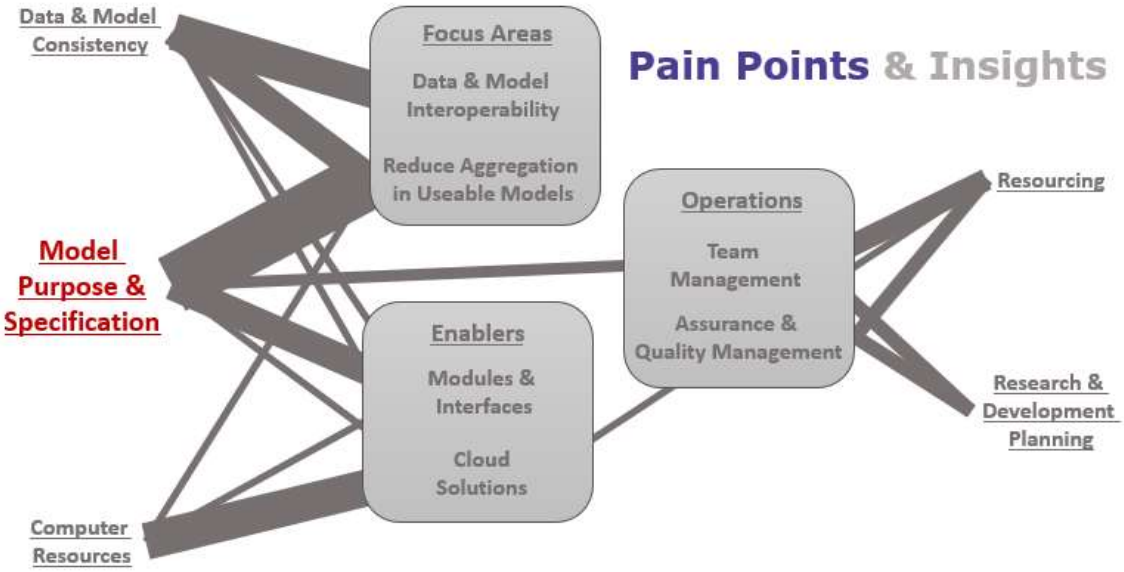
- **Limited segmentation** – existing transport models can have limited traveller segmentation that limits understanding of the user experience or building an economic narrative.

- **Acceptance of innovative approaches** – current value for money assessments can limit the impact of more uncertain, innovative approaches required to capture new benefits.

- **Understanding non-marginal market failures** – conventional modelling and appraisal is designed for more marginal change and may only partially represent the impacts of major improvements where there has historically been poor connectivity, or the combined impacts of interventions at the programme level.

- **Understanding the scope for shaping new markets** – conventional modelling and appraisal does not measure the transformational impacts of mega-projects on travel patterns, or the combined impacts of interventions at the programme and portfolio level.

- **Incomplete assessments can present one-sided appraisal** – displacement effects can introduce disagglomeration as higher productivity jobs move from say London to South Yorkshire. But the benefits of extra space, lower costs, etc. plus decongestion benefits in London are often not included.



Computer Resources Pain-Points

Models are not fully exploiting contemporary computer resources, as listed below.

- **Model runtimes** – conventional models often use processes and algorithms optimised for the efficient use of early computer resources (with roots as far back as the 1970s), and do not easily adapt to new approaches and technologies, for example data parallelisation required to exploit advanced Graphics Processor Unit (GPU) technology.
- **Inconsistent IT platforms and software** – misunderstanding of the optimal approach for running models and holding data can create significant inefficiencies.
- **Limited data sharing** – misunderstanding of the optimal approach for transferring data can create significant inefficiencies.

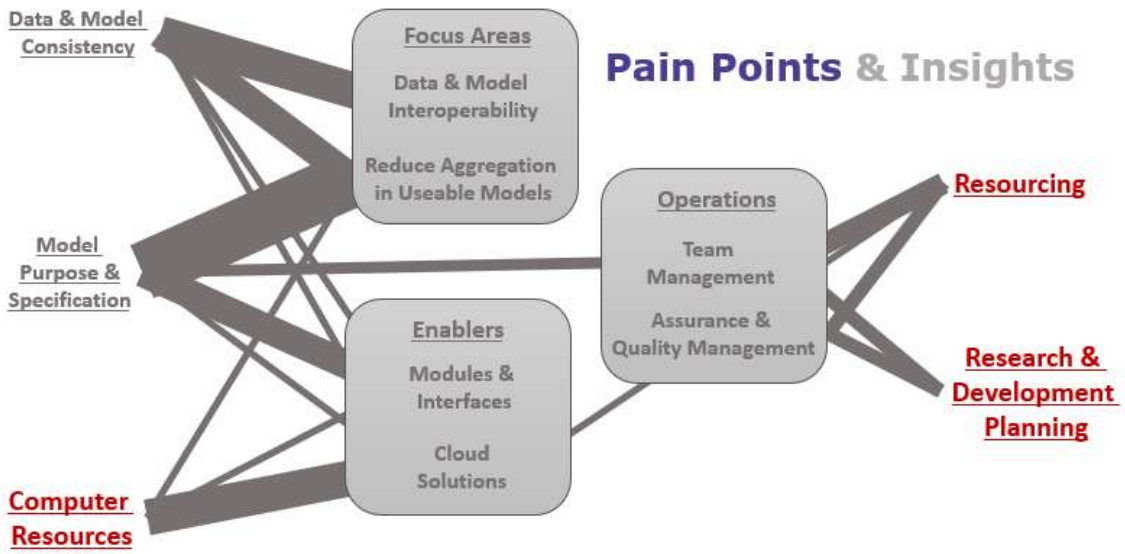
Resourcing Pain-Points

A number of resourcing and research and development experiences are listed below.

- **Team resilience** – rapid development and application at scale is challenging.
- **A great but limited supply chain** – even though we have chosen popular software platforms we still do not seem to have sufficient suppliers.
- **Limited access to external assurance support** – maybe a result of rapid development but clearly an issue with more innovative areas required.
- **Limited level of quality and technical assurance** – difficult to find transport modelling and appraisal experience.

Research & Development Pain-Points

- **Areas of innovation** – can be difficult to understand requirements and prioritisation, and can be difficult to scope and plan.
- Dealing with different geographies, models and complex collaborations has created **complex programme interdependencies**.



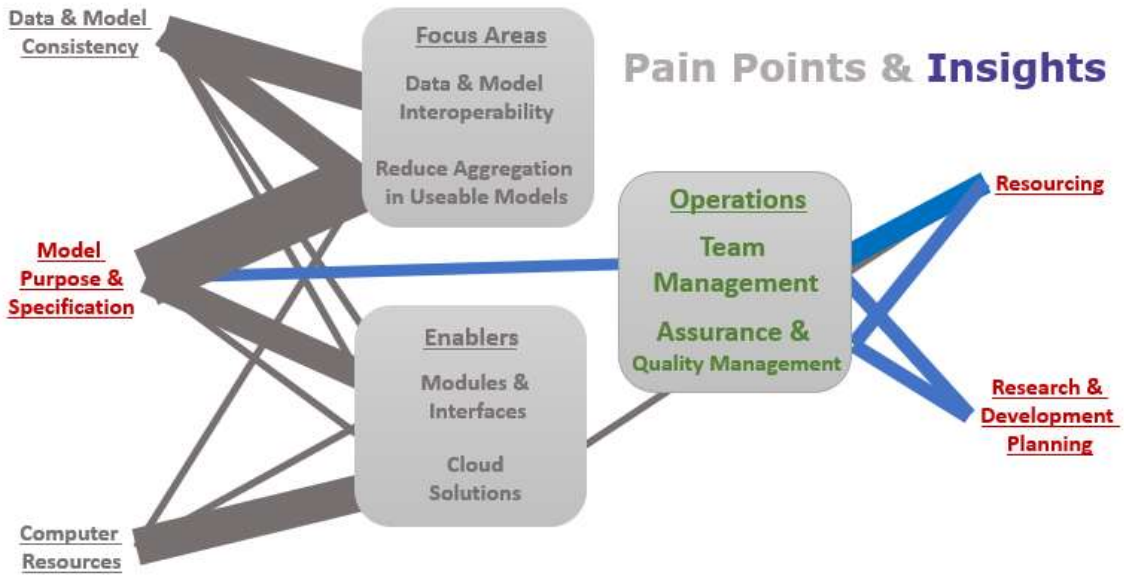
Pain-Point Assessment

Our assessment of pain-points has identified aspects of the Analytical Framework that need to be strengthened and helped set priorities for expansion and research. We have critiqued these into three separate groups of: Operations; Enablers; and Focus Areas.

Operations Improvements

We have identified the Operations improvements within two sub-groups of Assurance and Quality Management, and Team Management. Key improvements within these sub-groups are listed below.

- **Technical assurance system** – a system to provide consistent assurance across outputs, and one that can be better monitored.
- **Quality assurance system** – for developing new tools and aligned to the HM Treasury AQUA book.
- **Technical managers** – who provide the interface between project & programme managers, and analysts and modellers.
- **Agile innovation** – we have been given challenging programmes during which we must not only build datasets and models, and apply them into numerous programmes, but also much of this is innovative where we have limited previous experience. We've tackled this challenge through adopting disruptive and data driven improvements. In order to achieve the necessary pace of development and application we've had to adopt key principles of agile innovation, including:
    - having a clear vision and set of goals linked to our business needs;
    - not over thinking a solution before we start and letting the problem evolve as we go;
    - adapting to whatever today throws at us and not being afraid to change direction;
    - trusting our team to self-organise around change and see each team member as a leader;
    - learning from mistakes and finding positives out of failure, and whatever happens, keep going; and
    - we have had to be bold and disrupt to meet our objectives.



Enablers

The Enablers group has been further split into two sub-groups of: Modules and Interfaces; and Cloud Solutions. Both sub-groups could feature in guidance and are summarised below.

Modules and Interfaces

- **Modularisation** – building strong interfaces to widen the options for particular areas of functionality, and thereby avoiding 'tie-in' to single software suppliers or models, and to allow better integration of models and, ultimately, leading to high levels of model interoperability.

- **Consistent interfaces** – introduce standardisation to make data and models more accessible, work towards high levels of data interoperability and have reporting at different levels of access, from expert modellers to members of the public.

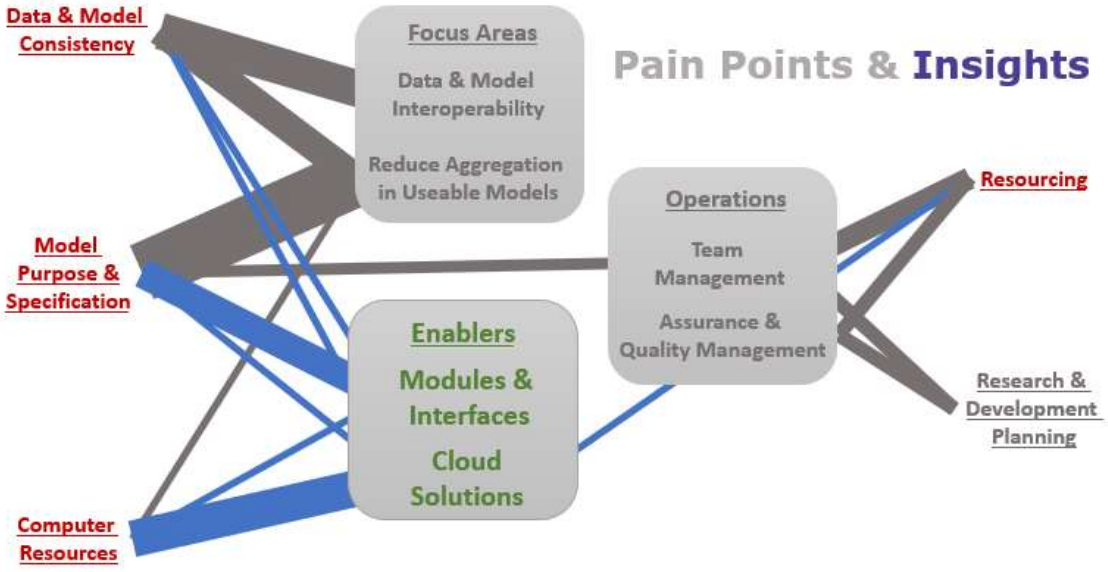
Cloud Solutions

- **Move to cloud based 'Virtual Machines' (VMs) and file storage**, and so:

    - provide scalable computing for use as a modelling platform and data analytics platform, with scope for introducing GPU and machine learning enhancements;

    - allow the sharing of VMs throughout the model and appraisal ecosystem, and allow upload to and download from common file share, saving double handling of data; and

    - provide a more cost-effective platform in terms of software and hardware costs.



Focus Areas

The Focus Areas group has been further split into two sub-groups of: Data & Model Interoperability; and Reducing (the effects of) Aggregation in Useable Models. These two areas will become focus areas as we strengthen and expand our data and tools over the next period of development.

Data & Model Interoperability

Key areas to strengthen are listed below.

- **Consistent base data and forecasts** – this should be given a high priority in the next period of development as it is likely to remove many of the current pain-points.

- **Automating the development of zone correspondence** – this is feasible as data is consistently held at property or full postcode level throughout England, and with sufficient coverage for the rest of mainland Great Britain.

- **Automated & consistent model components** – there are numerous options to automate the creation of model components, including travel matrices and basic networks. This could introduce significant quality improvement and consistency, and cost efficiencies.

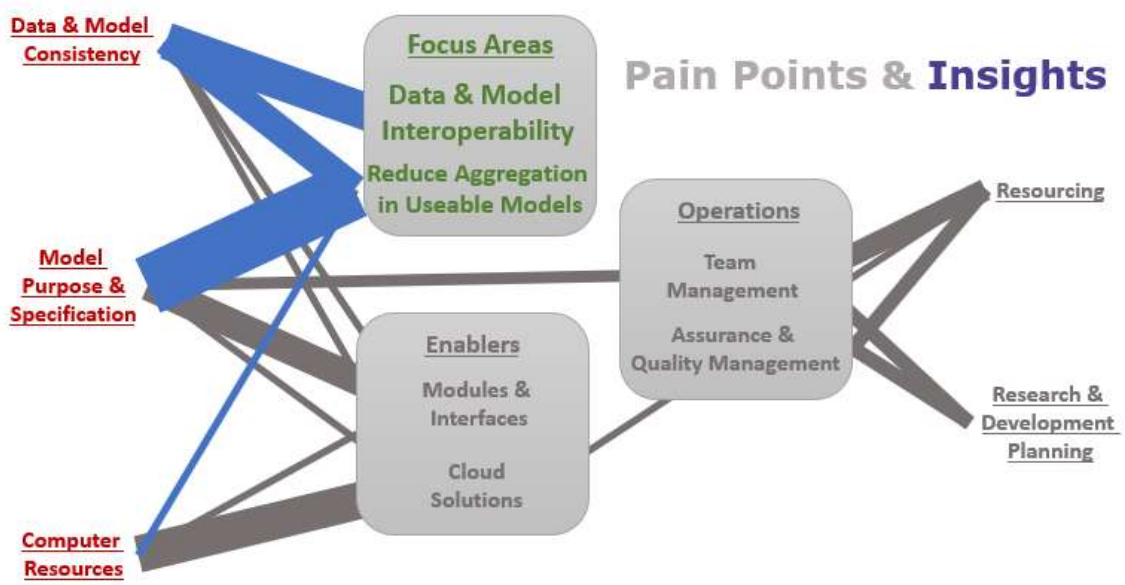
- **Develop data model** – a unified data model for better data interoperability.

Reducing Aggregation in Useable Models

Current modelling and appraisal approaches favour major schemes where high congestion already exists and is potentially restricting economic growth (causing market failures).

The key focus area for expanding the Analytical Framework is therefore to develop exploratory tools, appropriate for market shaping and more transformational programmes.

A key feature of typical exploratory tools is the high level of segmentation and short runtimes. Unfortunately, currently this can only be achieved by the application of aggregate and more abstract transport supply models. Furthermore, the application of transport models for wide reaching programme assessments also requires significant levels of supply model aggregation. However, the 'dampening' effects of aggregation could be a key obstacle to improving the robustness of



economic cases and providing compelling economic narrative.

To help focus development we will continue with the two-tier model architectures, with the upper-tier holding our exploratory tool and the lower-tier holding our conventional transport models, and focus our efforts on improving the exchange of information between the two modelling tiers.

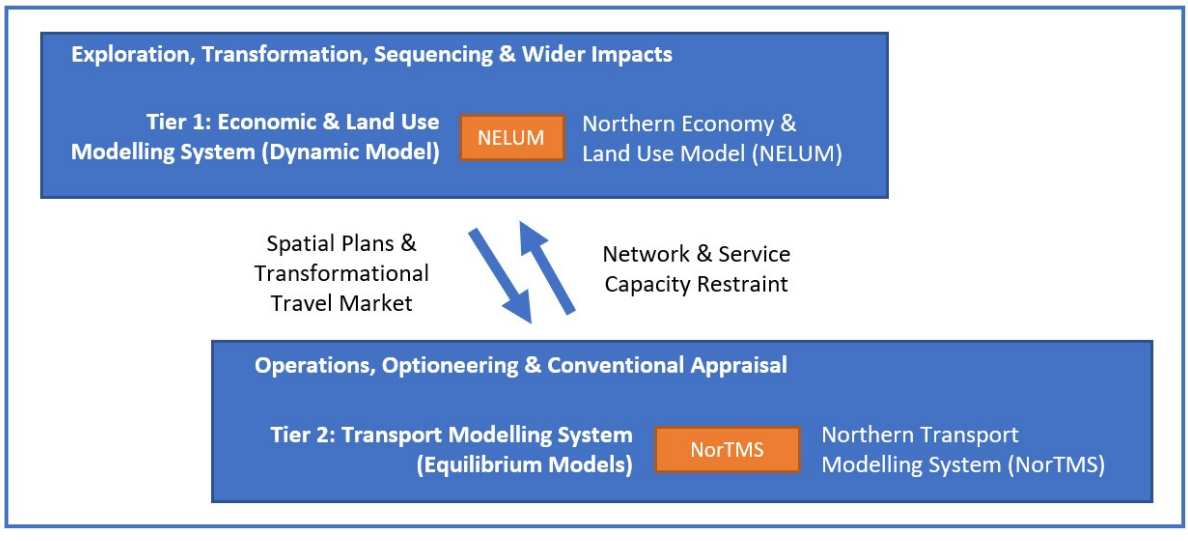
Following this, we will focus on ways of improving the exploratory nature of the upper-tier tool, and for both tiers investigating ways to achieve useable runtimes and reduce the dampening effects of aggregation.

Further Scope and Priorities

Our expansion and research of the Analytical Framework will also recognise further generic improvement areas listed below.

- Recognise transport impacts much more widely on the economy, society and environment, and capture a more holistic 'systems' view in modelling and appraisal.
- Recognise limitations of narrower 'predict-and-provide' approaches and work towards 'vision-and-validate', enabling policy tests against a range of futures.
- Accept that we need to achieve better representation of the constraints that people and businesses experience, but this must not be at the expense of short model runtimes to explore many futures.
- Recognise that exploration needs a more dynamic land use / transport interaction with many timesteps that better match real population and business behaviours and account for better connectivity enhancing an area's attractiveness.
- Consider the most relevant people and business segments for understanding the impacts of interventions within an uncertain future and consider new segments that are more likely to experience change up to 2060.
- Build a system that can better model the cumulative effect of sequencing many individual interventions within the whole lifecycle of our Investment Programme.
- Look to exploit new technology and data parallelisation to keep runtimes useable.

Analytical Framework: Core Future Year Forecasting System



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