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Transpennine Route Upgrade

This is one of 15 case studies informing the Infrastructure Systems Review.

System: Transpennine rail delivery.

Systems contribution and value: Established enterprise governance, requirements architecture, and whole-railway integration for scope, interface and readiness decisions. Potential to reduce integration risk, late change and rework.

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Summary

The Transpennine Route Upgrade (TRU) is an £11 billion, 130km railway programme in the north of England. Three configuration stages, representing over 40% of the programme, have been completed to date, including new electrification on 25% of the route and the opening of three stations. This work has improved railway performance and passengers' travel experience.

Strong programme performance has been enabled by a systems approach:

- Creating an enterprise delivery organisation, with key stakeholders involved in governance and decision making from the outset, all equally committed to delivery, and with systems integration at its heart.
- Specifying and contracting focused on outputs and outcomes, with clearly defined business case benefits.
- Systems integration approaches used to identify and communicate scope, interfaces and dependencies.
- Systems thinking applied across all functions in the organisation, taking it beyond engineering into sponsorship, schedule, risk, cost and benefits delivery.
- Phased delivery linked to funding, with stakeholder confidence gained from early benefits delivery.

The operating model takes a whole railway approach, focused on delivering agreed outcomes for passengers and freight.

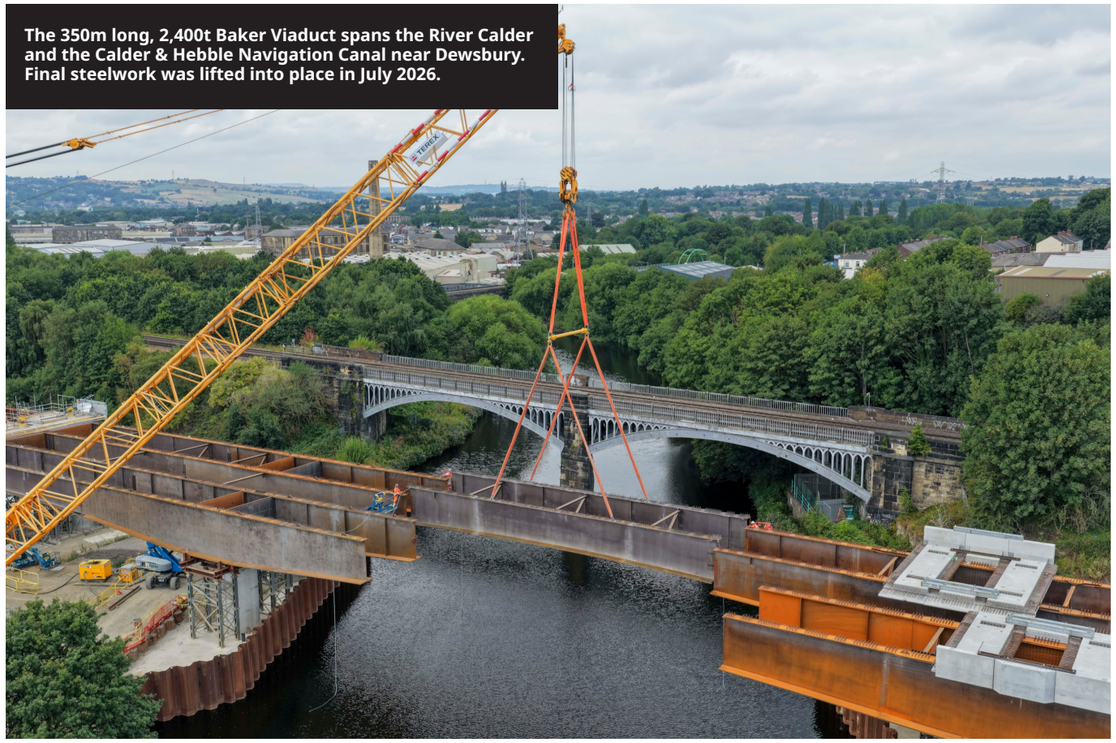
Scope

TRU is upgrading the existing east-west corridor between Manchester, Huddersfield, Leeds and York. It consists of more than 100 interventions, or projects, at various stages from development to in-delivery, completed and in-service. The programme's scope includes creating new assets, maximising the use of existing assets, improving reliability and enabling cost-effective future maintenance. Work will continue until the late 2030s.

While Manchester to York is the core 'system of interest' (figure 1), TRU's scope encompasses the origination and destination of services across the wider rail network. The 'system boundary' extends from first to last mile of each journey, for both passengers and freight; and it includes train operations, new and existing rolling stock, the timetable, railway infrastructure, train control and maintenance.

Outcomes

TRU will deliver significant environmental, social and economic benefits in the north of England by creating a faster, more reliable and lower-carbon railway. This is expected to support economic growth by improving access to employment and improving connectivity between regional economic hubs. Improved rail transport will make the region more competitive within the UK and internationally. TRU will enable the removal of up to 1,200 lorries per day from the M62, providing greater capacity and reduced journey times. The rail system itself will shift from diesel to electric trains.



The 350m long, 2,400t Baker Viaduct spans the River Calder and the Calder & Hebble Navigation Canal near Dewsbury. Final steelwork was lifted into place in July 2026.

Systems requiring integration

— 6 signalling systems
— 10 classes of civil structures
— 1 DNO connection
— 3 electrical control rooms
— 3 high voltage feeder stations
— 8 traction section cabins
— 2 communication systems
— 1 diversionary route
— 2 new stations
— 22 existing stations
— 6 stabling and maintenance depots
— 1 freight terminal
— Track
— Switches and crossings
— 4 connecting routes
— Trains
— Train operations and timetabling
— Lighting
— Security
— Passenger and customer information
— Revenue collection
— Local environment
— Adjacent routes

The TRU benefits map (figure 3) shows how government strategic missions and obligations (outcomes) translate into projects. Benefits include:

- A 50% improvement in train punctuality
- Reduced journey times between Manchester, Leeds and York from 74 to 64 mins
- More frequent trains and better connections
- 30% more seating capacity, to achieve 80,000 seats per day
- Additional hourly passenger services and a new container freight capacity
- Electrification of the route and introduction of electric and battery trains to reduce carbon emissions

The existing railway was characterised by ageing infrastructure, constrained capacity, poor performance, and fragmented delivery. Performance was poor, with only 38% of trains arriving within a minute of the scheduled time, compared to a national average of 65%. Delays, crowding and inconsistent quality blighted passenger services; freight and operational flexibility were limited. Carbon emissions were high due to the route's reliance on diesel traction.

TRU has set simple, clear target outcomes and used them to define interventions. Through a system integration and management plan (SIMP), TRU has strengthened requirements traceability, interface management and system assurance. This has improved decisionmaking, reduced rework and ensured that individual project outputs combine to deliver whole-system benefits. Service performance and operational needs are better aligned, enhancing reliability, safety and long-term asset performance.

Figure 1. TRU system of interest – core (shaded box) and extended.

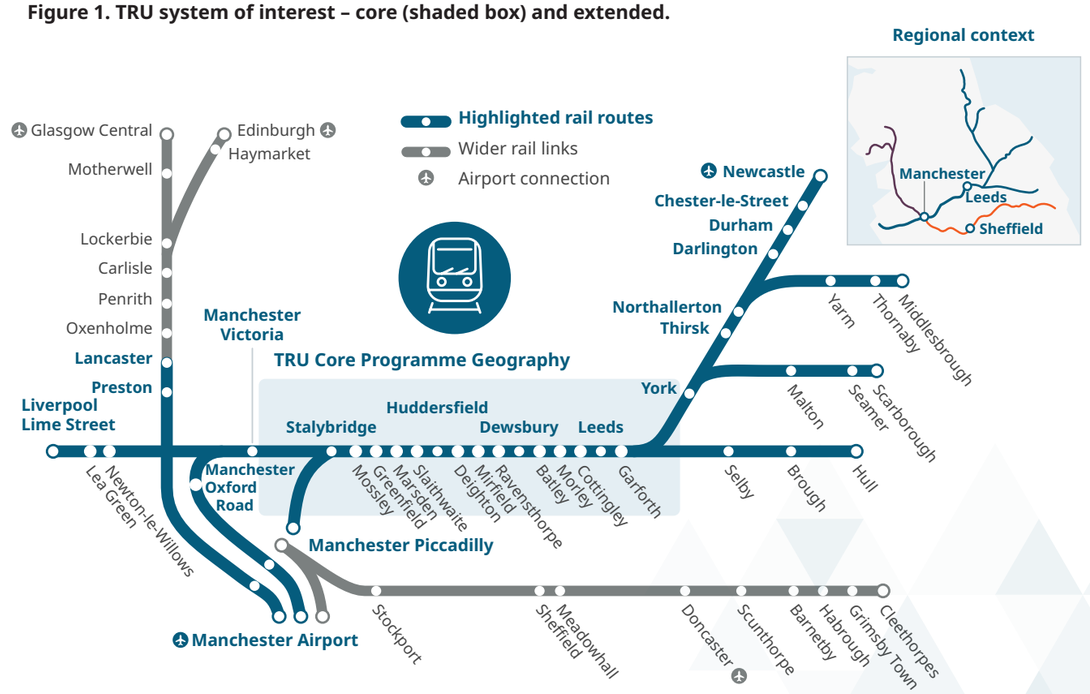
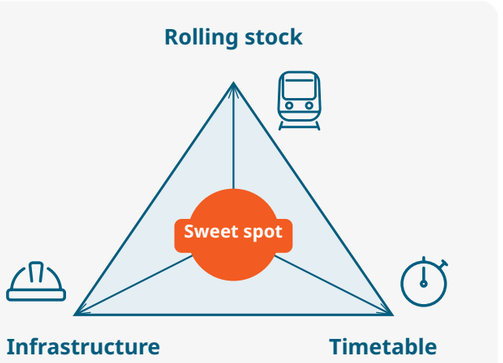


Figure 2. TRU investment sweet spot.



From a stakeholder perspective, passengers benefit from improved journey quality, while operators gain a more reliable and flexible railway. However, delivery partners have faced increased coordination requirements and governance complexity. Trade-offs have included balancing short-term disruption and revenue impact during construction against long-term gains, and managing cost, schedule, and scope within a live railway environment.

Developing outcome-led solutions that balance infrastructure, railway and train operational needs has required close working within the enterprise. It has 'scanned ahead' to determine risks and solve them early.

Systems

TRU can be understood as a complex system of systems, combining physical, organisational, operational and digital elements. Physically, it includes track, electrification, structures, stations, and rolling stock. Organisationally, it brings together Network Rail, the Department for Transport, the North of England Mayoral Authorities, train and freight operators, and a diverse supply chain. Digitally, it incorporates signalling systems, requirements databases, configuration tools, and assurance processes.

All these elements are highly interdependent, with performance outcomes emerging from their interactions rather than any single component.

At the outset of TRU, there was evidence of performance-related challenges stemming from fragmented delivery, discipline silos, a reliance on statutory rights to protect stakeholder perspectives, and limited visibility of cross-project dependencies. Further challenges were added by the condition of legacy infrastructure and poor operational performance, impacting customer experience. Together, they created the potential for weak alignment between design, delivery and operational performance.

Applying systems thinking enabled the development of a structured understanding of relationships and requirements. Tools such as requirements traceability, interface management frameworks, and configuration control enabled the programme to map and manage dependencies across physical and organisational boundaries. This established a baseline view of the railway as an integrated system, clarifying how infrastructure performance translates into service outcomes, such as reliability and capacity.

Key leverage points included improving interface definition between disciplines, aligning requirements to operational needs, and strengthening integration governance. These influenced investment sequencing, ensuring that interventions delivered cumulative, system-wide benefits rather than isolated gains. Governance structures were adapted to support cross-discipline decision making and whole system assurance.

Value of the integration approach was unlocked through reducing rework, improving coordination, and enabling best for programme decision-making across delivery partners. The approach also enhanced long-term service performance by ensuring that new and existing assets function cohesively. Overall, understanding the system holistically allowed TRU to move from fragmented upgrades to a coordinated transformation.

A useful tool for communicating the changes which TRU will deliver, and the dependencies it has on external factors, has been the enterprise project architecture. It defines the total system changes needed to deliver TRU outcomes, and has been commended for its ability to communicate scope, forming part of the TRU baseline delivery documentation. It proves that simplicity is essential to communicate systems thinking successfully.

Interventions

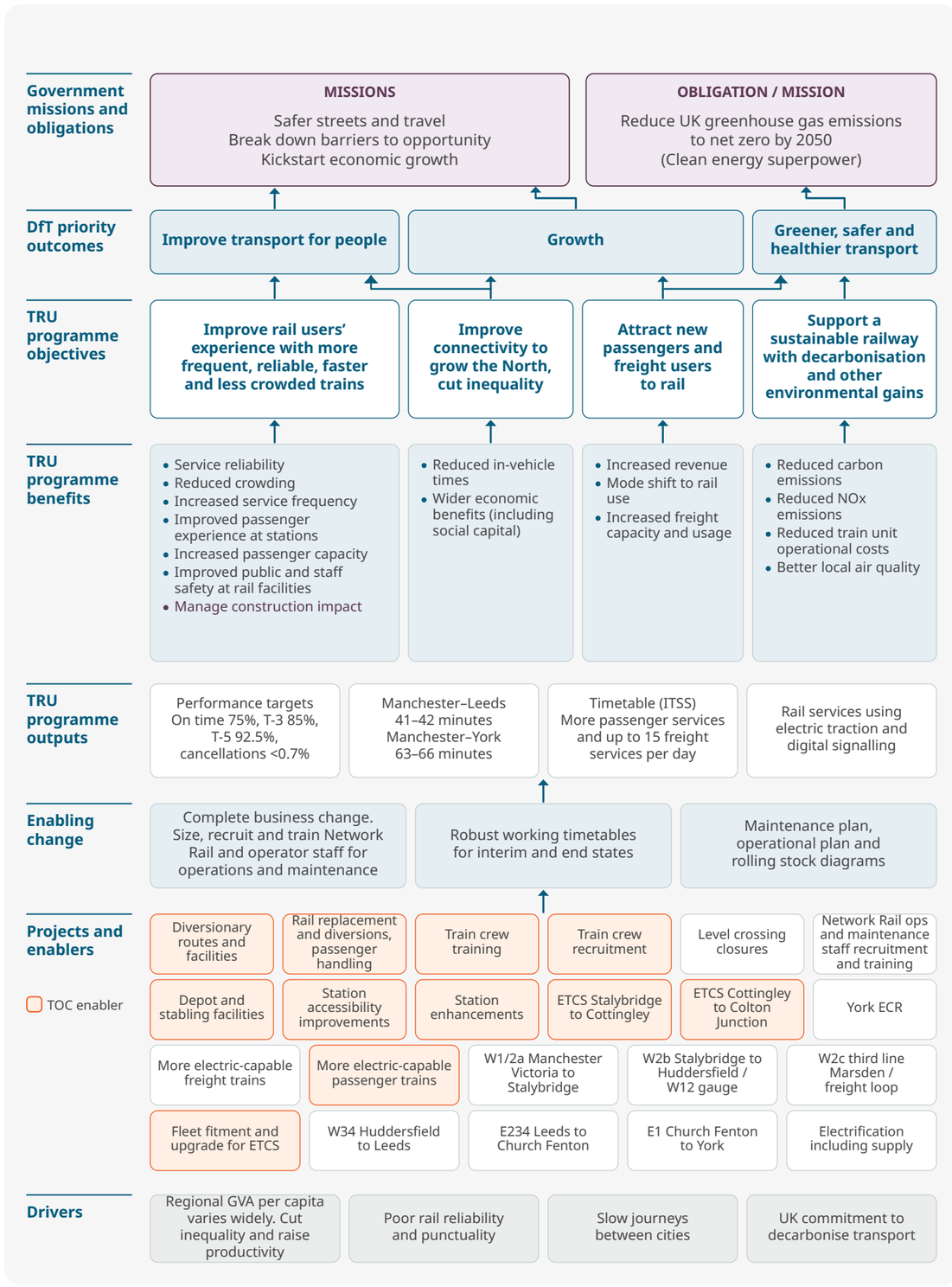
When TRU was initiated, Network Rail was focused on the delivery of infrastructure. The DfT was separately focused on integration, working with operators. The TRU enterprise model brought all the stakeholders together to ensure that joint 'best for programme' decisions would be made, consider how projects and assets would be integrated, and where best value for the investment can be achieved.

In practice, this has enabled the enterprise to find the TRU 'investment sweet spot', providing best system-wide value by finding the optimum trade-offs between rolling stock, timetable and infrastructure (figure 2).

Key interventions to close the gap between the railway's existing performance and expected outcomes include:

- **Timetable.** Alternative solutions were developed, testing the frequency of services, rolling stock needs, train lengths, freight gauges and infrastructure interventions. The railway service timetable has been restricted so that punctuality performance can be maintained during the programme; services will be increased post-completion to six fast and two local passenger trains, and one freight service per hour.
- **Rolling stock.** Aged diesel rolling stock will be replaced by electric trains with in-train digital signalling, delivering increased capacity. Battery technology will be used to overcome challenges with full route electrification – for example under low bridges and in tunnels. The train-platform interface will be improved to achieve better accessibility.
- **Infrastructure.** Capacity 'bottlenecks' will be removed by

Figure 3. TRU benefits map.



using digital signalling to allow reduced headway – trains will be able to operate at closer intervals. Electrification will allow the operation of new rolling stock. Infrastructure work has been planned and executed to minimise impacts on the operational railway and passenger service.
- **Maintenance.** Railway assets have been fitted with sensors to improve condition monitoring and fault detection, allowing proactive maintenance and rapid repairs. Maintenance scheduling has been amended to allow freight services to operation 24/6, aligning with customers' needs.
- **Stations.** New and upgraded stations improve accessibility and customer experience.

Investment trade-offs between interventions are aligned with their contribution to programme outcomes. The TRU enterprise developed a 'hot house' decisionmaking forum to reach decisions transparently and quickly.

One of the most significant physical interventions on TRU was the Baker Viaduct between Huddersfield and Dewsbury. It supports the operation of reliable fast train services between Leeds and Manchester by providing an 'overtaking' path for faster trains. Due to the strength and quality of the benefits case, giving confidence that the solution was the best whole enterprise system solution, it progressed smoothly through its Transport and Works Act Order consents process, which was a potential schedule risk.

Economic assessment

TRU was established against a backdrop of major rail enhancement programmes that offered significant lessons in the importance of integrating infrastructure delivery, train operations and passenger outcomes. Under traditional delivery models, infrastructure sponsors, infrastructure managers, train operators, freight operators and suppliers operate within separate organisational and contractual boundaries. While individual organisations can be incentivised to optimise their own objectives, there is often no equivalent mechanism to optimise the delivery and performance of the railway system as a whole.

This approach can create several failure modes.

Information can be fragmented across organisations, making it difficult to understand how decisions made in one part of the programme could affect performance elsewhere. The benefits arising from integration between infrastructure, operations, rolling stock and timetable changes may not be visible to all organisations, creating a risk that opportunities delivering wider system value get overlooked. Incentives can be misaligned, with projects capable of meeting their own objectives while still creating constraints on railway operations or limiting the benefits ultimately experienced by passengers and freight users.

Several reviews of significant rail programmes have illustrated how the complexity of rail systems delivery in a disaggregated environment can lead to undesired outcomes. The National Audit Office reported that the Great Western Electrification Project[1] and Intercity Express Programme[2] experienced cost increases of approximately £2.1 billion and delays of 18-36 months, leading to around £330 million of additional operating costs and a reduction in programme scope. Crossrail also made clear the importance of creating a dedicated, central team at the very start of a programme, with responsibility to actively manage system integration.

TRU's systems-informed enterprise approach to delivery has resulted in project costs that compare favourably with other large programmes.

The principal economic benefits realised to date arise through improved decisionmaking, risk reduction and sequencing of investment. The approach has reduced the risk of incompatible decisions, improved management of interfaces and dependencies, and enabled benefits to be realised progressively through phased delivery.

Key outcomes delivered to date include:

- Additional infrastructure and train capacity to provide up to three trains per hour on diversion routes, while construction on the core TRU route is under way, thereby minimising service disruption.
- Introduction of electric passenger services between Manchester and Stalybridge. Improved railway performance and reduced emissions in areas of high population.
- Introduction of electric passenger services between Church Fenton and York, including integration with East Coast Main Line power upgrades. Delivers faster train services by removing historic restrictions and reduces emissions in the York area.
- Further outcomes will be delivered through the remainder of the programme, reflecting the changing configuration of the railway as infrastructure and digital signalling is delivered, new rolling stock is introduced, and operation and maintenance approaches change.

Defined and agreed key outcomes hold the enterprise and programme to account and build confidence for future investment decisions.

There have so far been in excess of 100 commissioning stages. The TRU systems assurance case (TSAC), developed from a similar Crossrail tool, provides a structured approach to demonstrating readiness at each stage.

Additional value has been realised through systems thinking led efficiency focus. So far, some £900 million worth of efficiencies have been identified through integrated programme delivery and operator input.

While the programme is still in delivery, stronger integration has improved decision quality, reduced delivery risk and increased confidence that passenger, freight and decarbonisation outcomes will be delivered effectively.

1 Modernising the Great Western railway, NAO, Nov 2016
2 Procuring new trains, NAO, July 2014

The evidence base for systems change Transpennine Route Upgrade

Systemic assessment

This case study highlights several systemic inefficiencies and barriers that can constrain performance under traditional delivery approaches. These include fragmented governance structures, siloed funding and investment decisions, and misalignment between policy objectives and operational railway outcomes. Regulatory and assurance processes are often applied at project level rather than system level, limiting visibility of cross-interface risks and increasing the likelihood of late stage issues. Additionally, organisational silos across disciplines and supply chain partners can inhibit information sharing, reduce transparency, and drive duplication of effort and cost.

The industry transition to Great British Railways represents an opportunity to adopt the enterprise structure developed by TRU, setting a benchmark for rail programme delivery across the network.

The relative strength or weakness in any system approach for railway programmes arises from:

- where the programme or system boundaries are drawn
- the relative control the programme enterprise has over decision making and integration choices

For TRU this is illustrated by its interfaces in Manchester and with the East Coast Main Line, considering the activities and aspirations of other programmes. There may be benefits from a wider enterprise programme approach, which could be driven by Great British Railways.

TRU's focus on outcomes requires a clear decomposition and traceability to outputs, and allocation to the enterprise partners. It is not yet a standard approach to managing integration in rail projects, but offers great potential. It needs promotion or formalisation within future Great British Railways delivery models.

A successful enterprise approach has reduced TRU's dependencies on traditional regulatory processes to approve schemes. This has been notable for network change and station change schemes. Avoiding delay has allowed schedules to be maintained, and created confidence in the quality of delivered outputs.

Historically, silos between DfT, Network Rail and train operators have caused technical compatibility, cost and delay challenges in train procurement. Integration of train procurement and infrastructure has the potential to overcome these issues – again requiring Great British Railways intervention.

TRU has mitigated potential inefficiencies resulting from a complex standards landscape by developing application guidance documents in conjunction with government, the regulator and other stakeholder bodies. There is an opportunity to learn from these to create a more efficient, more integrated approach between rail stakeholders.

The planned investments in Northern Powerhouse Rail (NPR) and East West Rail (EWR) provide ideal opportunities for the implementation of the TRU integration approach, noting the scale of investment and the current maturity of development.

Investment trade-offs between interventions are aligned with their contribution to programme outcomes. The TRU enterprise developed a 'hot house' decision making forum to reach decisions transparently and quickly.

Recommendations

TRU demonstrates that an engaged enterprise organisation and the early and consistent application of systems thinking is critical to successfully managing complexity and delivering whole-system outcomes.

Key lessons from TRU include the need to establish clear requirements traceability, strong interface ownership, and integrated governance and assurance across organisational functions from the outset. Fragmented governance and siloed delivery has been proven to significantly increase cost and risk, while the TRU coordinated systems approach improves alignment, reduces rework, and enhances long-term performance. The programme also highlights that value is improved when investment decisions focus on service outcomes, and these are used to guide asset delivery.

Priority recommendations:

- **Government**. Align funding and requirements with whole-system outcomes. Ensure business cases prioritise service performance, resilience and net zero, rather than defining discrete project interventions which cannot be traced directly to benefits. Mandate systems integration strategies for major programmes.
- **Clients.** Support upfront investment in enterprise delivery models, including systems engineering capability, recognising that modest early costs deliver significant downstream savings and risk reduction. Support enterprise-wide decision making, early enough to avoid inefficiency.
- **Programme delivery teams.** Implement industry learning processes, standardise systems engineering practices, align incentives, and strengthen cross-organisational collaboration. Address trade-offs to find optimal solutions aligned with mutually agreed outcomes. Focus on how best to deliver outputs, finding a 'sweet spot' between stakeholders' competencies, capabilities and capacity. Link outputs to outcomes.

Together, these actions will improve investment effectiveness, enable scalable delivery models, and support more coherent, resilient infrastructure systems.

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