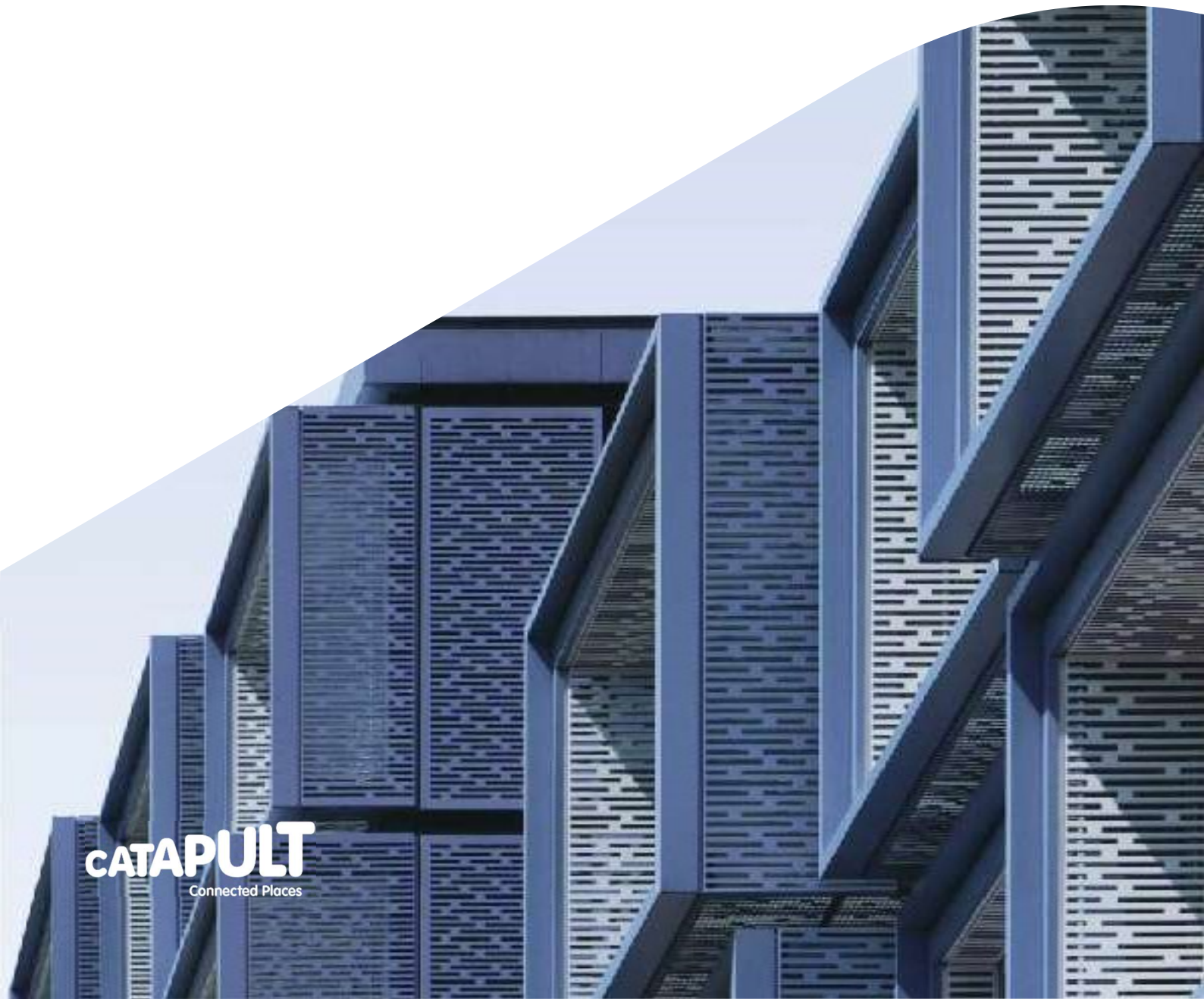
July 2021

# High Speed 1

## Innovation in Rail



CATAPULT
Connected Places

# Executive summary

## High Speed One (HS1) is committed to maintaining its reputation as a market leader in rail asset management. To this end, they have engaged the Connected Places Catapult (CPC) as an innovation partner to drive a move towards a more focussed strategy in this space.

The first part of this strategy involved developing a small number of challenge statements against which HS1's future partners can deliver solutions. CPC developed these challenge statements through many interviews and workshops with HS1, Network Rail HS (NRHS) and relevant stakeholders. These interviews aimed to understand the range of issues and challenges facing the various areas of the business before delving into deeper detail around a smaller number of issues.

Original challenges identified and subsequently prioritised through this work were:

- Automated inspection
- Cross-domain integration
- Efficient possessions

The following document outlines a brief description of the process we followed to arrive at these challenges, a summary of each challenge statement and a series of recommendations for how HS1 can take these challenges forward and begin to work towards addressing them.

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# 1. Process

In developing the following challenge statements, we sought to work closely with both HS1 and its relevant stakeholders. To this end, we conducted around 20 interviews with individuals from HS1, NRHS, a relevant Train Operating Company (TOC), CPC's internal subject matter experts and our academic network.

These initial interviews were exploratory in nature, trying to understand the range of potential problems that impact HS1's business and how they can be grouped and mapped out across the various domains. This led us to a total of five challenge areas alongside two essential requirements. These five challenges were narrowed down to three via a survey of HS1 and relevant stakeholders to provide a greater focus to the programme. Those challenges that were deprioritised via the survey were:

- High-speed modelling - aimed at better understanding the impact of running high speed rail operations compared to normal line speeds.
- Station structural monitoring - aimed at analysing the various stations' ongoing conditions to demonstrate acceptable conditions when handed back at the end of the lease.

For each of the three final challenge statements, we then ran small workshops with relevant internal stakeholders to understand:

- Underlying drivers of each problem
- The impact of the associated problems
- Previous attempts at solutions
- Responsibility/ownership across various teams
- Red lines that would definitively rule a solution out

Finally, we considered the nature of each of these challenge statements concerning the various methods of accessing innovation to arrive at several recommendations for the next steps for HS1 to take to advance their position concerning these challenges.

# 2. Challenges statements

## 2.1 Cross-domain integration

HS1's asset maintenance and inspection are currently organised and managed down domain lines, i.e. track, signals, power, and civils are managed and addressed separately.
This organisational structure is standard in the rail industry but is not without drawbacks. Perhaps most significant is the issue of communication and collaboration between the various domains. With data being captured, processed and acted upon within these existing domains, it is often challenging to spot opportunities for synergy between groups.

Based on the current practice of managing inspections, faults and maintenance within individual domains, there is not enough skilled labour within the business to meet the requirements.
Rough estimates suggest that around 50% of jobs could be carried out in an integrated way, and currently only 5% are - there is enormous scope for improvement in this area.

For example, if a tunnel is leaking water which damages a signal, the leak fault will be captured and conveyed to the civils team and the signals fault to the signals team. These faults will be considered and rectified separately despite their intrinsic connection. This results in multiple track possessions being scheduled at a high cost and the potential recurrence of the problem.

Cross-domain integration separates into two key areas:

1. Planning - Track access and possession for maintenance/inspection is managed centrally but with little focus on synergy. Plans are managed individually but not at a system level. An integrated view would drive a significant efficiency in the operational expenditure.
2. Data - Several issues exist with the data capture, processing and presentation, including:
    1. Inconsistency of data - some teams capture detailed, accurate data, whereas others routinely leave fields blank.
    2. Lack of accurate geographical asset information means that it is challenging to spot potential connections between faults and to take advantage of integrating works.
    3. No root cause assignation on forms or inspection reports means that linkages are not identified proactively.
    4. No clear visual output for review of overall asset condition or linkages between domains.

Red lines - any solution involving the following characteristics will not be considered:

1. Any solution that adds an extra layer of processing
2. A non-agnostic software system, i.e., anything that requires proprietary models or systems, cannot integrate with HS1's existing stack.
3. Any requirements to change HS1's current Enterprise Asset Management (eAM) system - currently Oracle.
4. Anything that creates, transfers or processes data in a non-secure manner, either from a cyber security or GDPR standpoint.

# 2.2 Automated inspection

Asset inspection on HS1's network is predominantly carried out almost entirely in a manual fashion. This is consistent with how rail assets have been managed since their inception. To improve upon HS1's asset management strategy, there is a need to adopt a new approach, enabled by the array of solutions coming available on the market.

Specifically, HS1 is seeking to apply these new technologies to overcome the following challenges that exist with the current system.

- Dynamic real-time measurement - the current manual approach to asset inspection means that static data is captured at fixed intervals. At best, there is a simplistic view of asset degradation rates and behaviours.
- Data quality - human inspection of assets leads to inconsistency and, at times, low-quality data recording.
  - Inconsistency - Various fault-finding inspections of the same assets by different engineers have shown a near 100% difference.
  - Low quality - Human inspection is often visual (i.e., not overly detailed) and captures qualitative (i.e., non-comparable) data types.
- Cost - Human inspection of assets can be prohibitively expensive due to staffing levels, equipment, taking possessions, etc. All have significant costs attributed.

Focus areas

Whilst we are open to ideas that address the above issues, we are particularly focussed on innovations in the following areas.

Trackside inspections
One area of inspection which is currently very costly, but is perceived as challenging to automate, is that of trackside or 'offtrack' inspection. These inspections currently involve teams of engineers walking the length of the HS1 asset over a period of weeks to capture many non-routine issues, including anything from broken fences to overgrown vegetation or fly-tipping.
Given the nature of these inspections covering various potential issues, there is currently no alternative to a human inspection.

On demand maintenance
One significant opportunity presented by automated inspection solutions is moving away from the current practice of conducting maintenance on a planned or scheduled basis. This maintenance schedule is driven by having to build a margin for error into maintenance to allow for the lack of insight into dynamic asset conditions. By developing its automated inspection capability, HS1 can begin to conduct maintenance operations on an as-needed basis - driving significant savings in the network.

Despite the importance of these specific areas of the challenge, we are not limiting our interest. We are interested in exploring opportunities for automating inspection activities across the network, including structures (tunnels, bridges, etc.) and signalling.

Red lines

- As far as possible, we would seek solutions that depend upon currently existing hardware. Some additions may be feasible but significantly increase time, cost and project complexity.

# 2.3 Efficient possessions

Taking possession of a section of track to conduct inspections, maintenance, renewals etc. is the mechanism by which workers' safety is ensured. It ensures that trains are not running (accidentally or otherwise) on track sections with workers. In the case of isolations, it also ensures the power is not live in the overhead lines.

The process around taking possession is a significant cause of cost and inefficiency in the current system. This problem stems from the following issues - all of which we are seeking solutions for:

- Forward planning - the current system for scheduling possessions is manual, cumbersome, and predominantly Excel-based. Schedules are initially planned over a year in advance and go through various iterations to ensure a lack of clashes in either geography or time, as well as looking to take opportunities for synergy in maintenance works, i.e. lining up multiple works during the same possession.
- Operational issues
  - Track possession - Taking possession of an area of track requires significant paperwork to be filled out on-site, with various people needed to verify and exchange information. This part of the process takes time and manpower to complete.
  - Power isolation - Much like taking possession, the process for isolating and ensuring isolation is lengthy, manual, and inefficient. Many aspects of the process are, quite rightly, driven by the safety-critical nature of this activity. There are, however, opportunities for efficiency which do not undermine worker safety.

The impact of the forward planning issue predominantly presents in terms of time taken to schedule and the difficulty of leveraging opportunities for efficiency. The former means that possession requests can take anything up to half a day each to schedule, owing to the possibility for human error and the need to be checked and sometimes rechecked. The latter issue means that all too often multiple possessions are taken over various time periods where various crews go out and where a single possession could have served the need.

The impact of operational issues is primarily in terms of the amount of time it takes on the day to take and return possessions and isolations. Typically, HS1 has approximately 4 hours available for maintenance between the last and first trains passing through. The process of taking possession can take approximately 30-45 minutes at the start and end of a shift - a total of up to 1.5 hours out of a 4-hour slot. This severely limits the amount of work possible within an overnight shift and increases the number of works that need to be scheduled. Any innovation that would accelerate the process in this regard would have a significant impact on HS1.

A further impact of the current methods of isolation is that it requires specialist teams to implement. This leads to more human resources being designated to each job and relatively low utilisation of on-site teams.

<u>Red lines</u>

- Any organisations tackling the operational side of this challenge will need to demonstrate experience dealing with critical safety systems.
- Organisations addressing the planning system aspect will need to demonstrate a plan for Network Rail High Speed's IT team to manage the system after implementation.

# 3. Solution requirements

## 3.1 Human-centred solutions

### Great technologies collapse when they fail to consider the human in the loop.

Discussions with our academic network pointed to the necessity of building solutions with the end-users in mind. Failure to demonstrate the value of a new tool to operational staff can lead to it not being used; failure to train properly can lead to incorrect usage; presenting data in suboptimal ways can lead to outputs being ignored; and so on. Without developing a comprehensive plan for each of these (and many other) factors of the integration phase, there is a severe chance of failure built into the various systems.

Therefore, we recommend that HS1 build a framework for this integration and work with suppliers to ensure suitable integration instead of considering more off-the-shelf solutions.

## 3.2 Data to inform decisions

### We cannot continue to collect data for data's sake.

One of the frustrations apparent across virtually all of our interviews and workshops was the perception of new projects and innovation creating vast swathes of new data without any clear valuable insight created. When working with innovators and solution providers in the next phase of this project, HS1 will need to insist on a clear line to be drawn between any new data generated and the final decisions that said data informs.

# 4. Recommendations

For each of these challenge areas there may be different routes to attempting to find a solution.

## 4.1 Automated inspection

CPC Innovation Marketplace proposition

The automated inspection challenge is the most well-defined in terms of the types of solutions sought. Essentially this challenge is one in which various solutions to particular areas of the challenge are sought. CPC recommend commissioning an Innovation Marketplace to identify new suppliers and solutions to these challenges and to ensure exposure to the broadest range of possible solutions on the market. This would allow HS1 to lay out individual elements of the challenge, e.g., lineside inspections and Medway structural data capture, and to simply see what the market has to offer with a limited financial commitment. This is particularly suited to this kind of challenge where it is feasible that no particular solution is available in the market or where consortia may need to be formed in order to address the challenges that sit beyond the scope of any single company.

In addition, for this challenge, we would also suggest accessing expertise in human factors. As discussed above, one of the key factors that frequently undermines automation in the rail industry is a failure to consider how new systems integrate with the various humans in the loop. This expertise would help ensure that operations staff training, data presentation and analysis, safety, etc. are all considered and planned for from the project's inception, instead of being bolted on as an afterthought.

Further details on CPC's Innovation Marketplace proposition are detailed in the Appendix.

## 4.2 Efficient possessions

CPC led Horizon and technology scan & feasibility study

The safety-critical nature of this work leads us to advise HS1 to look at existing applications rather than to work with innovators on a new solution. It is understood from HS1 that other organisations have addressed the operational aspect of this project both in the UK and overseas with positive results. The next steps for this challenge would be to engage with the various parties involved in these projects to understand how it might be rolled out to HS1, to understand costs, timelines, feasibility etc. Alongside this engagement we would propose engaging with the various academic institutions working within the UK rail ecosystem to understand alternative solutions that are either coming to market soon or are currently implemented internationally.

This project is essentially a question of:

- Horizon and technology scanning – understanding what is out in the market in and outside of rail, both domestically and internationally.
- Feasibility study – which elements of these solutions are well suited to HS1 and which ones would not fit for either technical, financial or other reasons.

Further details on CPC's Horizon and Technology Scan proposition are detailed in the Appendix.

# 4.3 Cross domain integration and possession planning

### CPC's Innovation Marketplace proposition

There is an opportunity to consider a single tool to enable cross domain integration and the planning aspect of possessions challenge. Ultimately, both fields require a single view of the network against which problems can be logged, possessions can be scheduled and viewed, etc. HS1 has never had success with an off-the-shelf solution and would welcome a solution provider to spend time in-house developing and customising a solution.

Again, we would suggest an innovation competition as the best route for this challenge. By conducting a competition such as this, HS1 could very clearly scope out requirements, data access, timelines etc., but more importantly would have the opportunity to work with solution providers over some time during development - ensuring that any solution is well aligned.