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# UK Connected and Automated Mobility Roadmap: Simulation to 2030

United Kingdom

# Introduction

*It is widely accepted that 'at scale deployment' of safe and secure Connected and Automated Mobility (CAM) will require millions, if not billions of testing miles to be driven. This number of miles simply isn't feasible in the physical world alone, and the development challenge is even greater when considering the necessary edge-case scenarios to test that are too expensive or high-risk for the real world.*

In addition to development, the role of simulation extends into future CAM certification processes, in-service support applications, as well as digital twins. These outcomes cover the entire CAM lifecycle, and it's with simulation that the safety, security and performance of CAM across this lifecycle can be enhanced.

By employing simulation and virtual tools, we can far more effectively address the larger CAM opportunity at hand. To do this path, it's important we chart our path correctly, outlining the various outcomes, timeframes and interdependencies involved. This needs to be rooted in robust stakeholder engagement, accounting for the voice of experts across the CAM ecosystem.

This roadmap, the *UK Connected and Automated Mobility Roadmap: Simulation to 2030*, charts that path, outlining a clear route to 2030 specifically for simulation.

# Stakeholder engagement process

*This simulation roadmap is based upon comprehensive engagement with a group of leading industry experts from a wide range of organisations. They included representatives from OEMs, Tier 1 suppliers, start-ups, certification authorities, hardware and software venders, public research organisations, consultants, and service and tools providers. These organisations cover a broad cross-section of stakeholders from the UK's CAM value chain, both new and long established, along with comparative perspectives from overseas for reference.*

The industry experts' views were captured in semi-structured interviews and a workshop during September-October 2021, distilled and shared back to those involved in November 2021, and finalised with feedback in January 2022. The findings and recommendations were used to develop this simulation roadmap, presented in the form of interdependent pathways to four significant outcomes: ***National digital twin***, ***Sharing models IP***, ***Certification support***, *and* ***In-service support***, which are detailed further in this report. The entirety of the underlying pathway data can be found on an interactive version of the roadmap at zenzic.io/roadmap.

Those representatives from organisations with responsibility for simulation activity were further consulted on the accuracy and expected timing of these four pathways in February 2022. Views often differ, particularly on the likely timing of activities, which may depend on external factors such as funding. However, the four pathways were refined based on this feedback, to ensure a majority consensus across the leading industry experts consulted.

Outcomes

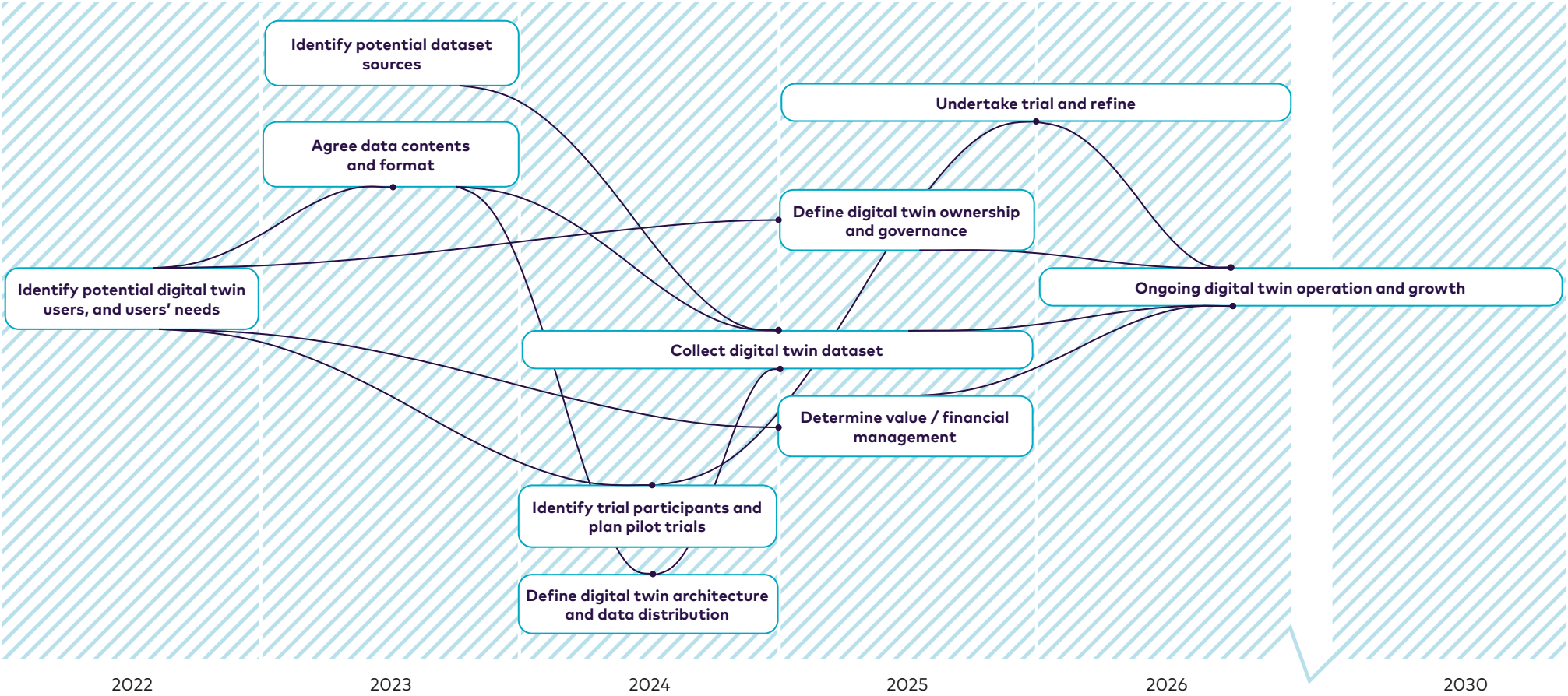
# National digital twin

*The operation of many Connected and Automated Vehicles (CAVs) involves localisation based on a digital model of the area. At present, developers or operators must undertake this digital model development themselves, with little incentive to share the digital model thereafter. This could lead to the same area being scanned multiple times, sometimes frequently to ensure digital models are kept up to date. While mapping and digital scanning service companies may emerge to offer these services in areas of high demand, a national digital twin will provide the potential for those CAVs, whose localisation function depends on a digital model, to operate in all areas, including areas of low demand. This could be a national asset.*

The national digital twin would also support investigation of CAV operation in its Operational Design Domains (ODD) prior to deployment, helping to refine and calibrate engineering decisions and, potentially, provide data to support assurance certification.

There are further stakeholders with interests in a national digital twin. These include transport authorities, roads infrastructure companies, utilities companies, emergency services, etc. By taking account of their various uses and developing a digital model which meets their needs for content, resolution, spatial data format, etc., a national digital twin could achieve maximum impact.

## *National digital twin*



# National digital twin

## Needs

The success of the national digital twin depends on its ability to meet user needs effectively, underpinned by the identification and agreement of data content, format and sources.

The first pathway milestone, *Identify potential digital twin users, and users' needs 2022-2022* starts with the end in mind, seeking to identify dynamic users and understand their needs, particularly for considerations such as fidelity, latency and availability. These needs could correspond to use cases such as navigation re-routing, risk mitigation and road network management.

Based on these needs, the following milestones, *Identify potential dataset sources 2023-2023, and Agree data contents and format 2023-2023*, seek to establish the data content, format and sources required. Authorisation and authentication of data are paramount to ensure trustworthiness of the national digital twin. This, coupled with the agreement on open, common formats (e.g. OpenDRIVE, OpenSCENARIO), ensures the overall capability is assured and widely compatible for digital twin users.

## Solution

Once the digital twin needs and data sources are established, the required digital infrastructure must be defined, *Define digital twin architecture and data distribution 2024-2024 and data collected, Collect digital twin dataset* 2024-2025. This will involve all stakeholders defining and agreeing a common approach for the geospatial and data architectures, and content specification, which will then enable the large-scale data gathering and modelling that is required for operation.

*Define digital twin ownership and governance* 2025-2025 and *Determine value / financial management* 2025-2025 then focus on the ownership and financial management considerations for operation. These activities will be crucial in defining robust governance structures, including responsibilities and liabilities involved.

## Trial and operate

A trialling period for the digital twin will be crucial to ensure safe, secure and beneficial operation. This process begins with *Identify trial participants and plan pilot trials* 2024-2024 which prepares for *Undertake trial and refine* 2025-2026 where the digital twin will be assessed, reviewed and refined through iterative loops of trialling.

The results and findings of the trialling will inform *Ongoing digital twin operation and growth* 2026-2030, involving ongoing developments in coverage, updates and fidelity, as well as maintenance of the capability.

Outcomes

## Sharing models IP

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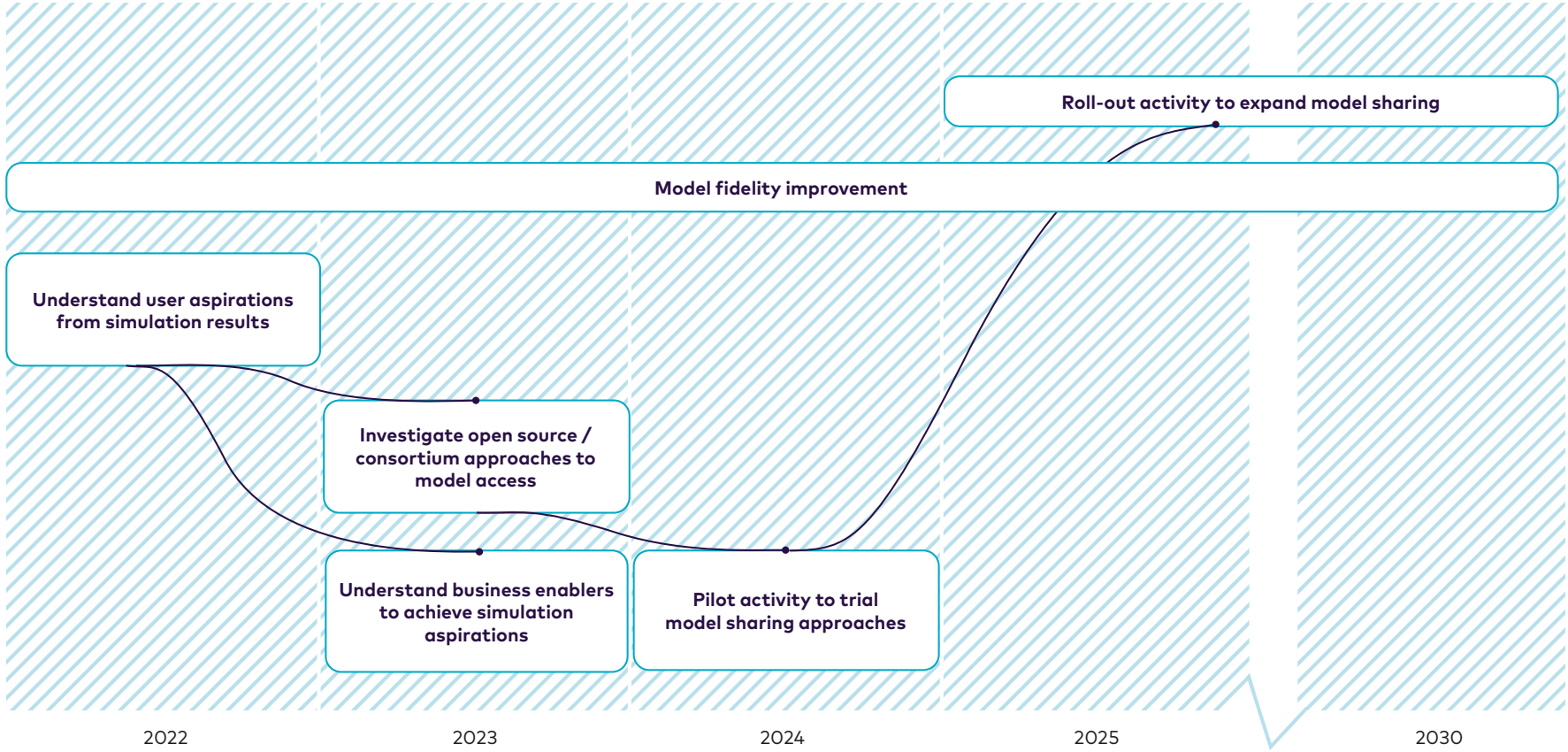
While some technical approaches exist which attempt to protect IP, such as turning models into executable functions or locating models remotely with only input and output signals available, these are neither foolproof nor common. Nor are there enough robust approaches to providing accompanying verification evidence or accepting responsibility for model outputs. For simulation to be fully utilised in development and certification, the barriers to the sharing of simulation models between CAM value chain stakeholders must be addressed, in commercial, legal, and technical terms.

## *Sharing models IP*



Outcomes

# Sharing models IP

## Aspirations and understanding

It's important to begin this pathway with the end in mind, to *Understand user aspirations from simulation results* 2022-2022. This will involve consulting a wide range of stakeholders on their individual aspirations, seeking to align them into a consensus view, particularly regarding certification support.

To achieve these aspirations, two key next steps are to *Understand business enablers to achieve simulation aspirations* 2023-2023 and *Investigate open source / consortium approaches to model access* 2023-2023. The first will investigate and agree the contractual and commercial enablers to achieve aspirations, particularly relating to enabling common activities, IP access and model sharing. The second will explore open source and pre-commercial consortium approaches to model access, which will complement the national digital twin.

## Fidelity

An ongoing activity, stretching beyond the timeframe of the roadmap, is *Model fidelity improvement* 2022-2030. This encapsulates the continuous improvement of simulation model fidelity (e.g. environmental conditions, dynamic elements, sensors), which is crucial to modelling the physical world ever more accurately in simulation.

## Development

Building on the prior activities, periods of trialling, *Pilot activity to trial model sharing approaches* 2024-2024, and roll-out, *Roll-out activity to expand model sharing* 2025-2030, should take place. These activities will investigate common interfaces and technical frameworks for trusted model sharing, whilst also seeking to improve model coverage, and refine and update the processes through which models are shared.

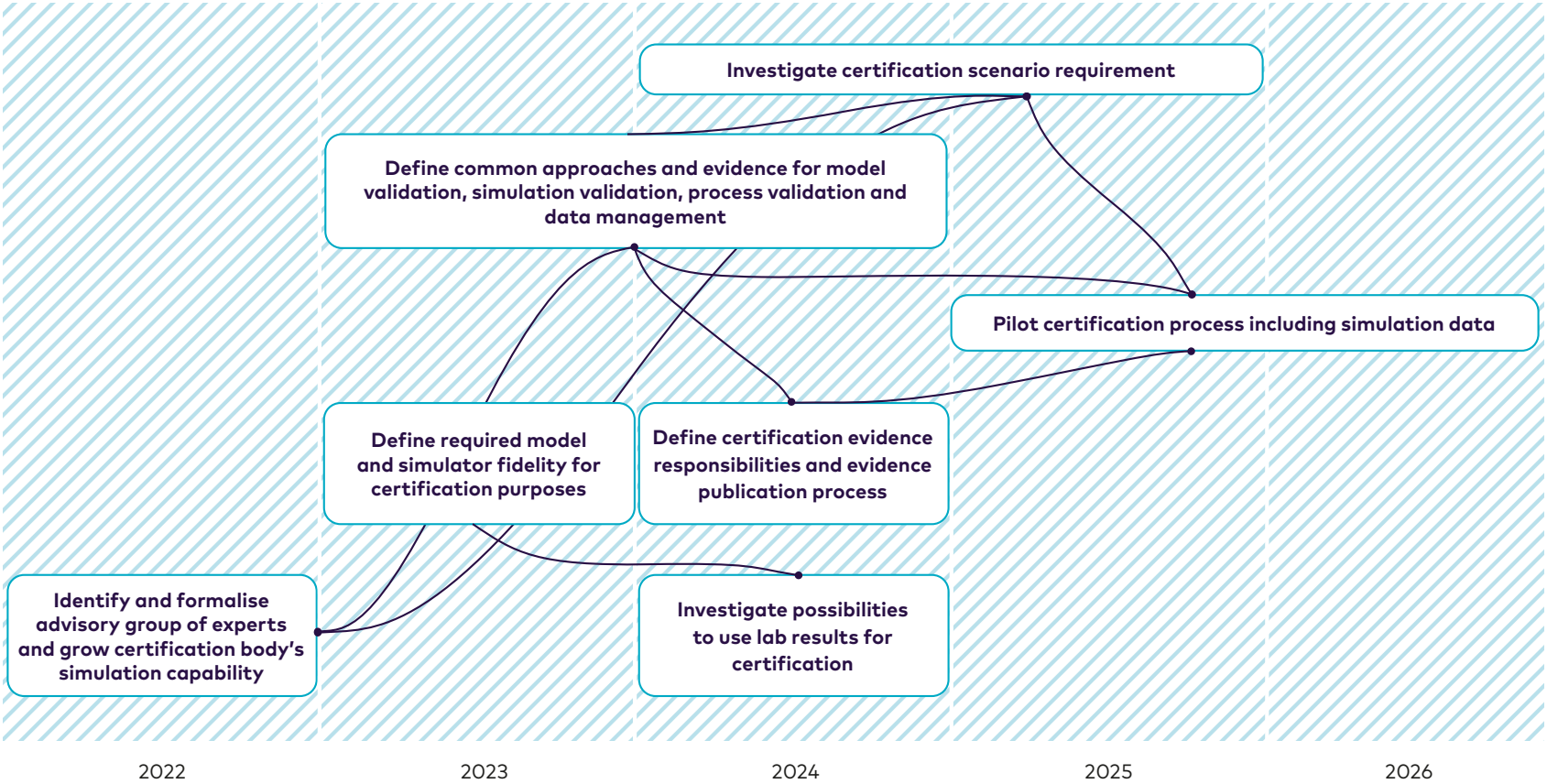
# Certification support

*It is widely acknowledged that CAV certification and assurance will require more data evidence than can be collected by physical testing alone. It is expected that simulation results will make up this shortfall.*

However, greater understanding will be required on the part of developers and certification bodies about the expectations on, and capabilities of, simulation. Such understanding will lead to defined approaches that shall deal with not only simulation results, but also approaches to how simulation models are created and verified, version managed, used and maintained, and how their data outputs are collected and processed.

This activity is a major undertaking that will require the collective effort of specialists and stakeholders from across the CAM value chain, but the outcome will provide critical benefits without which CAM deployment will be difficult.

### *Certification support*



Outcomes

# Certification support

## Definitions and requirements

*Identify and formalise advisory group of experts and grow certification body's simulation capability* 2022-2022 begins this pathway as the first, foundational milestone. A diverse group of experts will be required to review and agree common approaches and provide support to assurance bodies. These bodies will need to build up modelling and simulation understanding as it plays a growing role in certification processes.

There will need to be capability built up to undertake simulation for the purposes of assurance, or re-run simulations (e.g. investigations). This capability could belong to the assurance bodies, or dedicated independent / third parties. These roles and responsibilities should be agreed through the course of this pathway.

The advisory group established, and related stakeholders, will be responsible for the definitions and investigations across the following activities in this pathway:

- *Define common approaches and evidence for model validation, simulation validation, process validation, data management* 2023-2024
- *Define required model and simulator fidelity for certification purposes* 2023-2023
- *Investigate certification scenario requirement* 2024-2025
- *Investigate possibility to use lab results for certification* 2024-2024

These activities, alongside *Model fidelity improvement* 2022-2030, as outlined under the *Sharing models IP* section, will form core building blocks of the certification process. These will span considerations such as simulator performance, model fidelity performance, adherence to defined methods, acceptance of 'X'-in-the-Loop (XiL) testing for assurance and the potential need for a standardised set of scenarios with sufficient coverage.

## Evidencing

Simulation evidence will be central in adhering to the certification process. *Define certification evidence responsibilities and evidence publication process* 2024-2024 will define the relevant responsibilities between assurance body and manufacturer such as tool validation, evidence gathering and running simulation testing. This activity will also define the role of third party tools and models. A standardised certification publication method will be defined, and consultation undertaken with potential operators and the public regarding use of and presentation of simulation results.

## Pilot

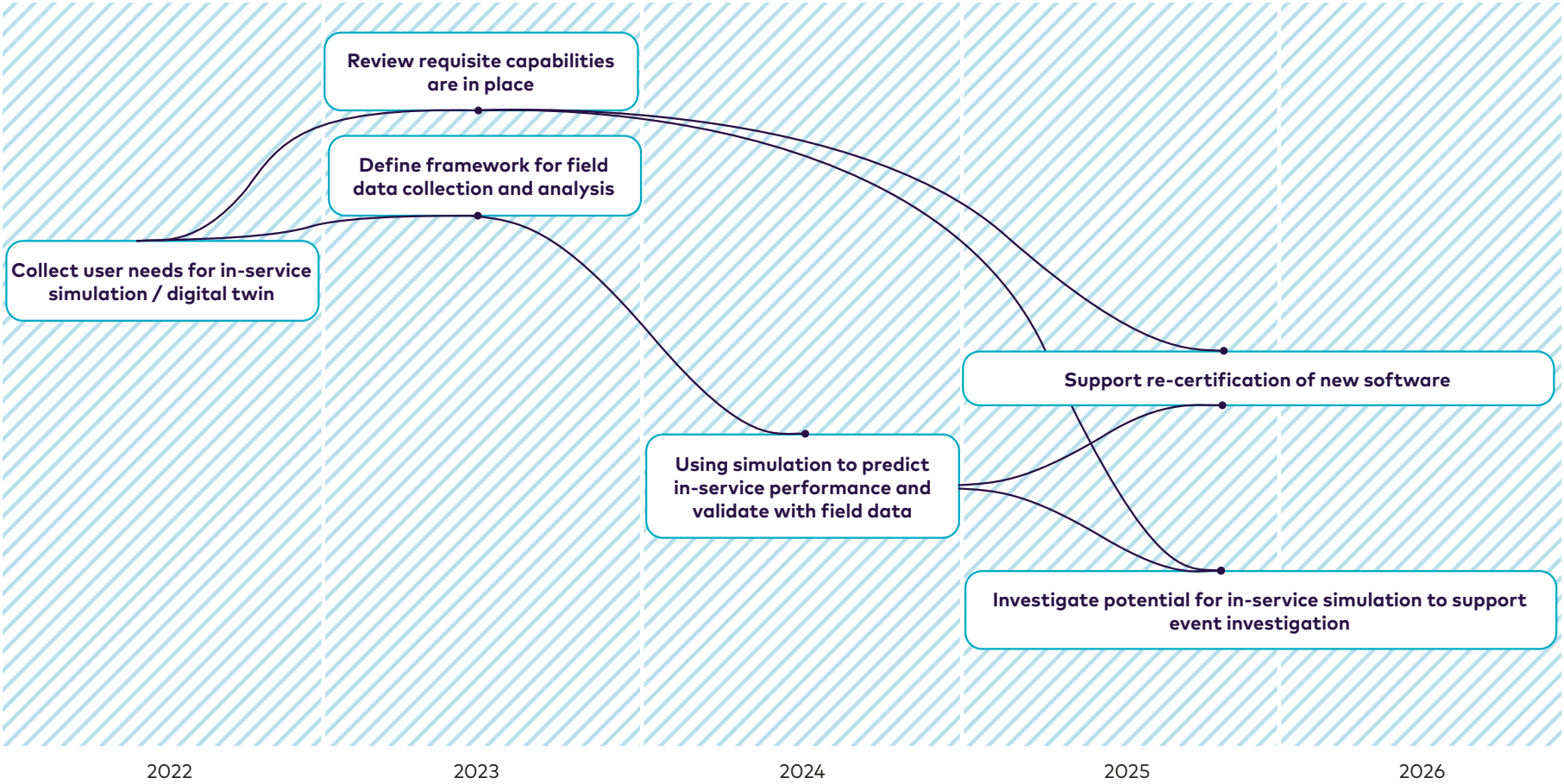
Once the foundational definitions, requirements and evidencing considerations have been addressed a *Pilot certification process including simulation data* 2025-2026 will begin. This will build up a comprehensive body of initial verification data through trials covering various applications and ODDs.

# In-service support

*Data gathered during CAV deployment will offer opportunities to developers and other stakeholders to improve their detailed understanding of CAV operation, that can be reflected into improved simulation or further verification of existing simulation. Such simulation capability could support re-certification where vehicle updates need to be made in-service. It could also support performance prediction activity and help understand any tolerances on design domain limitations, so that CAV operation might be modified.*

A further use will be to support independent investigation of events involving collisions or unexplained behaviour, and potentially inform recommendations made by accident investigation agencies in other travel sectors. An important enabler for this will be a framework for collection of field data.

### *In-service support*



Outcomes

# In-service support

## Needs and capabilities

Establishing needs, *Collect user needs for in-service simulation / digital twin* 2022-2022 and current capabilities to address them, *Review requisite capabilities are in place* 2023-2023 forms the first part of this pathway. These activities will seek to understand user needs of a vehicle product digital twin from manufacturer, operator and assurance body stakeholders. Then by assessing the maturity of the national digital twin and simulation capabilities, the ability to meet these needs with requisite capabilities can be assessed.

## Performance and analysis

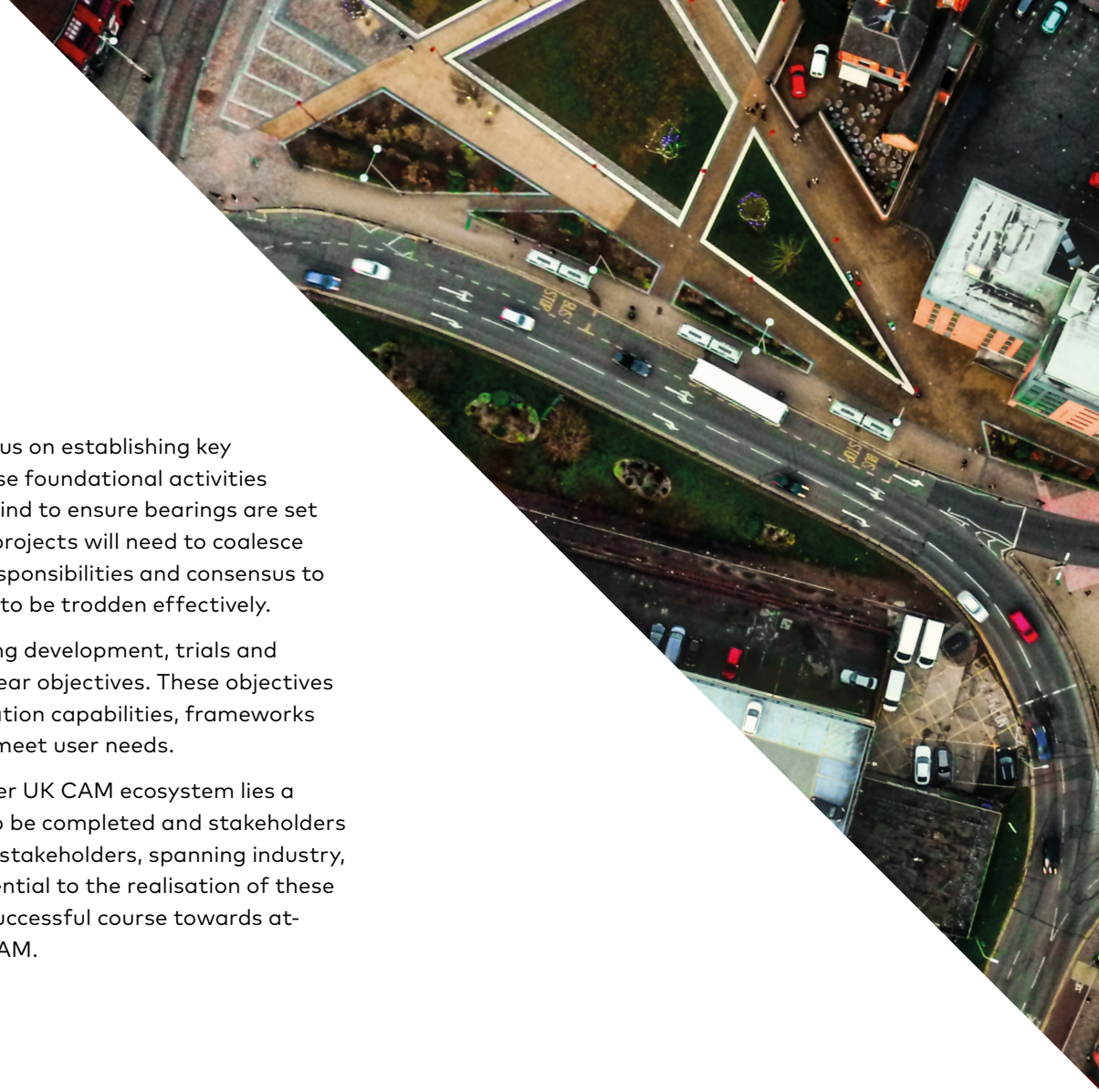
The ability to analyse vehicle performance through in-service support capabilities is a primary goal of this pathway. *Define framework for field data collection and analysis* 2023-2023 will establish a data collection and analysis framework to analyse Field Operational Test (FOT) vehicle data and events. *Using simulation to predict in-service performance and validate with field data* 2024-2024 will utilise in-service data to predict future vehicle performance, investigate current service performance and investigate the functional behaviour of potential new software.

## Updates and event investigation

Two additional aspects with potential to be supported by in-service support are new software updates and event investigation. *Support re-certification of new software* 2025-2026 will explore the potential for shadow running to assess new vehicle functionality before it's certified and updated to a vehicle. *Investigate potential for in-service simulation to support event investigation* 2025-2026 will undertake simulation projects that reconstruct collision / incident scenarios to better understand causes and liabilities in these events. The findings of these projects can support investigating experts and authorities in developing their understanding.

# What's next?

*This roadmap lays out clear pathways towards key simulation outcomes for CAM. But this is just the beginning. With the pathways laid, their undertaking begins.*



Early activities across all pathways focus on establishing key definitions, needs and aspirations. These foundational activities must have the pathway outcomes in mind to ensure bearings are set correctly. Key stakeholder groups and projects will need to coalesce around these activities, establishing responsibilities and consensus to enable the remainder of the pathways to be trodden effectively.

With strong foundations set, proceeding development, trials and deployment can take place based on clear objectives. These objectives will guide the approach towards simulation capabilities, frameworks and processes required, ensuring they meet user needs.

Even in this one component of the larger UK CAM ecosystem lies a broad and diverse range of activities to be completed and stakeholders involved. Collaboration between these stakeholders, spanning industry, academia and government, will be essential to the realisation of these simulation outcomes, setting us on a successful course towards at-scale deployment of safe and secure CAM.

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