A digital roadmap

FOR THE UK AUTOMOTIVE INDUSTRY

For more details please contact Andy Scarisbrick:
Email – andy.scarisbrick@DETC.uk
Tel - 02038235656

VERSION CONTROL

Version	Date	Author	Comments/Changes
1.0	18.05.16	A. Scarisbrick & S. Pereira	First published version.
1.1	02.06.16	S. Pereira	EMF roadmap pictures added.
1.2	27.06.16	A. Scarisbrick	APC modifications included
1.3	11.07.16	S. Pereira	Further APC modifications included.

CONTENTS

1 EXECUTIVE SUMMARY

The Advanced Propulsion Centre (APC) has been "set up to secure the long term future of the automotive sector by growing the UK share of the value chain and by getting ahead of the game in research and development (R&D) on ultra-low emission vehicles." It is widely accepted that the calibre of the R&D and innovation carried out in the UK is excellent, however the proportion of this innovation that reaches production is low. In order to improve this, the roadblocks that impede the flow of innovative R&D to the OEMs and Tier 1s must be identified and removed. The Digital Engineering and Test centre (DETC) aims to play a key role in this process through the coordination, development, dissemination and application of the enabling digital engineering tools and methodologies. The first step towards this goal was a workshop attended by an invited audience from academia, OEMs, tier 1 suppliers, the supply chain and representatives from the gaming sector. The goal of the workshop was for each of four breakout groups to identify the drivers and vision for these tools as well as the tasks that will be required to attain this vision. The subsequent analysis of the tasks, augmented with a literature review has resulted in a roadmap separated into a number of challenges:

1. Framework for collaboration.
2. Virtual environment, tools and interfaces.
3. Models that are fit for purpose.
4. Creating and handling large data sets.
5. Real time testing and optimisation.
6. Training requirements and opportunities.
7. Political and business relationships and licensing models.

In addition to the above challenges that were generic to all the breakout groups, the Gaming Methods and Tools group had two additional challenges:

8. Zero Physical Testing
9. Smarter Factories

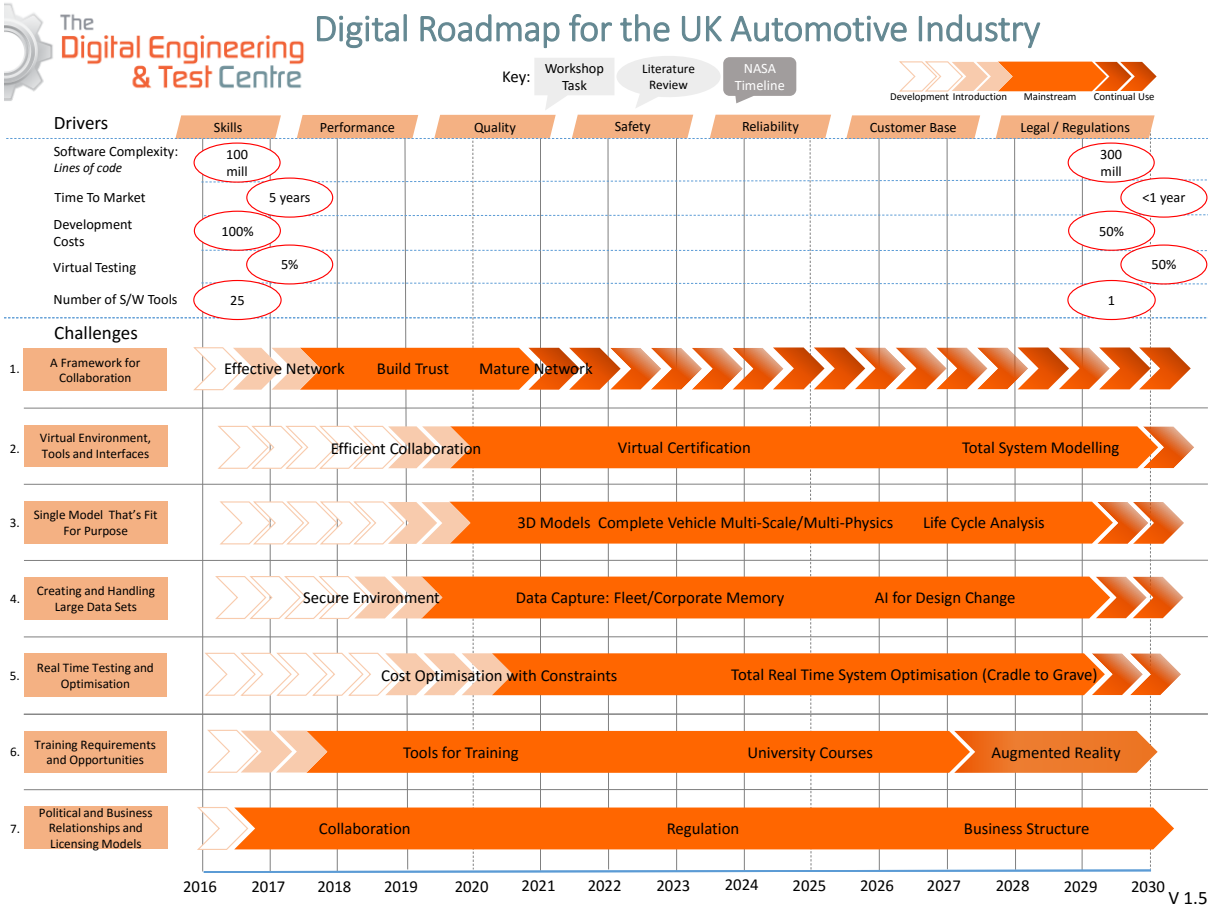


Figure 1 Digital Engineering & Test Roadmap 2016

2 MOTIVATION

Digital engineering and test is a vital part of tomorrow's manufacturing, product development and testing. For the UK to remain competitive as a leading automotive producer it must adopt and develop digital tools to make manufacturing more efficient and compete with low cost labour.
In product design environments, digital tools allow products to be visualised and tested under multiple conditions, cutting down the development costs and reducing the time to market.
The UK is currently at risk of falling behind other nations in adopting digital technologies. With its advanced research and development culture and a growing manufacturing capability, the UK is well positioned to succeed in an increasingly competitive global market, provided it can identify and encourage the necessary enablers.
The roadmap looks to identify the tasks in the field of digital engineering and test required to secure a future for automotive product design and manufacture. Its aim is to identify the state of digital engineering and test in the UK and to predict the progress required over the next 15 years.

3 OBJECTIVE AND WHO THIS ROADMAP IS INTENDED FOR

This roadmap is intended to provide DETC, their host organisations and affiliates with a scope for the work they will be required to undertake over the next 5 years and possibly beyond. The DETC has a management board and an advisory board who will refer to this document to identify and regularly prioritise the centre's goals and direction. The raw results and the conclusions reached have been made available for inclusion into the Automotive Council digital roadmap. The roadmap will be re-visited on a regular basis to take into account changes in industry requirements and advances in technologies available.

3.1 WHAT THIS ROADMAP IS NOT INTENDED FOR.

The resources available will not allow all the areas identified to be studied within DETC. Regular prioritisation by the management board and the advisory board will aim to maximise the value of the available resources.

4 WORKSHOP

The roadmap was developed through in-depth research and consultation with automotive industry and academic experts as well as representatives from the gaming industry. The major source of data for the roadmaps was obtained from a 1-day workshop where 52 delegates from an invited list of over 80 individuals attended. Delegates were selected to represent a range of organisations including OEMs, tier1s, suppliers, consultants and academia. Several representatives from outside the automotive industry were invited including specialists from finance, visualisation, digital media, defence, simulation and testing. These representatives were invited to develop an understanding of how innovations in other industries can benefit the automotive industry.

4.1 WORKSHOP OBJECTIVE AND SCOPE

The aim of the day was deliberately very focussed:

"To identify the digital tools required to support the UK automotive industry leading to 2030."

The scope was also kept simple with all contribution assumed to be in scope. It was felt that imposing bounds on the scope would restrict ideas.

4.2 PROCESS

The workshop was split into two breakout sessions each preceded by presentations designed to encourage delegates to think without constraints. For the breakout sessions the delegates were split into four groups as detailed in (Scarisbrick, Roadmap Workshop Breakout Process, 2016).

- Manufacturing 10 delegates
- Gaming methods and tools 14 delegates
- Product development 13 delegates
- Testing 15 delegates

Delegates were arranged in groups to give a good range of expertise within each group. Delegates were not necessarily allocated to groups on the basis of their expertise. Each group was allocated a leader with particular experience in the area as well as a facilitator whose role was to manage the process and ensure that the whole group participated in the conversation and any decisions that were made. The ideas for each breakout group were recorded onto cards using a different colour card for each of the tasks.

The process is described in more detail in (Scarisbrick, Roadmap Workshop Breakout Process, 2016).

4.3 DRIVERS

The drivers ask the question: Why do we have to change the way we work? This was the first task that the breakout groups were asked to carry out. A number of generic drivers had been identified before the workshop such as Skills, Quality and Safety; the teams were asked to add to the list if necessary and quantify some of these.

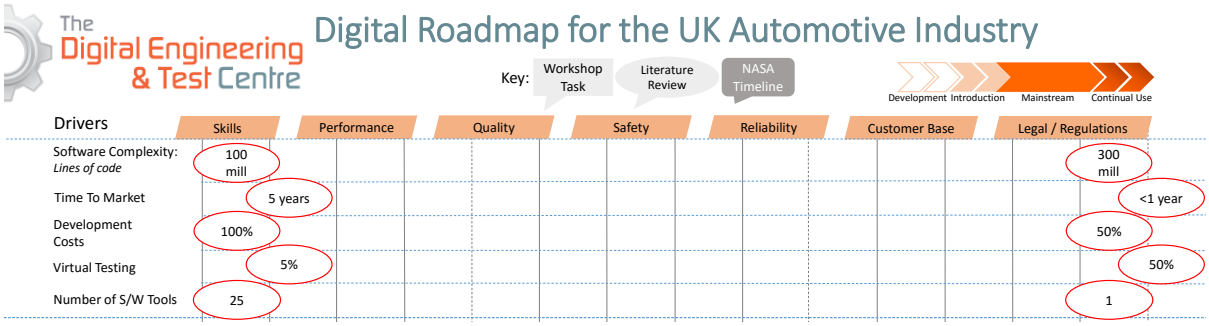


Figure 2 Drivers in Digital Engineering & Test Roadmap 2016

Generic drivers were not considered in detail however several references were made to the generic "Customer base" driver including:

- How will market demand influence changes to digital developments?
- How will the market react to changes in digital developments?

Answers to these questions are out of scope for this exercise.

The drivers that were quantified by the Product and Manufacturing teams were:

- Software complexity - It was agreed that this metric could be measured by the lines of code likely in a high end production vehicle, increasing from 100 million in a current vehicle to 300 million in 2030. This will drive the need for automated software development and verification.
- Time to market - DETC has declared an objective to halve the development time however the consensus of the groups was that the driver was to reduce the time to market from the current 5 years to less than 1 year by 2030.
- Development costs - DETC has also declared an objective to halve the development cost. This driver metric was unchanged with the timeframe being 2030.
- Virtual testing - Reduced development time and cost are expected to be delivered largely through an increase in the proportion of testing and verification carried out in simulation. The target agreed was to increase the proportion of virtual testing carried out from 5% to 50% by 2030. The proportion of virtual verification would be significantly lower than this.

- Number of software tools - This additional metric was identified by the Manufacturing team. The driver is the need for improved communication between software tools with the target to decrease the different platforms from 25 to a single integrated system by 2030.

4.4 HORIZONS

Although not explicitly identified in the workshop, the three horizon model was used to structure the thinking of the breakout groups. Each breakout group was asked to concentrate on their particular area: Manufacturing, Gaming methods, Product development and Testing. More details are given in (Scarisbrick, Roadmap Workshop Breakout Process, 2016).

Horizon 3 was discussed first in order to answer the question; what digital goals (tools and processes) will be required in 2030 if the automotive industry is to meet all the drivers already discussed?

Horizon 1: Each team was then asked to identify what the industry is currently doing that might help us get to these goals?

Horizon 2: This was the most important task of the workshop as it aimed to identify what has to be achieved to take the industry from Horizon 1 (today) to Horizon 3 (2030) and therefore the likely tasks and potential deliverables of DETC.

The outputs from these breakout sessions are shown in (Walsh & McConaghy, 2016).

Figure 3 The three horizons into which the workshop was divided. (DETC 2016)

4.5 WORKSHOP ANALYSIS

Following the workshop, the raw data obtained in the form of cards from each group: Product, Manufacturing, Test and Gaming Methods and Tools was used to capture both strategic and tactical aspects of where the industry is predicted to be in 2030, where it is currently considered to be and what will be required to bridge the two.

In order to produce the final roadmap, the data collected from the workshop was recorded in both a graphic and spreadsheet format. This enabled the ideas to be re-ordered and re-categorised until similar themes were seen between the separate groups (Scarisbrick & Pereira, Workshop Verbatim Analysis, 2016). These themes were then renamed as Challenges, where 7 were common in all four roadmaps.

5 LITERATURE SEARCH

A literature search was executed in two phases; pre workshop and post workshop.

5.1 PRE WORKSHOP

An initial literature search of academic papers was carried out in order to familiarise the team with the possible technical areas that might be covered in the workshop. The results were collated and organised in a spreadsheet (Kirby, Ingram, & Pereira, 2016) for each of the following categories: Gamification, Manufacturing, Product, Virtual Reality and Augmented Reality. Each having challenges with industrial needs that subcategorised into:

- Targets – Interim, short term and vision
- Key Performance Indicators
- Applications in Digital Engineering

5.2 POST WORKSHOP

The post workshop literature search was carried out by re-analysing the original literature search in order to establish if there were any challenges or tasks that were missed by the workshop. The challenges in the original search that weren't raised in the workshops were evaluated and included in the roadmap as separate circular callouts, as opposed to the rectangular speech boxes that represented the workshop data.

This search included papers and technology roadmaps carried out by other organisations. The two roadmap examples that were most influential were:

- (Jackson, 2015) Energy & Fuels Road Map. Automotive Council UK. The format of this roadmap was chosen as it is the most recent example of the Automotive Council's preferred road-mapping approach.
- (NASA, 2015). NASA Technology Roadmaps TA 11: Modelling, Simulation, Information Technology, and Processing. NASA Technology Roadmaps. The technical content of this roadmap is very detailed and the process used rigorous. The timing of the Virtual environment, Single model, Data and Optimisations challenges were checked against this NASA roadmap.

6 CHALLENGES

The Challenges form the framework of the final roadmap. Each challenge will have its own potential deliverables:

1. Framework for collaboration.

A network is required that will encourage the active participation of all parties who could potentially benefit from this initiative; from individual inventors to OEMs, from academia and industry and from all industrial sectors.

   a. Who are the interested parties?
   b. How do all the interested parties work together?
   c. What are the agreed objectives?

2. Virtual environment, tools and interfaces.

The network created in Challenge 1 will require a simulation environment in which:

   a. Ideas, issues and solutions can be shared, providing a shop window for innovators.
   b. OEM and Tier 1 requirements can be disseminated.
   c. Solutions can be tested.
   d. Affordable access to tools can be provided for all.
   e. All users are confident that their data and IP is secure and their technical and business requirements are paramount.

3. Models that are fit for purpose.

The simulation environment will require models. In order to deliver these models efficiently the environment would encourage:

   a. A detailed description of the shortfall of existing models and the resulting objective and specification for each new model required.
   b. Coordinated national effort to develop the models required for the jobs identified, thereby minimising duplication.
   c. Tracking and protection of any IP associated with each model.

4. Creating and handling large data sets.

High quality models will require:

   a. Sharing of and secure access to high quality data
   b. Access to data sets suitable for the task required of the model.
   c. Affordable access to high performance computing.

It is also predicted that the volume of customer data available will increase dramatically. This data will need similar tools to allow high quality information to be extracted from it.

5. Real time testing and optimisation.

Armed with suitable models and a national simulation environment, it will be possible to:

   a. Carry out networked HIL (Hardware in the loop), SIL (software in the loop), CIL (component in the loop) and PIL (processor in the loop) testing.
   b. Develop and assess the latest optimisation algorithms and tools.
   c. Provide all parties with affordable access to these tools and high performance computing.

6. Training requirements and opportunities.
   a. What training is required to achieve these challenges and deliverables?
   b. How can the tools be used to train existing and new engineers?
7. Political and Business relationships and Licensing Models.
   a. How do we create a sustainable business model for DETC?
   b. How can we leverage funding opportunities?

Many of the tasks identified in the workshop called for political and business changes that are beyond the scope of DETC, however these have been included here for completeness.

- How can we influence international standards?
- What regulations/policies will be needed to achieve/facilitate the goal?
- Are there any regulatory barriers?
- What are the current economic barriers?

In addition to the above challenges that were generic to all the breakout groups, the Gaming Methods and Tools group had two additional challenges:

8. Zero Physical Testing
    a. What training is required to achieve these deliverables?
    b. What tools are needed to deliver virtual test capability for zero Physical Testing?
9. Smarter Factories
    a. How do we create an Internet of Things connectivity toolset?
    b. How can we develop AI controlled reconfigurable manufacturing systems?

The Gaming roadmap is reported in more detail in a separate document (Rampersad & Ingram, 2016) "A digital roadmap for gaming methods and engineering tools."

7 ROADMAP GRAPHICS

Appendix A: Roadmap. Includes a single graphic showing all the challenges as well as further details of each of the challenges. The individual challenges are each shown with a summary of the ideas from all of the breakout groups, additional ideas from the literature search and possible technology introduction dates taken from the NASA report. (NASA, 2015). Slide 5 in Appendix A includes a guide to the terminology and graphics used.

8 NEXT STEPS

Challenge 1 from the roadmap is to create a 'Framework for collaboration'. The first steps towards achieving this will include:

- Disseminate findings to:
    - DETC Advisory board
    - Participants and invitees to the workshop.
    - APC hub and spokes.
    - DETC launch on 16th June 2016
    - Create and promote a LinkedIn group.
- Add to this report by further cross referencing the tasks and challenges to:
    - The upcoming Automotive Council roadmap on Digital tools. Close collaboration between the authors of both roadmaps has identified good levels of agreement despite the different objectives and target audiences.
    - Recent global publications to establish the state of the art.
    - UK funding since 2010 to establish the current expertise.

Challenge 2 from the roadmap is to develop a virtual environment. This will require:

- Identify resources available (heads and tools)
    - Within affiliates of DETC - this support will qualify for matched government funding.
    - Within spokes
    - From other potential members. Use LCV2016 to promote need for affiliates and other contributors.
    - From past effort in the public domain.
- Identify gaps in knowledge, tools and heads prior to recruiting core DETC heads and PhDs.
- Create 5 year plan to fill these gaps bearing in mind the need to have a sustainable business model when matched funding is not available.

9 CONCLUSION

Following the workshop, a peer reviewed process has been executed that the authors are confident has resulted in a roadmap that will contribute to the future decisions of the customer audience. Using a combination of a day long workshop attended by 52 delegates from the automotive industry and other interested sectors as well as a literature search, a total of seven generic challenges and two gaming specific challenges were identified. All the tasks identified during the workshop were categorised into one or more of these challenges. This roadmap and the identified challenges will form a firm foundation on which to build an environment that is capable of providing the tools and skills required to support the long term digital aspirations of the UK automotive industry.
This document and the associated roadmap will be revisited as more contributions are received, as technology advances or as requirements change.

10 BIBLIOGRAPHY

Horsley, J., & Scarisbrick, A. (2016). *Digital Engineering Roadmap Workshop.* DETC.

Jackson, N. (2015). *Energy & Fuels Road Map.* Automotive Council UK. Retrieved March 2016

Kirby, J., Ingram, M., & Pereira, S. (2016). *Digital Roadmap Literature Search.* DETC. Retrieved from C:\Users\andy.scarisbrick\SharePoint\Kevin Rampersad 1\DE&T Shared Documents\Road Maps\Workshop references

NASA. (2015). *NASA Technology RoadmapsTA 11: Modeling, Simulation, Information Technology, and Processing.* NASA Technology Roadmaps. Retrieved April 2016

Petrick, I. J. (2008). *Developing and Implementing Roadmaps – A Reference Guide.* The Pennsylvania State University. Retrieved March 2016

Rampersad, K., & Ingram, M. (2016). *A digital roadmap for gaming methods and engineering tools.* DETC.

Scarisbrick, A. (2016). *Roadmap Workshop Breakout Process.* DETC.

Scarisbrick, A., & Pereira, S. (2016). *Workshop Verbatim Analysis.* DETC.

The Advanced Propulson Centre. (2013). *Internal Combustion Engines: UK Opportunities.* Automotive Council UK.

Walsh, R., & McConaghy, R. (2016). *DETC Roadmap Workshop 2016 Write Up.* Simply Change.

11 APPENDICES:

11.1 APPENDIX A: ROADMAP.

Digital Roadmap for the UK Automotive Industry

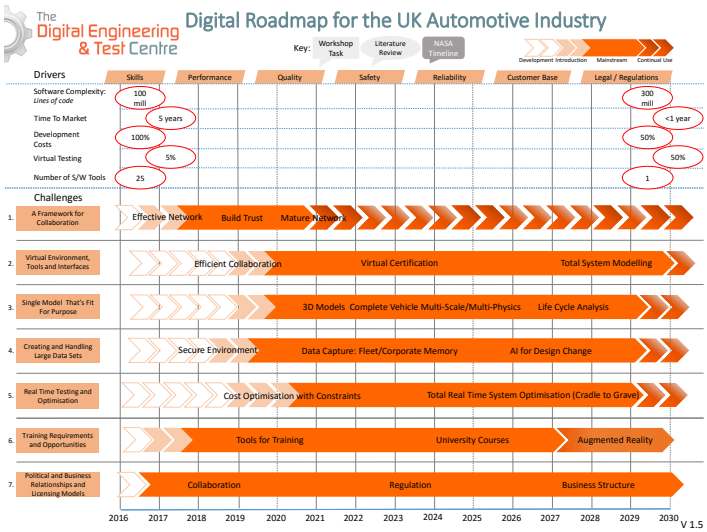
May 2016

www.detc.uk

V 1.5

Roadmap Overview

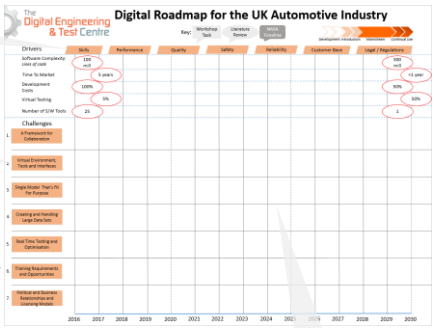
- Digital engineering and test is a vital part of tomorrow's automotive industry including product development, testing and manufacturing.
- For the UK to remain competitive as a leading automotive producer it must become more efficient through the development and application of digital tools.
- With its advanced research and development culture and a growing manufacturing capability, the UK is well positioned to succeed in an increasingly competitive global market, provided it can identify and encourage the necessary enablers.
- This roadmap looks to identify the tasks in the field of digital engineering and test required to secure a future for automotive product design and manufacture. Its aim is to identify the state of digital engineering and test in the UK and to predict the progress required over the next 15 years



- The Automotive Council and the Digital Engineering and Test Centre have worked in parallel on complementary digital roadmaps. These initiatives were created in close collaboration but used different processes as they are intended for different audiences and cover different timeframes. Unsurprisingly, they have arrived at similar conclusions.

V 1.5

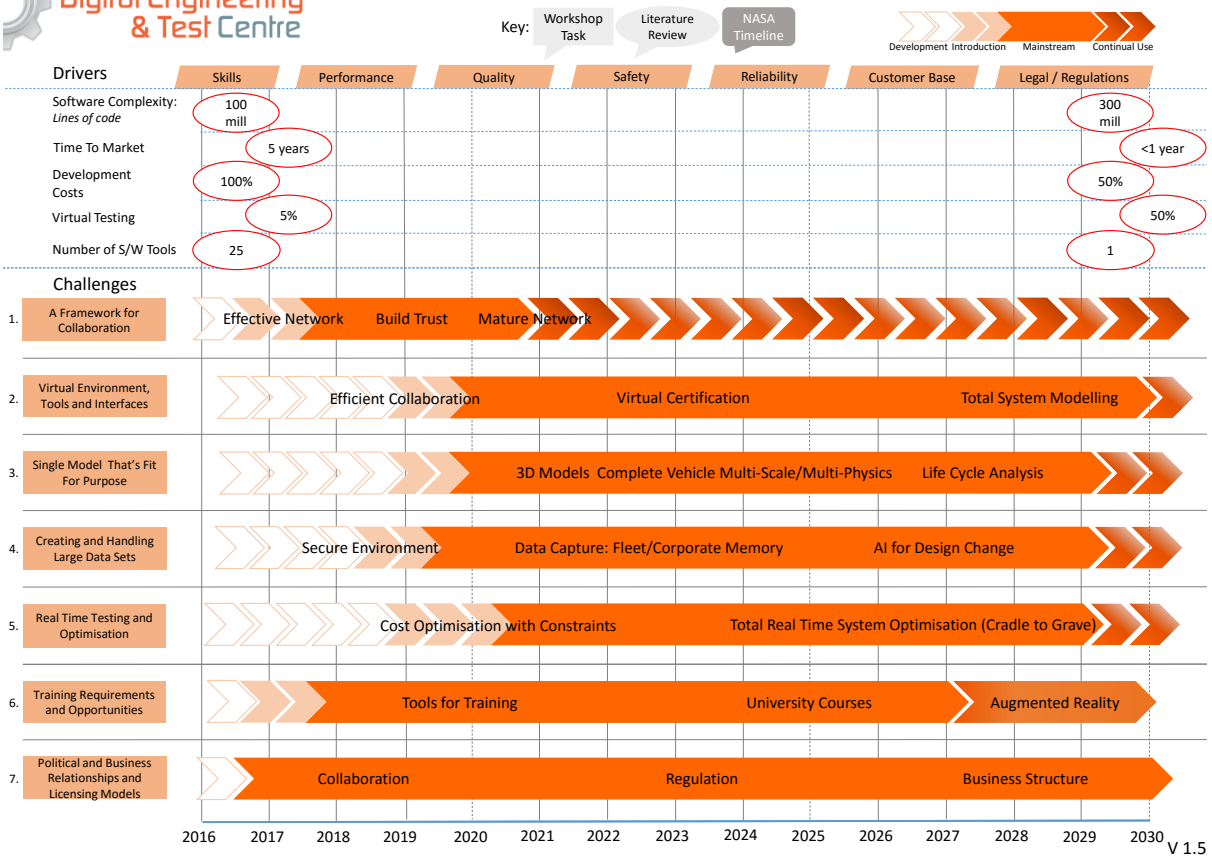
Challenges



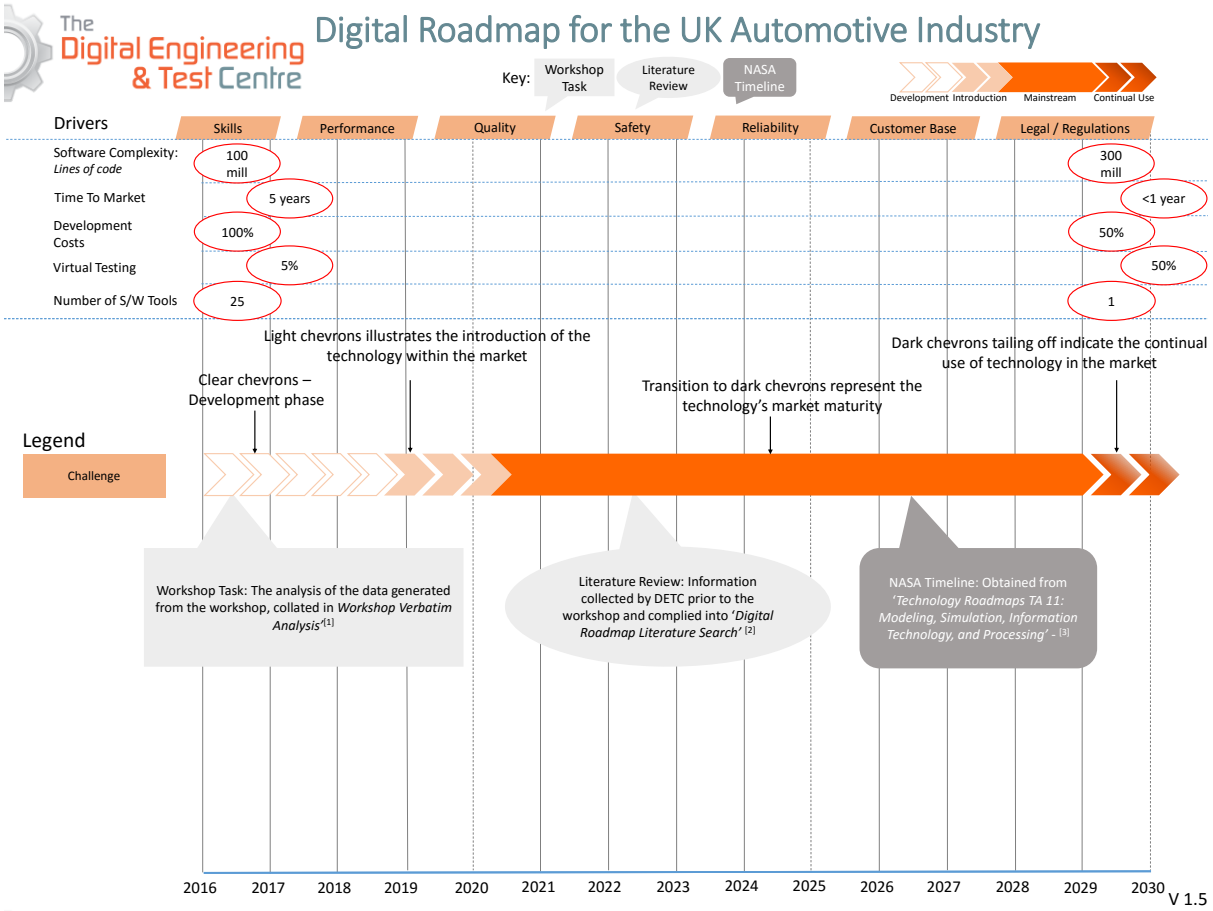
1. Framework for collaboration
   - Who are the interested parties?
   - How do all the interested parties work together?
   - What are the agreed objectives?
2. Virtual environment, tools and interfaces
   - A virtual environment where:
     - Ideas, issues and solutions can be shared. A shop window for innovators.
     - OEM and Tier 1 requirements can be disseminated
     - Solutions can be tested.
   - Affordable access to tools for all
3. Single model that is fit for purpose.
   - Coordinated national effort to develop the models required for the jobs identified.
4. Creating and handling large data sets.
   - Sharing of and secure access to high quality data
   - Access to data sets suitable for the task required of the model.
   - Affordable access to high performance computing.
5. Real time testing and optimisation
   - Development and assessment of latest optimisation algorithms and tools.
   - Affordable access to these tools and high performance computing.
6. Training requirements and opportunities
   - What training is required to achieve these deliverables?
   - How can the tools be used to train existing and new engineers?
7. Political and Business relationships and licensing models
   - How do we create a sustainable business model for DETC?
   - How can we leverage funding opportunities?
   - How can we influence international standards?

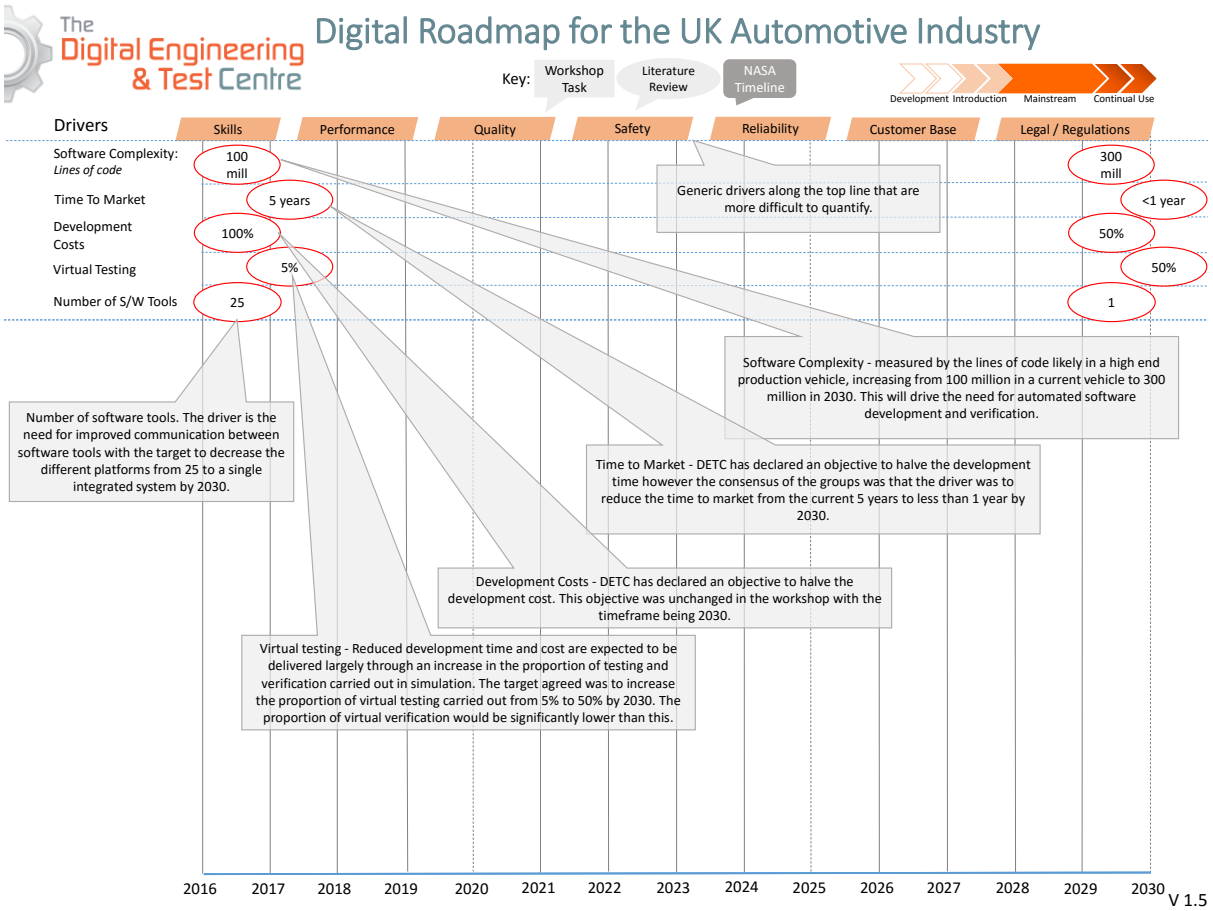
V 1.5

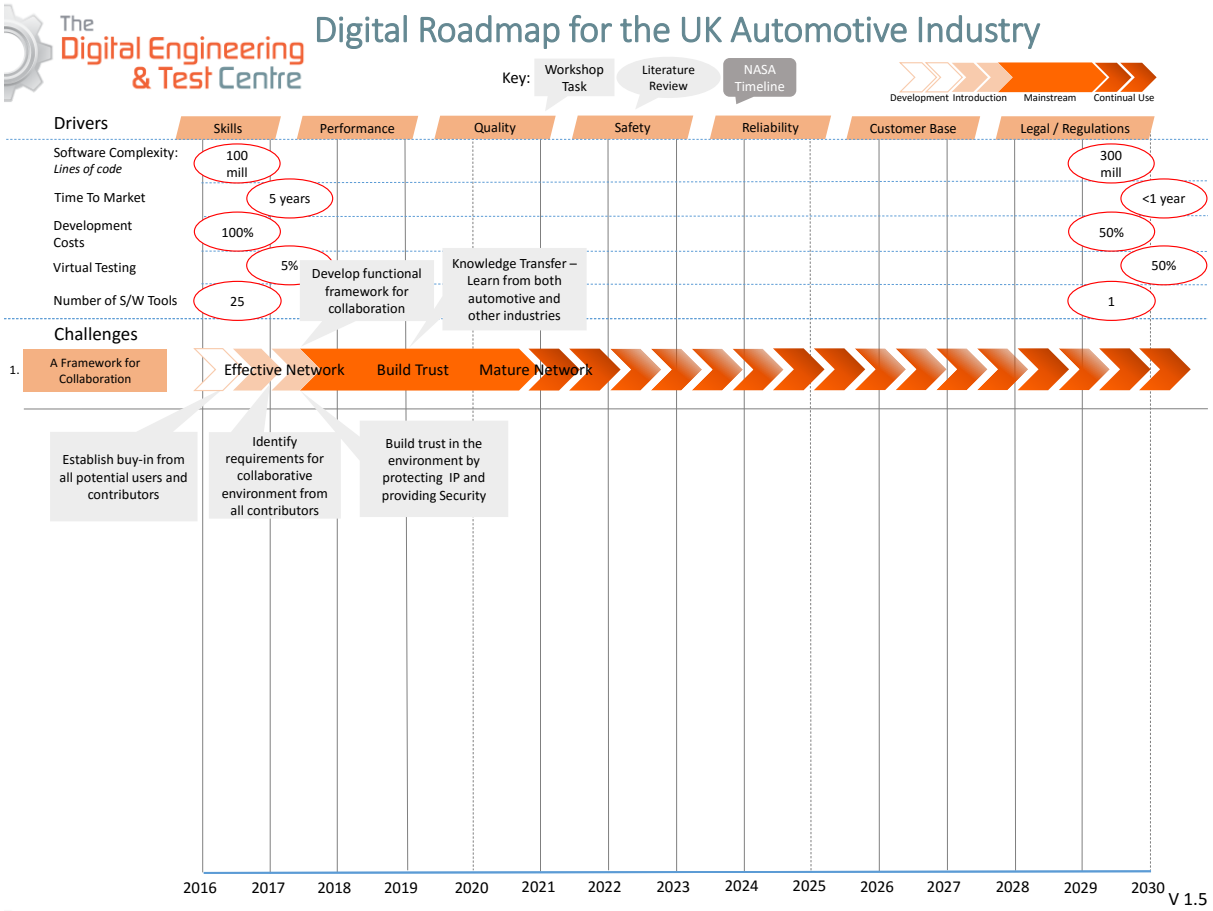
Digital Roadmap for the UK Automotive Industry

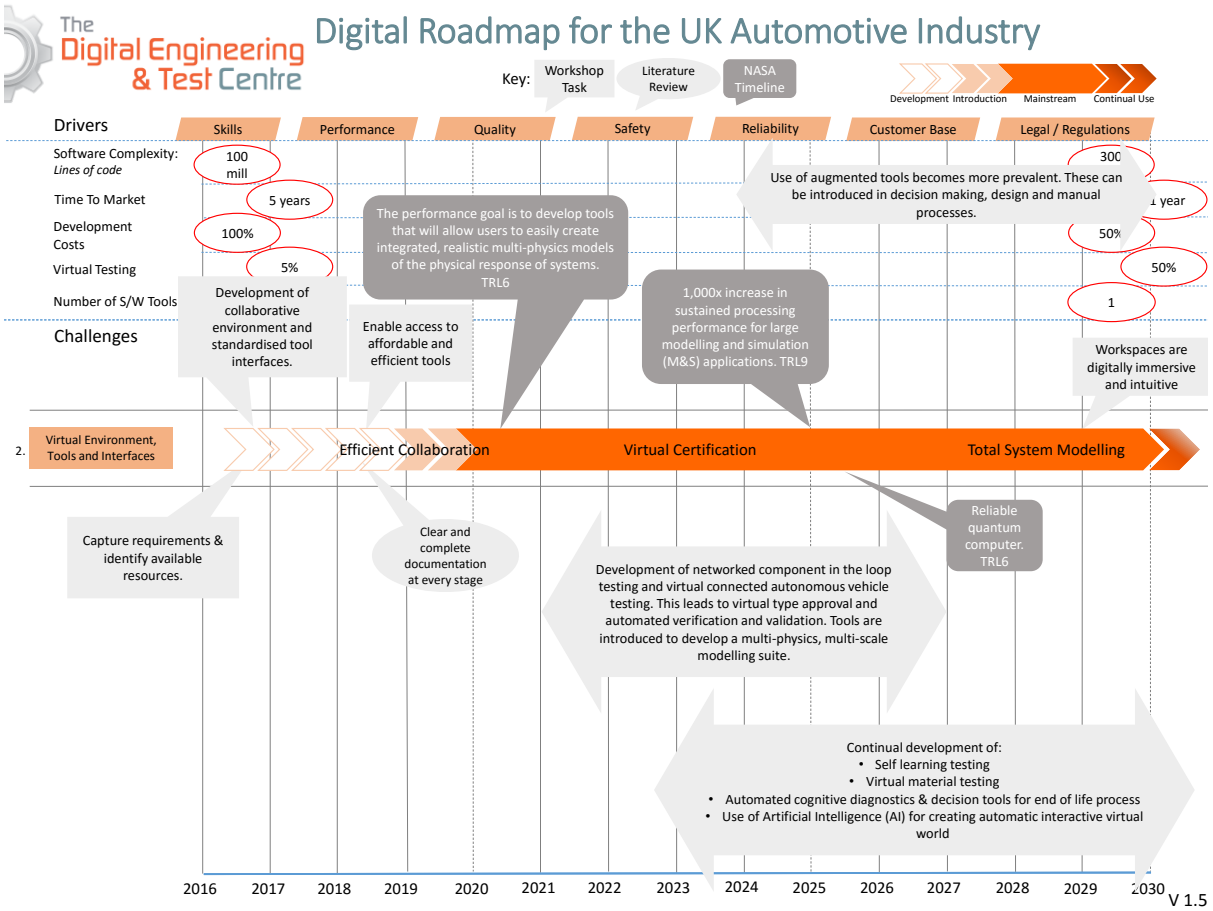


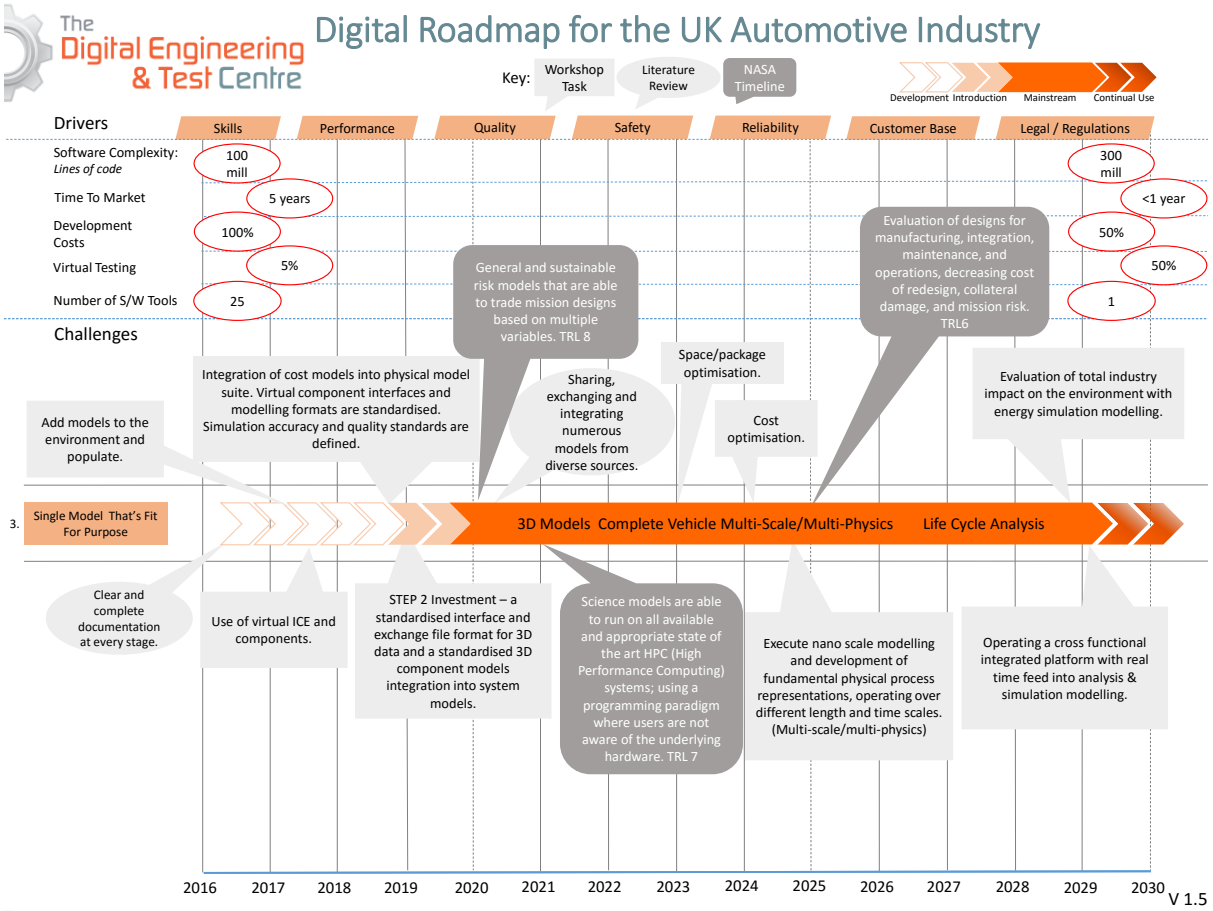
V 1.5

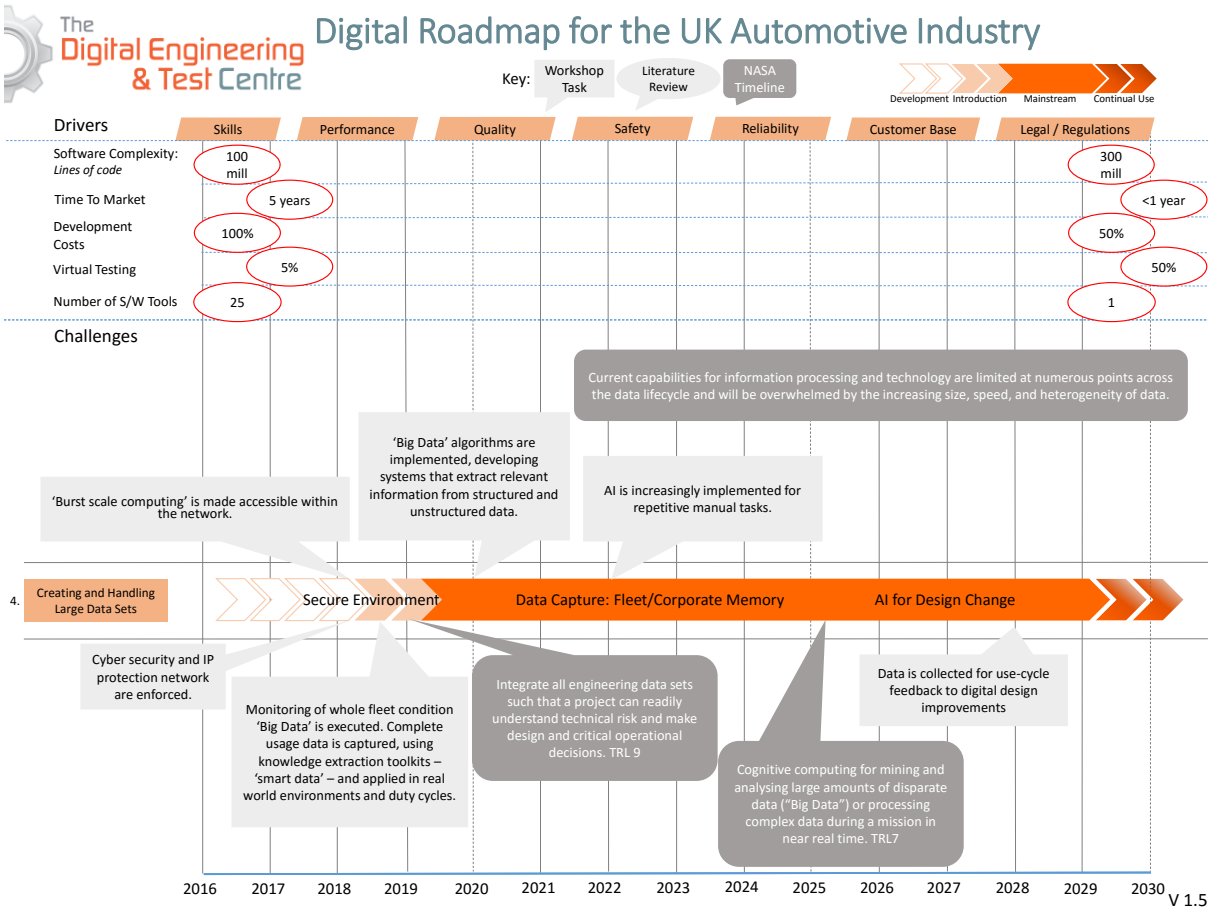

The Digital Engineering & Test Centre
Digital Roadmap for the UK Automotive Industry
Key:
Workshop Task
Literature Review
NASA Timeline
Development
Introduction
Mainstream
Continual Use
Drivers
Skills
Performance
Quality
Safety
Reliability
Customer Base
Legal / Regulations
Software Complexity: Lines of code
100 mill
300 mill
Time To Market
5 years
<1 year
Development Costs
100%
50%
Virtual Testing
5%
50%
Number of S/W Tools
25
1
Light chevrons illustrates the introduction of the technology within the market
Clear chevrons – Development phase
Transition to dark chevrons represent the technology's market maturity
Dark chevrons tailing off indicate the continual use of technology in the market
Legend
Challenge
Workshop Task: The analysis of the data generated from the workshop, collated in Workshop Verbatim Analysis'[1]
Literature Review: Information collected by DETC prior to the workshop and complied into 'Digital Roadmap Literature Search' [2]
NASA Timeline: Obtained from 'Technology Roadmaps TA 11: Modeling, Simulation, Information Technology, and Processing' - [3]
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
V 1.5

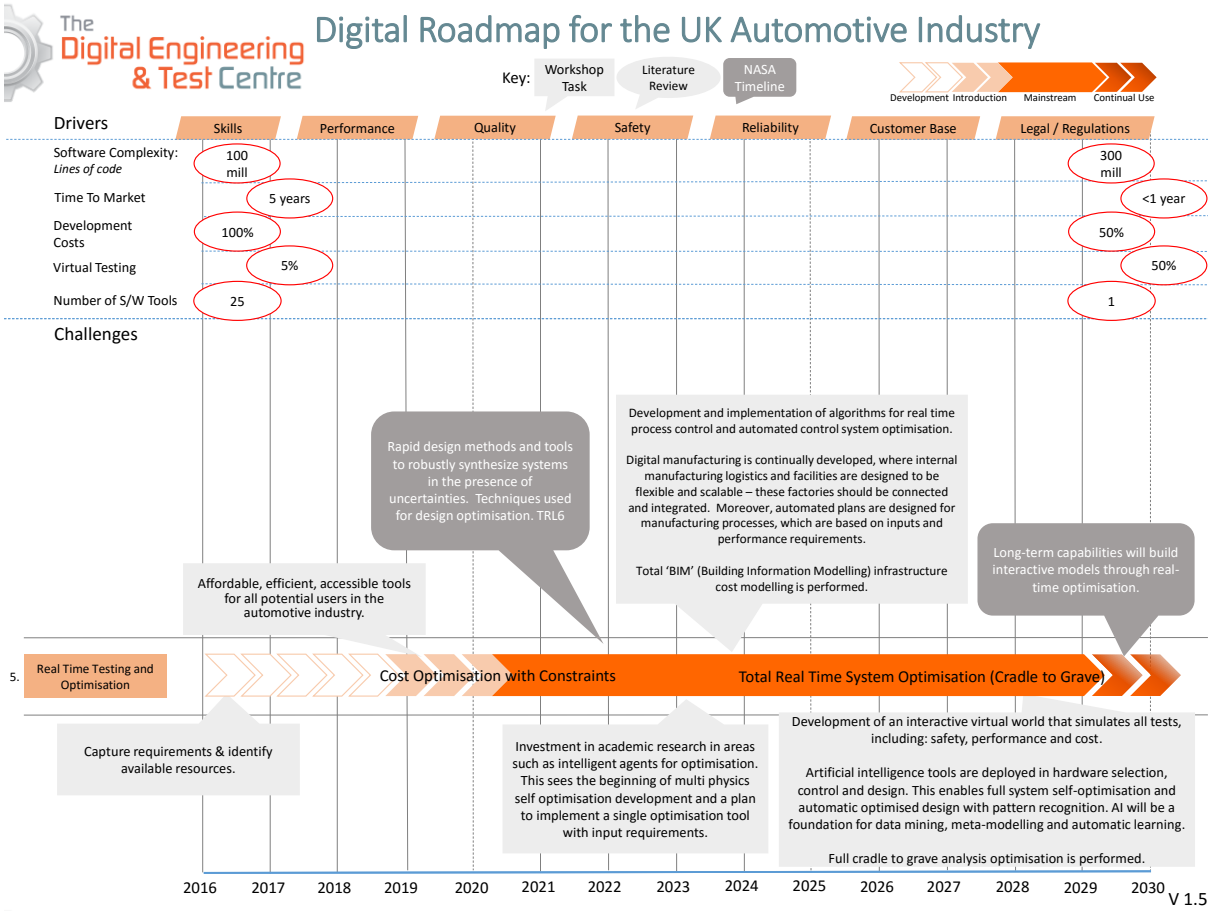

The Digital Engineering & Test Centre
Digital Roadmap for the UK Automotive Industry
Key:
Workshop Task
Literature Review
NASA Timeline
Development
Introduction
Mainstream
Continual Use
Drivers
Skills
Performance
Quality
Safety
Reliability
Customer Base
Legal / Regulations
Software Complexity: Lines of code
100 mill
300 mill
Time To Market
5 years
<1 year
Development Costs
100%
50%
Virtual Testing
5%
50%
Number of S/W Tools
25
1
Generic drivers along the top line that are more difficult to quantify.
Software Complexity - measured by the lines of code likely in a high end production vehicle, increasing from 100 million in a current vehicle to 300 million in 2030. This will drive the need for automated software development and verification.
Number of software tools. The driver is the need for improved communication between software tools with the target to decrease the different platforms from 25 to a single integrated system by 2030.
Time to Market - DETC has declared an objective to halve the development time however the consensus of the groups was that the driver was to reduce the time to market from the current 5 years to less than 1 year by 2030.
Development Costs - DETC has declared an objective to halve the development cost. This objective was unchanged in the workshop with the timeframe being 2030.
Virtual testing - Reduced development time and cost are expected to be delivered largely through an increase in the proportion of testing and verification carried out in simulation. The target agreed was to increase the proportion of virtual testing carried out from 5% to 50% by 2030. The proportion of virtual verification would be significantly lower than this.
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
V 1.5

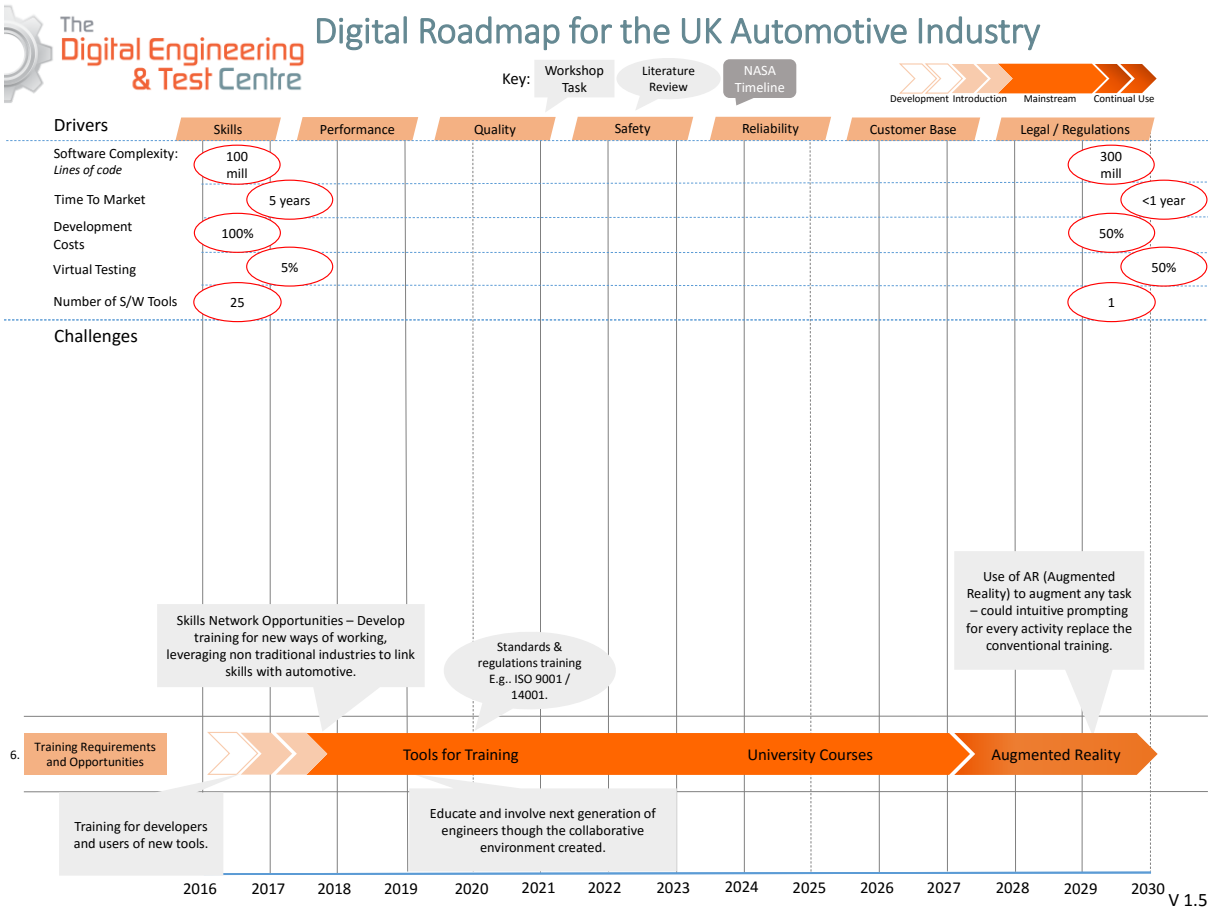

The Digital Engineering & Test Centre
Digital Roadmap for the UK Automotive Industry
Key:
Workshop Task
Literature Review
NASA Timeline
Development
Introduction
Mainstream
Continual Use
Drivers
Skills
Performance
Quality
Safety
Reliability
Customer Base
Legal / Regulations
Software Complexity: Lines of code
100 mill
300 mill
Time To Market
5 years
<1 year
Development Costs
100%
50%
Virtual Testing
5%
50%
Number of S/W Tools
25
1
Develop functional framework for collaboration
Knowledge Transfer – Learn from both automotive and other industries
Challenges
1.
A Framework for Collaboration
Effective Network
Build Trust
Mature Network
Establish buy-in from all potential users and contributors
Identify requirements for collaborative environment from all contributors
Build trust in the environment by protecting IP and providing Security
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
V 1.5

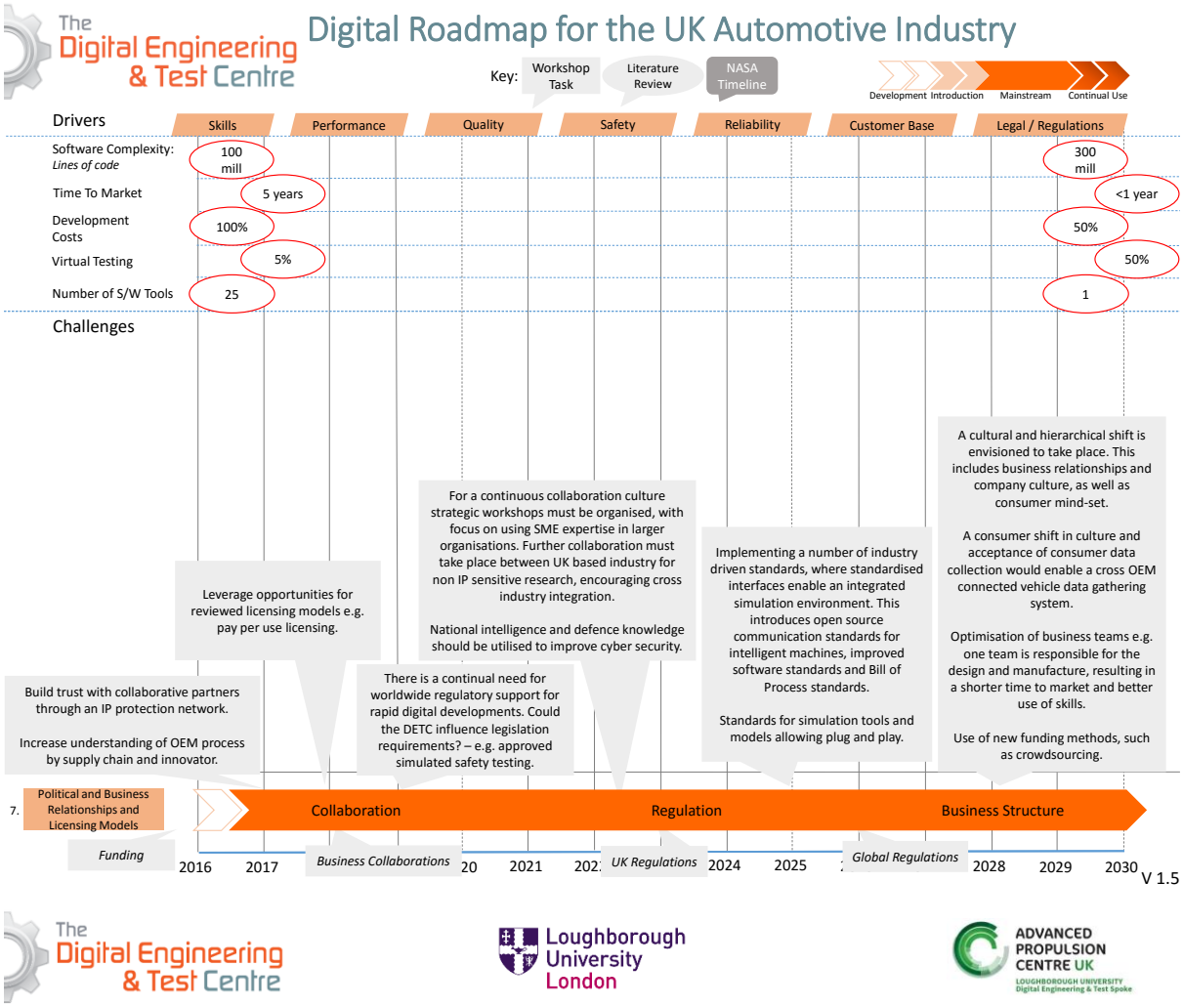

The Digital Engineering & Test Centre
Digital Roadmap for the UK Automotive Industry
Key:
Workshop Task
Literature Review
NASA Timeline
Development
Introduction
Mainstream
Continual Use
Drivers
Skills
Performance
Quality
Safety
Reliability
Customer Base
Legal / Regulations
Software Complexity: Lines of code
100 mill
Time To Market
5 years
Development Costs
100%
Virtual Testing
5%
Number of S/W Tools
Challenges
Development of collaborative environment and standardised tool interfaces.
Enable access to affordable and efficient tools
The performance goal is to develop tools that will allow users to easily create integrated, realistic multi-physics models of the physical response of systems. TRL6
1,000x increase in sustained processing performance for large modelling and simulation (M&S) applications. TRL9
Use of augmented tools becomes more prevalent. These can be introduced in decision making, design and manual processes.
Workspaces are digitally immersive and intuitive
2.
Virtual Environment, Tools and Interfaces
Efficient Collaboration
Virtual Certification
Total System Modelling
Capture requirements & identify available resources.
Clear and complete documentation at every stage
Development of networked component in the loop testing and virtual connected autonomous vehicle testing. This leads to virtual type approval and automated verification and validation. Tools are introduced to develop a multi-physics, multi-scale modelling suite.
Reliable quantum computer. TRL6
Continual development of:
• Self learning testing
• Virtual material testing
• Automated cognitive diagnostics & decision tools for end of life process
• Use of Artificial Intelligence (AI) for creating automatic interactive virtual world
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
V 1.5


The Digital Engineering & Test Centre
Digital Roadmap for the UK Automotive Industry
Key: Workshop Task
Literature Review
NASA Timeline
Development Introduction Mainstream Continual Use
Drivers
Skills
Performance
Quality
Safety
Reliability
Customer Base
Legal / Regulations
Software Complexity: Lines of code
100 mill
300 mill
Time To Market
5 years
<1 year
Development Costs
100%
50%
Virtual Testing
5%
50%
Number of S/W Tools
25
1
Challenges
General and sustainable risk models that are able to trade mission designs based on multiple variables. TRL 8
Evaluation of designs for manufacturing, integration, maintenance, and operations, decreasing cost of redesign, collateral damage, and mission risk. TRL6
Integration of cost models into physical model suite. Virtual component interfaces and modelling formats are standardised. Simulation accuracy and quality standards are defined.
Sharing, exchanging and integrating numerous models from diverse sources.
Space/package optimisation.
Cost optimisation.
Evaluation of total industry impact on the environment with energy simulation modelling.
Add models to the environment and populate.
3.
Single Model That's Fit For Purpose
3D Models Complete Vehicle Multi-Scale/Multi-Physics
Life Cycle Analysis
Clear and complete documentation at every stage.
Use of virtual ICE and components.
STEP 2 Investment – a standardised interface and exchange file format for 3D data and a standardised 3D component models integration into system models.
Science models are able to run on all available and appropriate state of the art HPC (High Performance Computing) systems; using a programming paradigm where users are not aware of the underlying hardware. TRL 7
Execute nano scale modelling and development of fundamental physical process representations, operating over different length and time scales. (Multi-scale/multi-physics)
Operating a cross functional integrated platform with real time feed into analysis & simulation modelling.
2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030
V 1.5


The Digital Engineering & Test Centre
Digital Roadmap for the UK Automotive Industry
Key: Workshop Task
Literature Review
NASA Timeline
Development Introduction Mainstream Continual Use
Drivers
Skills
Performance
Quality
Safety
Reliability
Customer Base
Legal / Regulations
Software Complexity: Lines of code
100 mill
300 mill
Time To Market
5 years
<1 year
Development Costs
100%
50%
Virtual Testing
5%
50%
Number of S/W Tools
25
1
Challenges
Current capabilities for information processing and technology are limited at numerous points across the data lifecycle and will be overwhelmed by the increasing size, speed, and heterogeneity of data.
'Big Data' algorithms are implemented, developing systems that extract relevant information from structured and unstructured data.
'Burst scale computing' is made accessible within the network.
AI is increasingly implemented for repetitive manual tasks.
4.
Creating and Handling Large Data Sets
Secure Environment
Data Capture: Fleet/Corporate Memory
AI for Design Change
Cyber security and IP protection network are enforced.
Monitoring of whole fleet condition 'Big Data' is executed. Complete usage data is captured, using knowledge extraction toolkits – 'smart data' – and applied in real world environments and duty cycles.
Integrate all engineering data sets such that a project can readily understand technical risk and make design and critical operational decisions. TRL 9
Data is collected for use-cycle feedback to digital design improvements
Cognitive computing for mining and analysing large amounts of disparate data ("Big Data") or processing complex data during a mission in near real time. TRL7
2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030
V 1.5


The Digital Engineering & Test Centre
Digital Roadmap for the UK Automotive Industry
Key: Workshop Task
Literature Review
NASA Timeline
Development Introduction Mainstream Continual Use
Drivers
Skills
Performance
Quality
Safety
Reliability
Customer Base
Legal / Regulations
Software Complexity: Lines of code
100 mill
300 mill
Time To Market
5 years
<1 year
Development Costs
100%
50%
Virtual Testing
5%
50%
Number of S/W Tools
25
1
Challenges
Rapid design methods and tools to robustly synthesize systems in the presence of uncertainties. Techniques used for design optimisation. TRL6
Development and implementation of algorithms for real time process control and automated control system optimisation.
Digital manufacturing is continually developed, where internal manufacturing logistics and facilities are designed to be flexible and scalable – these factories should be connected and integrated. Moreover, automated plans are designed for manufacturing processes, which are based on inputs and performance requirements.
Total 'BIM' (Building Information Modelling) infrastructure cost modelling is performed.
Long-term capabilities will build interactive models through real-time optimisation.
Affordable, efficient, accessible tools for all potential users in the automotive industry.
5.
Real Time Testing and Optimisation
Cost Optimisation with Constraints
Total Real Time System Optimisation (Cradle to Grave)
Capture requirements & identify available resources.
Investment in academic research in areas such as intelligent agents for optimisation. This sees the beginning of multi physics self optimisation development and a plan to implement a single optimisation tool with input requirements.
Development of an interactive virtual world that simulates all tests, including: safety, performance and cost.
Artificial intelligence tools are deployed in hardware selection, control and design. This enables full system self-optimisation and automatic optimised design with pattern recognition. AI will be a foundation for data mining, meta-modelling and automatic learning.
Full cradle to grave analysis optimisation is performed.
2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030
V 1.5


The Digital Engineering & Test Centre
Digital Roadmap for the UK Automotive Industry
Key: Workshop Task
Literature Review
NASA Timeline
Development Introduction Mainstream Continual Use
Drivers
Skills
Performance
Quality
Safety
Reliability
Customer Base
Legal / Regulations
Software Complexity: Lines of code
100 mill
300 mill
Time To Market
5 years
<1 year
Development Costs
100%
50%
Virtual Testing
5%
50%
Number of S/W Tools
25
1
Challenges
Use of AR (Augmented Reality) to augment any task – could intuitive prompting for every activity replace the conventional training.
Skills Network Opportunities – Develop training for new ways of working, leveraging non traditional industries to link skills with automotive.
Standards & regulations training E.g.. ISO 9001 / 14001.
6.
Training Requirements and Opportunities
Tools for Training
University Courses
Augmented Reality
Training for developers and users of new tools.
Educate and involve next generation of engineers though the collaborative environment created.
2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030
V 1.5



References

[1] Scarisbrick, A., & Pereira, S. (2016). *Workshop Verbatim Analysis.* DETC.
[2] Kirby, J., Ingram, M., & Pereira, S. (2016). *Digital Roadmap Literature Search.* DETC.
[3] NASA. (2015). *NASA Technology Roadmaps TA 11: Modeling, Simulation, Information Technology, and Processing.* NASA Technology Roadmaps. Retrieved April 2016

11.2 APPENDIX B: ATTENDEES FOR EACH BREAKOUT GROUP

Following is a list of those that attended the workshop and contributed to the roadmap.

Manufacturing	
Mike Woodcock – Leader	APC UK
David Stewart – Facilitator	HSSMI
Andrew Baker	Ford Motor Company
Matt Collett	Austin Consultants
Trevor Dutton	Dutton Simulation Ltd
Tosin Famusudo	HSSMI
Neil Gladwin	CNHi
James Kirby	DETC
Rhia Visavdia	EPSRC
Duncan Sime	Science & Technology Facilities Council

Gaming Methods & Tools	
Kevin Rampersad – Leader	DETC
Simon Barnes - Facilitator	HSSMI
Afzal Ali	UK Defence Solutions Centre (UKDSC)
John Erkoyuncu	Cranfield University
Annabel Jefferies	McLaren Automotive
Tanya Laird	Digital Jam
Rob Lewis	TotalSim
Maria Murcia	UCL (HSSMI PhD)
Ciaran Branney	McLaren Automotive
Riccardo Palmarini	Cranfield University (HSSMI PhD)
Tony Waller	Lanner Group
Sanj Surati	Holition(1st session only)
John Lippe	Ford Motor Company (1st session only)
Andy West	Loughborough University

Product	
Andy Scarisbrick - Leader	DETC
Hosein Torabmostaedi - Facilitator	HSSMI
Pierre-Paul Andriani	Tata Motors
Shahab Arif	HSSMI
Chris Brace	University of Bath
Julian Dizy	CMCL Innovations
Neville Jackson	Ricardo
Nick Jones	Transport System Catapult
Christopher May	APC UK
David Moore	Caterpillar, IPSD
Elfed Roberts	UK Defence Solutions Centre (UKDSC)
Hikari Todoroki	Nissan Technical Centre
Dennis Witt	Ford Motor Company

Test	
Byron Mason- Leader	Loughborough University
Axel Bindel - Facilitator	HSSMI
Geoff Davis	HORIBA MIRA
Joe Duran	Fujitsu
Paul Evans	University of Nottingham
Lionel Grealou	Tata Technologies
Bernadette Longridge	AVL
Neil McCarthy	NPL
Ashish Naik	National Instruments
Robert Norris	Ricardo
Simone Pereira	DETC
James Smith	Majenta Solutions
Ian Pennington	Ford Motor Company
Alistair Walshaw	CNH
Wen Zhang	ComSol

11.3 APPENDIX C: WORKSHOP AGENDA

10:00	Speaker - Jon Horsley - Welcome Introduction HSSMI/DETC	Jon Horsley
	Agenda,	Jon Horsley
10:10	Speaker - Neville Jackson – Ricardo	Neville Jackson
10:30	Explain Workshops and how to get in groups - Structure of breakout groups. Leader & Facilitator - Welcome guests from outside auto industry	Andy Scarisbrick
10:40	**Product Design, Manufacture, Test and Gaming Workshops** - Expected outcome – 15 year roadmaps for each area o Introductions o Review Drivers and quantify where possible. o Q1 – What will be new or normal in 2030? o Q2 – What is current practice or progress do we expect in the next six months?	
12:10	Lunch + Networking - HSSMI pitch	HSSMI
13:00	Speaker – Holition	Sanj Surati
13:10	Summarise findings from morning workshop - One thing for product groups - One thing for gaming group - One thing for manufacturing group - Three things you have for 2030 - The hardest thing you have parked	Feedback to room by Group Leaders
13:40	**Follow up workshops** - Expected outcome – trends per area - Finish your work from the morning session. - For the "What needs to be done, Q3" o Can you see the trends, and name them? – Dot the major ones.... o Are there any clear priorities / dependencies o Sticky technologies – UK benefit, now & future	
14:45	Priorities & sticky technologies	
15:10	Wrap up - One challenge from group A - One challenge from group B etc. - Keep going to no more challenges identified	Rob Exit Survey
15:25	Next steps - First draft by end March - June 9th	Andy Scarisbrick
15:30	Networking	