

Insight report

Software Product and Software Factory Maturity Levels

ADVANCED PROPULSION CENTRE UK

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The Advanced Propulsion Centre UK (APC) operational costs are funded by the UK Government's Department for Business, Innovation, Science and Trade (BIST) and industry contributions. BIST is the ministerial department for economic growth, supporting businesses to invest, grow, and export, creating jobs and opportunities across the country. Our combined mission is to accelerate the development of advanced propulsion technologies to reduce greenhouse gas emissions, minimise embedded carbon, and improve air quality.



Foreword

The automotive industry is entering a fundamental period of transformation. Electrification and the emergence of Software Defined Vehicles (SDVs) are reshaping vehicle architectures and changing how vehicles are designed, developed, operated and continuously improved.

This shift is changing where value is created. The ability to develop, integrate, validate and continuously deploy software at scale is becoming an industrial capability in its own right. It will help determine which companies compete successfully in the next generation of mobility. This creates a significant opportunity for the UK. We have established strengths across software engineering, advanced control systems, electronics, systems engineering and motorsport, alongside a globally recognised automotive research and innovation base.

The challenge is to translate these strengths into scalable industrial capability and capture a greater share of the value created by the transition to software defined mobility. The expanded scope of the DRIVE35 programme (as part of the Government's Industrial Strategy and growth plan) recognises the importance of these technologies to the future competitiveness and growth of the UK automotive sector.

This report provides a practical contribution to that challenge through two complementary frameworks: Software Product Readiness and Software Factory Readiness. Together, they provide a common language for assessing maturity across the journey from early concepts and virtual development through integration, physical validation, production deployment and fleet-scale operation. These frameworks can support more than technology assessment. They can help companies identify capability gaps, inform investment decisions, accelerate development and provide a clearer pathway from innovation to industrial deployment.

The opportunity extends across a broader ecosystem of UK businesses, from software platforms, development and validation tools to cybersecurity, digital engineering and advanced electronics. Building these capabilities can strengthen the competitiveness of UK vehicle manufacturing while also creating opportunities for existing and new technology businesses and high-value jobs.

We hope this report provides a useful foundation for industry, academia and government to develop a shared understanding of software readiness and, ultimately, to help the UK build and capture greater value from the next generation of automotive technology.

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Introducing the Software Product and Software Factory Maturity Frameworks

As the automotive industry transitions to Software Defined Vehicles (SDVs), software has become a primary source of vehicle functionality, differentiation and customer value. Unlike traditional vehicle programmes, software continues to evolve throughout a vehicle's lifecycle through updates, new features and continuous improvement.

As vehicles become increasingly software-defined, existing Technology Readiness Levels (TRLs) do not fully capture the maturity of software products or the environments used to develop, validate and deploy them. Software Readiness Levels (SRLs) complement traditional TRLs by providing a common framework for assessing software maturity across the innovation lifecycle.

Industry consultation identified that software maturity can no longer be considered as a single measure. Vehicle readiness depends on:

Software Product Maturity	Software Factory Maturity
• The readiness of the software itself • Requirements, design, development, integration, safety, cybersecurity and runtime behaviour	• The readiness of the environment used to create, validate, deploy and maintain software. • Toolchains, automation, virtualisation, CI/CD, validation capability, OTA deployment and fleet operations.



Together these frameworks provide a consistent language for assessing software readiness across research, development, demonstration and deployment.

Understanding Software Readiness Levels
Both frameworks use nine maturity levels

Level	Description
1-3	The software concept and supporting development environment have been established and demonstrated in virtual development environments.
4-6	The software and development capability have been integrated, tested and verified in increasingly realistic virtual environments.
7	The software and development environment have been validated on representative physical hardware or vehicle systems.
8	The software and supporting deployment capability are ready for production use.
9	The software is operating successfully in real-world use and is supported by mature deployment, monitoring and update capabilities.

The frameworks are evidence based rather than purely sequential. Organisations may progress more rapidly where equivalent evidence exists and where virtualisation, platform maturity or reusable software assets accelerate development.

Software Product Readiness measures whether the software itself is ready.

Software Factory Readiness measures whether the organisation can reliably build, validate, deploy, and maintain that software at scale.

Glossary

API Application Programming Interface
CI Continuous Integration
ECU Electronic Control Unit
HiL Hardware-in-the-loop
MiL Model-in-the-loop
OSS Open-source software
OTA Over-the-air
PSIRT Product Security Incident Response Team
SDV Software-defined vehicle
SiL Software-in-the-loop
SOA Service-oriented architecture
SOTA Software-over-the-air
vECU Virtual Electronic Control Unit
ViL Vehicle-in-the-loop

Software Product Readiness Framework

What is Software Product Readiness?
Software Product Readiness measures the maturity of the software capability itself, from initial concept through to deployment and operation in customer vehicles. It considers software requirements, architecture, implementation, integration, safety, cybersecurity and operational performance.

Typical progression
Level 1-3 Concept definition, requirements development and model-based validation
Level 4-6 Virtual integration, digital twins, runtime validation, resource analysis and safety/security verification.
Level 7-9 Physical integration, production deployment, OTA updates, fleet monitoring and lifecycle management.

Level	Description	Software Maturity Milestones
1	Concept Formulation	Core functional concept defined (algorithm/model intent). High-level assumptions and boundaries understood.
2	Application Definition	Use-cases and requirements defined and measurable. System boundaries, interfaces, and safety/security expectations established. SOA and zonal communication constraints identified for the feature.
3	Analytical Prototype (model only)	Function validated in MiL or simulated environment. Digital twin model fidelity class established
4	Virtual Software Component Validation (SiL / Digital Twin)	Binary is executed deterministically in SiL. Digital twin model fidelity defined and accepted. Initial cloud-edge-vehicle execution assumptions validated
5	Integrated Software Components	Subsystem-level integration validated in constrained virtual environment. Mixed-criticality behaviour assessed.
6	High-Fidelity, Correlated Virtual Integration & Platform Runtime Conformance	Software operates correctly within SDV runtime (services / APIs/ orchestration). High-fidelity simulation correlated with real-world data or telemetry data.
7	Operational Prototype	Physical testing confirms real-world timing and interaction behaviour inc. zonal controllers. No new integration defects appear during HIL/VIL.
8	Production-Ready Integration	Validated across all hardware/software variants. Diagnostics, safety, and cybersecurity requirements fully implemented
9	Lifecycle Mature	Stable operation across fleet and multiple SOTA cycles. Continuous monitoring and learning embedded.

Software Factory Readiness Framework

What is Software Factory Readiness?
Software Factory Readiness measures the maturity of the development, integration, validation and deployment environment used to create and maintain automotive software. It includes automation, virtual testing, orchestration, digital engineering, OTA capability and fleet operations.

Typical progression
Level 1-3 Establishing tools, traceability, automation and virtual execution.
Level 4-6 Building scalable digital engineering capability through integration, virtualisation and orchestration.
Level 7-9 Extending the factory to physical systems, OTA deployment and fleet-scale software operations.

Level	Description	Software Maturity Milestones
1	Tooling 7 Modelling Foundation	Factory has minimal capability to support software concept exploration, modelling, and version control. Basic modelling tools operational. Version control and artifact (e.g. software, models etc.) storage architecture established.
2	Requirements & CI Foundation	Factory supports requirements management, early automation, and consistent traceability. Requirements toolchain active. Basic CI pipeline operational.
3	Virtual Execution Capability (SiL/vECU)	Factory can reliably build and execute compiled binaries in virtual environments. Deterministic SiL environment operational. vECU provisioning and repeatable execution available.
4	Virtual Integration Capability	Factory supports integration of software with middleware, services, OSS and runtime abstractions in virtual environments. Service/middleware simulation supported. Contract tests automated.
5	Right-Fidelity Virtualisation Capability	Factory can simulate subsystem-level behaviour with high fidelity, including resource constraints and mixed-criticality. CPU/memory/network resource modelling automated. Mixed-criticality analysis virtualised.
6	Runtime Orchestration & Platform Conformance	Factory can validate software within an SDV runtime environment: service discovery, container orchestration, and secure operation. Containerised services orchestrated correctly. Recovery, restart, and isolation flows validated
7	Physical Integration Capability (HiL Maturity)	Factory reliably orchestrates HIL environments; physical timing/latency and cross-domain behaviour validated as audit-only HIL orchestration automated. Real-time performance extraction integrated.
8	Vehicle Integration + OTA Factory Capability	Factory fully supports variant-wide automation, OTA packaging, and end-to-end delivery to physical vehicles. Automated OTA package generation. Variant explosion handled through parallelisation.
9	Fleet-Scale Continuous Delivery	Factory enables safe, secure, continuous delivery across the fleet with full monitoring, analytics, and PSIRT integration. Telemetry ingestion and fleet analytics integrated. PSIRT workflows automated.

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Cover Image: Software defined modern vehicle system chip technology by Magnific.com

Further information

If you have any questions or would like more detail on any of the data email **info@apcuk.co.uk**

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