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3S Knowledge Limited and Jaguar Land Rover have developed this process model with best intention of enhancing product quality across the automotive industry. We have taken responsible steps in verification and independent review of this process assessment model.

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Process Reference and Assessment Model

Reference Model	Process ID	CAL.1
	Process Name	Calibration Requirements Analysis
	Process Purpose	The purpose of the Calibration Requirements Analysis Process is to transform the calibration related parts of the system requirements into a set of calibration requirements.
	Process Outcomes	As a result of successful implementation of this process: 1) the calibration requirements to be allocated to the calibration elements of the system and their interfaces to the system are defined; 2) calibration requirements are categorised and analysed for correctness and verifiability; 3) the impact of calibration requirements on the operating environment is analysed; 4) prioritisation for implementing the calibration requirements is defined; 5) the calibration requirements are updated as needed; 6) consistency and bidirectional traceability are established between system requirements and calibration requirements; 7) the calibration requirements are evaluated for cost, schedule and technical impact; and 8) the calibration requirements are agreed and communicated to all affected parties.
Performance Indicators	Base Practices	<p>CAL.1.BP1: Specify calibration requirements. Use the system requirements and the system architecture and changes to the system requirements and architecture to identify the required functions and capabilities of the calibration. Specify functional and non-functional calibration requirements in a calibration requirements specification. [Outcome 1, 5, 7]</p> <p>CAL.1.BP2 Structure calibration requirements. Structure the calibration requirements in the calibration requirements specification by e.g.</p> <ul style="list-style-type: none"> • grouping to project relevant clusters, • sorting in a logical order for the project, • categorising based on relevant criteria for the project, • prioritising according to stakeholder needs • developing use cases where appropriate <p>[Outcome 2, 4]</p> <p>CAL.1.BP3: Analyse calibration requirements. Analyse the specified calibration requirements including their interdependencies to ensure correctness, technical feasibility and verifiability, and to support risk identification. Analyse the impact on cost, schedule and the technical impact. [Outcome 2, 7]</p> <p>CAL.1.BP4: Analyse the impact on the operating environment. Analyse the</p>



	<p>impact that the calibration requirements will have on interfaces of system elements and the operating environment. [OUTCOME 3, 7] <i>NOTE 1: The operating environment is defined as the system or systems in which the calibration operates (e.g. controller or controllers, hardware, software, vehicle, etc.). Impacts could include: operational duty-cycle of components and effect on durability; visual or auditory impacts, such as warning lamps, intended or unintended sounds; or effects on other calibration elements or systems.</i></p> <p>CAL.1.BP5: Develop verification criteria. Develop the verification criteria for each calibration requirement that define the qualitative and quantitative measures for the verification of a requirement. [OUTCOME 2, 7]</p> <p>CAL.1.BP6: Establish bidirectional traceability. Establish bidirectional traceability between system requirements and calibration requirements. Establish bidirectional traceability between the system architecture and calibration requirements. [OUTCOME 6] <i>NOTE 2: Calibration requirements may satisfy the requirements of multiple systems, or multiple requirements within a single system.</i></p> <p>CAL.1.BP7: Ensure consistency. Ensure consistency between system requirements and calibration requirements. Ensure consistency between the system architecture and calibration requirements. [OUTCOME 6]</p> <p>CAL.1.BP8: Communicate agreed calibration requirements. Communicate the agreed calibration requirements and updates to calibration requirements to all relevant parties. [OUTCOME 8]</p>
Output Work Products	<p>13-04 Communication record → [OUTCOME 9] 13-19 Review record → [OUTCOME 7] 13-21 Change control record → [OUTCOME 6, 8] 13-22 Traceability record → [OUTCOME 2, 7] 15-01 Analysis report → [OUTCOME 3, 4, 5, 8] 17-08 Interface requirements specification → [OUTCOME 2] 17-13 Calibration requirements specification → [OUTCOME 1, 2] 17-50 Verification criteria → [OUTCOME 2]</p>

Reference Model	Process ID	CAL.2
	Process Name	Architectural Design for Calibration
	Process Purpose	The purpose of the Architectural Design for Calibration Process is to establish a Calibration Work Package architecture and to identify which calibration requirements are to be allocated to which elements of the architecture, and to evaluate the calibration work package architectural design against defined criteria.



Performance Indicators		
	Process Outcomes	<p>As a result of successful implementation of this process:</p> <ol style="list-style-type: none"> 1) a calibration architectural design is defined that identifies the work packages that are required to calibrate the system; 2) the calibration requirements are allocated to individual calibration work packages; 3) the boundaries of, and interactions between, the calibration work packages are defined; 4) consistency and bidirectional traceability are established between calibration requirements and calibration architectural design; 5) the calibration architectural design is agreed and communicated to all affected parties; 6) the strategy for how to structure calibration data files is defined, including format to be used, naming convention, mechanism for delivery of work package calibration data into projects; 7) a variant management strategy for calibration data files is defined, considering how to deal with application of the same software item across vehicle / engine hardware variants derivatives; 8) a configuration management strategy for calibration data is established; 9) a strategy for identification of application parameters with critical characteristics is defined; and 10) initial calibration methodology is developed.
	Base Practices	<p>CAL.2.BP1. Develop calibration architectural design. Develop and document the calibration architectural design that specifies the work package elements of the calibration with respect to functional and non-functional calibration requirements. [Outcome 1]</p> <p>CAL.2.BP2. Allocate calibration requirements. Allocate the calibration requirements to the work package elements of the calibration architectural design. [Outcome 2]</p> <p>CAL.2.BP3. Define interfaces of work package elements. Identify, develop and document the interfaces of each work package element, including sequencing interdependencies. [Outcome 3]</p> <p>CAL.2.BP4: Evaluate alternative system architectures. Define evaluation criteria for architecture design. Evaluate alternative calibration architectures according to the defined criteria. Record the rationale for the chosen calibration architecture. [Outcome 1] <i>NOTE 1: Evaluation criteria may include quality characteristics (modularity, maintainability, expandability, scalability, reliability, security and usability) and results of make-buy-reuse analysis.</i></p> <p>CAL.2.BP5: Establish bidirectional traceability. Establish bidirectional traceability between calibration requirements and work package elements of the calibration architectural design. [Outcome 4] <i>NOTE 2: Bidirectional traceability covers allocation of calibration requirements to</i></p>



the work package elements of the calibration architectural design.

NOTE 3: Bidirectional traceability supports coverage, consistency and impact analysis.

CAL.2.BP6: Ensure consistency. Ensure consistency between calibration requirements and the calibration architectural design. [Outcome 1, 2, 4, 5]

NOTE 4: Consistency is supported by bidirectional traceability and can be demonstrated by review records.

CAL.2.BP7: Communicate agreed calibration architectural design.

Communicate the agreed calibration architectural design and updates to calibration architectural design to all relevant parties. [Outcome 5]

CAL.2.BP8 Define calibration data file strategy. The file structure and format to be used to create, exchange and integrate calibration data is defined. [Outcome 6]

NOTE 5: The calibration data file strategy should include naming convention.

NOTE 6: The calibration data file strategy should include mechanism to link calibration status with calibration data.

CAL.2.BP9 Establish variant management strategy. Mechanism to deal with application of calibration of the same software unit across multiple projects or hardware platforms is established. [Outcome 7]

Note 7: For example, the use of common software on two vehicle variants leads to potential for multiple calibration variants.

Note 8: This should include identification of how to deal with common and variant specific elements within a specific calibration work package.

CAL.2.BP10 Configuration management strategy established. Definition of how calibrations are configuration managed, including how compiled calibrations are identified and released to users. [Outcome 8]

Note 9: See SUP.8 for configuration management

CAL.2.BP11 Application parameter critical characteristic strategy defined.

Method for identification and management of application parameters that have critical or significant characteristics in relation to their impact on one or more areas within the system is defined. [Outcome 9]

Note 10: This should include how to create and maintain a calibration hot list identifying these critical and significant characteristics.

Note 11: This should include process for document agreement with stakeholders of appropriate application parameter values, including a defined escalation route.

Note 12: Stakeholders in relation to definition or agreement of critical or significant application parameters could include system suppliers.

CAL.2.BP12 Develop initial calibration methodology for work packages.

Methodology concept for each work package is created, indicating how to approach the calibration activity without defining specific of application parameter details.



	Output Work Products	<p>04-06 System architectural design → [OUTCOME 1, 2, 3, 4] 13-04 Communication record → [OUTCOME 5] 13-19 Review record → [OUTCOME 4] 13-22 Traceability record → [OUTCOME 4] 14-09 Work breakdown structure → [OUTCOME 1, 2] 14-11 Work product list → [OUTCOME 1, 2] 17-08 Interface requirements specification → [OUTCOME 3] 21-00 Work product → [OUTCOME 1, 2, 3]</p> <p>01-00 Configuration item → [OUTCOME 8] 06-05 Calibration guide → [OUTCOME x] 08-04 Configuration management plan → [OUTCOME 8] 08-17 Reuse plan → [OUTCOME 7] 17-14 Calibration hot list → [OUTCOME 9]</p>
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Reference Model	Process ID	CAL.3
	Process Name	Work Package Design and Calibration
	Process Purpose	The purpose of the Work Package Design and Calibration Process is to detail the application parameter content of a Work Package, and to establish and apply suitable calibration methodologies to derive the values of the application parameters.
	Process Outcomes	<p>As a result of successful implementation of this process:</p> <ol style="list-style-type: none"> 1) the application parameter content of a work package is defined; 2) the methodologies, tools, facilities and test properties required are specified; 3) test data is generated according to the specified methods and analysed; 4) application parameter values are generated and optimised, and any trade-offs required are evaluated; 5) a calibration data file, containing the application parameter values, is produced; 6) calibration status is published for the associated calibration data file, indicating the maturity and robustness of the parameter settings; and 7) a test report, including summary of characterisation and optimisation analysis and details of any trade-off choices is created and filed.
Performance Indicators	Base Practices	<p>CAL.3.BP1 Application parameter list. The details of application parameters within the calibration work package are specified and reviewed to ensure alignment with the calibration architectural design. [Outcome 1]</p> <p>CAL.3.BP2 Data collection methods established. The approach for data collection and characterisation of the hardware or system is understood. [Outcome 2]</p>



	<p>CAL.3.BP3 Data analysis tools specified. Any tools necessary to support the calibration of the work package, either data collection, characterisation or optimisation, are identified and specified. [Outcome 2]</p> <p>CAL.3.BP4 Collect test data. Perform testing using the identified methods to generate data to allow application parameter optimisation. [Outcome 3, 4]</p> <p>CAL.3.BP5 Test data analysis. Analyse the test data collected to derive the optimised application parameter settings. [Outcome 3, 4]</p> <p>CAL.3.BP6 Trade-off evaluation. Any areas where optimal application parameter settings conflict with other constraints (either at calibration, software or system levels) are analysed and appropriate trade-offs determined and documented. [Outcome 4]</p> <p>CAL.3.BP7 Calibration data file generation. Application parameter settings for a work package are collated into calibration data file to allow integration with other calibration work packages. [Outcome 5]</p> <p>CAL.3.BP8 Calibration status. Detail the validation status of application parameter values in an associated calibration data file. [Outcome 6] <i>NOTE 1: The status should indicate level of maturity of the calibration data, in terms of quantity and quality of testing completed.</i></p> <p>CAL.3.BP9 Work package report. Documentation summarising the work package calibration results is created and communicate them to all affected parties. [Outcome 7]</p> <p>CAL.3.BP10 Work package prerequisites identified. All prerequisites that are required to allow completion of the work package are identified, highlighted and tracked. Planning for completion of the work package is updated accordingly. [Outcome x, 6]</p> <p>CAL.3.BP11 Work package boundary and interfaces confirmed. The boundary, content and requirements of the work package are reviewed and confirmed, ensuring alignment with the calibration architectural design. [Outcome x]</p>
Output Work Products	<p>01-51 Application parameter → [OUTCOME 1, 5] 03-03 Benchmarking data → [OUTCOME 2, 4] 06-04 Training material → [OUTCOME 2] 06-05 Calibration guide → [OUTCOME 2] 08-52 Test plan → [OUTCOME 2, 3] 11-10 Calibration work package data → [OUTCOME 5] 13-14 Progress status record → [OUTCOME 6] 15-00 Report → [OUTCOME 7]</p>



Reference Model	Process ID	CAL.4
	Process Name	Work Package Verification
	Process Purpose	The purpose of the Work Package Verification Process is to verify calibration Work Packages and provide evidence for compliance with the calibration Work Package requirements
	Process Outcomes	As a result of successful implementation of this process: 1) a calibration work package verification strategy including regression strategy is developed to verify the calibration work packages; 2) criteria for calibration work package verification are developed according to the calibration work package verification strategy that are suitable to provide evidence for compliance of the calibration work packages with the calibration requirements; 3) calibration work packages are verified according to the calibration work package verification strategy and the defined criteria for calibration work package verification and the results are recorded; 4) consistency and bidirectional traceability are established between calibration work packages, criteria for verification and verification results; and 5) results of the work package verification are summarised and communicated to all affected parties.
Performance Indicators	Base Practices	<p>CAL.4.BP1 Develop calibration work package verification strategy including regression strategy. Develop a strategy for verification of the calibration work packages including regression strategy for re-verification if a related software unit is changed. The verification strategy shall define how to provide evidence for compliance of the calibration work packages with the calibration requirements. [Outcome 1]</p> <p>CAL.4.BP2 Develop criteria for work package verification. Develop criteria for work package verification that are suitable to provide evidence for compliance of the calibration work package with the calibration requirements according to the verification strategy. [Outcome 2]</p> <p>CAL.4.BP3 Collect and analyse calibration verification data. Collect data to support verification of the calibration and analyse according to the defined verification criteria. [Outcome 3]</p> <p>CAL.4.BP4 Conduct calibration peer review. Verify the calibration using the defined criteria for verification via a peer review. [Outcome 3]</p> <p>CAL.4.BP5 Establish bidirectional traceability. Establish bidirectional traceability between calibration work packages and verification results. [Outcome 4]</p> <p>CAL.4.BP6 Summarise and communicate results. Summarise the work package calibration results and communicate them to all affected parties. [Outcome 5]</p>



	Output Work Products	13-04 Communication record → [OUTCOME 5] 13-19 Review record → [OUTCOME 1, 2, 3] 13-22 Traceability record → [OUTCOME 4] 13-25 Verification results → [OUTCOME 1, 3] 15-01 Analysis report → [OUTCOME 3] 19-10 Verification strategy → [OUTCOME 1]

Reference Model	Process ID	CAL.5
	Process Name	Work Package Integration and Integration Test
	Process Purpose	The purpose of the Work Package Integration and Integration Test Process is to integrate the Work Package units to create a complete integrated calibration consistent with the calibration architectural design, and ensure the calibration work packages are tested to provide evidence for compliance of the integrated calibration with the calibration architecture.
	Process Outcomes	<p>As a result of successful implementation of this process:</p> <ol style="list-style-type: none"> 1) a calibration integration strategy consistent with the project plan, the release plan and the calibration architectural design is developed to integrate the calibration work packages; 2) a calibration integration test strategy including regression test strategy is developed to test the calibration interactions; 3) a specification for calibration integration test according to the calibration integration test strategy is developed that is suitable to provide evidence for compliance of the integrated calibration work packages with the calibration architectural design, including the interfaces between calibration work packages; 4) calibration work packages are integrated up to a complete integrated calibration according to the integration strategy; 5) test cases included in the calibration integration test specification are selected according to the calibration integration test strategy and the release plan; 6) calibration work package interactions are tested using the selected test cases and the results of calibration integration testing are recorded; 7) consistency and bidirectional traceability between the elements of the calibration architectural design and test cases included in the calibration integration test specification and bidirectional traceability between test cases and test results is established; 8) results of the calibration integration test are summarised and communicated to all affected parties; and 9) application parameters identified as having critical or significant characteristics are reviewed and confirmed as acceptable.
Pe rf	Base Practices	CAL.5.BP1 Develop calibration integration strategy. Develop a strategy for integrating the calibration work packages consistent with the project plan and the



release plan. Identify calibration work packages based on the calibration architectural design and define a sequence for integrating them. [Outcome 1]

CAL.5.BP2 Develop calibration integration test strategy including regression test strategy. Develop a strategy for testing the integrated calibration work packages following the integration strategy. This includes a regression test strategy for re-testing integrated calibration work package if a calibration item is changed. [Outcome 2]

CAL.5.BP3: Develop specification for calibration integration test. Develop the test specification for calibration integration test including the test cases for each integration step of a calibration work package according to the calibration integration test strategy. The test specification shall be suitable to provide evidence for compliance of the integrated calibration work packages with the calibration architectural design. [Outcome 3]

CAL.5.BP4: Integrate calibration work packages. Integrate the calibration work packages to an integrated calibration according to the calibration integration strategy. [Outcome 4]

Note 1: The integrated calibration could span several control modules.

Note 2: Ensure the calibration integration follows the sequence defined in the calibration integration strategy.

CAL.5.BP5: Select test cases. Select test cases from the calibration integration test specification. The selection of test cases shall have sufficient coverage according to the calibration integration test strategy and the release plan. [Outcome 5]

CAL.5.BP6: Perform calibration integration test. Perform the calibration integration test using the selected test cases. Record the integration test results and logs. [Outcome 6]

CAL.5.BP7: Establish bidirectional traceability. Establish bidirectional traceability between elements of the calibration architectural design and test cases included in the calibration integration test specification. Establish bidirectional traceability between test cases included in the calibration integration test specification and calibration integration test results. [Outcome 7]

CAL.5.BP8: Ensure consistency. Ensure consistency between elements of the calibration architectural design and test cases included in the calibration integration test specification. [Outcome 7]

CAL.5.BP9: Summarise and communicate results. Summarise the calibration integration test results and communicate them to all affected parties. [Outcome 8]

CAL.5.BP10: Review critical and significant application parameters. Any application parameter that has been identified as having critical or significant characteristics is reviewed to confirm that the calibration settings are within



	<p>expected range. <i>Note 2: This review could be facilitated by an automated check of the identified application parameter values against predefined ruleset.</i> <i>Note 3: The defined escalation process must be followed in relation to any application parameter that does not pass the predefined ruleset.</i></p>
Output Work Products	<p>08-50 Test specification → [OUTCOME 3, 5] 08-52 Test plan → [OUTCOME 1, 2] 13-04 Communication record → [OUTCOME 8] 13-19 Review record → [OUTCOME 7, 9] 13-22 Traceability record → [OUTCOME 7] 13-50 Test result → [OUTCOME 6, 8] 15-06 Project status report → [OUTCOME 8]</p> <p>11-08 Calibration release information → [OUTCOME 8] 11-09 Integrated calibration → [OUTCOME 4] 19-13 Calibration integration strategy → [OUTCOME 1]</p>

Reference Model	Process ID	CAL.6
	Process Name	Calibration Qualification Test
	Process Purpose	The purpose of the Calibration Qualification Test Process is to ensure that the integrated calibration is tested to provide evidence for compliance with the calibration requirements in the context of the whole system.
	Process Outcomes	<p>As a result of successful implementation of this process:</p> <ol style="list-style-type: none"> 1) a calibration qualification test strategy including regression test strategy consistent with the project plan and release plan is developed to test the integrated calibration; 2) a specification for calibration qualification test of the integrated calibration according to the calibration qualification test strategy is developed that is suitable to provide evidence for compliance with the calibration requirements; 3) test cases included in the calibration qualification test specification are selected according to the calibration qualification test strategy and the release plan; 4) the integrated calibration is tested using the selected test cases and the results of calibration qualification test are recorded; 5) consistency and bidirectional traceability are established between calibration requirements and calibration qualification test specification including test cases and between test cases and test results; and 6) results of the calibration qualification test are summarised and communicated to all affected parties.



Performance Indicators	Base Practices	<p>CAL.6.BP1: Develop calibration qualification test strategy including regression test strategy. Develop a strategy for calibration qualification testing consistent with the project plan and the release plan. This includes a regression test strategy for re-testing the integrated calibration if a software or calibration item is changed. [Outcome 1]</p> <p>CAL.6.BP2: Develop specification for calibration qualification test. Develop the specification for calibration qualification test including test cases based on the verification criteria, according to the calibration test strategy. The test specification shall be suitable to provide evidence for compliance of the integrated calibration with the calibration requirements. [Outcome 2]</p> <p>CAL.6.BP3: Select test cases. Select test cases from the calibration test specification. The selection of test cases shall have sufficient coverage according to the calibration test strategy and the release plan. [Outcome 3]</p> <p>CAL.6.BP4: Test integrated calibration. Test the integrated calibration using the selected test cases. Record the calibration test results and logs. [Outcome 4] <i>Note 1: See SUP.9 for handling of non-conformances</i></p> <p>CAL.6.BP5: Establish bidirectional traceability. Establish bidirectional traceability between calibration requirements and test cases included in the calibration qualification test specification. Establish bidirectional traceability between test cases included in the calibration qualification test specification and calibration qualification test results. [Outcome 5] <i>Note 2: Bidirectional traceability supports coverage, consistency and impact analysis.</i></p> <p>CAL.6.BP6: Ensure consistency. Ensure consistency between calibration requirements and test cases included in the calibration qualification test specification. [Outcome 5] <i>Note 3: Consistency is supported by bidirectional traceability and can be demonstrated by review records.</i></p> <p>CAL.6.BP7: Summarise and communicate results. Summarise the calibration qualification test results and communicate them to all affected parties. [Outcome 6] <i>Note 4: Providing all necessary information from the test case execution in a summary enables other parties to judge the consequences.</i></p>
	Output Work Products	<p>08-50 Test specification → [OUTCOME 2, 3] 08-52 Test plan → [OUTCOME 1] 13-04 Communication record → [OUTCOME 6] 13-19 Review record → [OUTCOME 5] 13-22 Traceability record → [OUTCOME 5] 13-50 Test result → [OUTCOME 4, 6] 19-00 Strategy → [OUTCOME 1]</p>



Work product definitions for Calibration SPICE

WP ID	WP Name	WP Characteristics
06-05	Calibration guide	<ul style="list-style-type: none"> • Documents methodology to be applied to deliver determine the set of application parameter values to meet the calibration work package requirements. • Identifies the required ranges within which the application parameters can be tuned • Details any interrelationship considerations/constraints between calibration elements, including potential trade-offs
11-08	Calibration release information	<ul style="list-style-type: none"> • Includes all associated release elements such as: <ul style="list-style-type: none"> ○ details of supported system hardware/software elements; ○ details of capability of the integrated calibration; ○ status of the integrated calibration in relation to the project plan; ○ integrated calibration unique identifier; ○ release date of the integrated calibration
11-09	Integrated calibration	<ul style="list-style-type: none"> • All elements of the calibration release are included • Unique identifier for the integrated calibration
11-10	Calibration work package data	<ul style="list-style-type: none"> • Collection of application parameters associated with a calibration work package
17-13	Calibration requirements specification	<ul style="list-style-type: none"> • Identifies the system requirements that are fully or partially delivered by calibration • Decomposes the system requirements into calibration requirements • Identifies any interrelationship considerations/constraints between calibration elements • Identifies any relationship considerations/constraints between the system elements, the software and the calibration • Describes the intended operational context of the calibration, including: <ul style="list-style-type: none"> ○ Legislative criteria ○ Related vehicle level attributes ○ User interactions ○ Environmental conditions and other external factors (e.g. pressures / temperatures, fuel types) ○ Use cases
17-14	Calibration hot list	<ul style="list-style-type: none"> • Identifies application parameters which have critical or



			<p>significant characteristics in relation to others areas of the calibration or system</p> <ul style="list-style-type: none"> • Defines the limit on the allowable range of values to be used for the identified application parameters
	19-13	Calibration integration strategy	<ul style="list-style-type: none"> • Identifies the calibration work packages to be integrated • Defines the integration sequence of the calibration work packages, paying attention to interdependencies and interactions