Fundamentals of Automotive Functional Safety Design

Unit Code: ASC/N8116

Version: 1.0

NSQF Level: 5.5

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Description

This NOS unit is about preparing comprehensively to perform design-analysis-development-validation of safety systems with the understanding of statutory and industry standards pertaining to functional safety. This NOS unit is about performing engineering design and the product development of Electrical/Electronic (E/E) systems Its about performing simulations (CAE) of CAD models (mechanical & electrical) to best correlate with the physical tests (lab & field)

Scope

The scope covers the following :

- Understand the latest trends of technology deployment to ensure functional safety effectively-swiftly-cost-effectively, aligning with the objectives of the Vehicle Development Program (VDP)
- Design the E/E systems through the stages - technology concept to prototype evaluation to vehicle assembly to manufacturing drawing release
- Follow the V-model MBSE of design development by tight integration with product (hardware) and system (software) suppliers/vendors
- Evaluate the safety functionality of E/E products and systems designed as per evolving technologies under all modes of performance validation all through the life-cycle of the vehicle - NPD to EoL
- Perform CAE simulations as per approved Virtual Product Development (VPD) plans for each phase of Product Life-Cycle (PLC) to validate part design (CAD) by correlating with validation tests

Elements and Performance Criteria

Engage fully for thorough understanding of functional safety

To be competent, the user/individual on the job must be able to:

PC1. Study the safety regulations that apply for the vehicle and its target markets

PC2. Examine the statutory compliance rules regionally applicable, homologation procedures and the industry standards pertinent to the vehicle program

PC3. Understand the functional safety goals stated in the VDP plan; and review the role of non-R&D departments (Manufacturing, Purchase, Quality) in processes linked to functional safety

PC4. Study the design targets set by the Vehicle Integration (VI) team as well as by the Sub-system Management Team (SMT) for the parts and assemblies in each of vehicle sub-systems

PC5. Learn the Virtual Product Development (VPD) stipulations for correlating simulations with safety testing in lab and field (FLM: Field-Lab-Math correlation

Align with the objectives of the Vehicle Development Program (VDP)

To be competent, the user/individual on the job must be able to:

PC6. Explore all safety stipulations in the light of VDP imperatives (Quality-Cost-Time)

PC7. Review the vehicle safety goals by the VI team – Crash safety, Fire safety, Safety limits for Warranty (Strength, Endurance) and Performance (Stiffness, Noise-Vibration-Harshness [NVH], Fuel economy [FE]), Vehicle dynamics and Aerodynamics (Cd)

PC8. Review the sub-system level safety goals by the SMTs in line with the VI targets and the VDP objectives

PC9. Analyse the Chassis-SMT’s safety goals for the functioning of Braking system, Fuel storage & distribution system, Suspension-Wheel-Axle system, Steering system and Exhaust system

PC10. Analyse the PowerTrain-SMT's safety goals for the functioning of IC engine (Gasoline/Diesel/LPG/CNG/LNG/H2) and EV (BEV/Solar) – combustion, ignition, cooling, lubrication and waste treatment / disposal

PC11. Analyse the Body-Interior-HVAC (Heating Ventilation Air-Conditioning) SMTs' safety goals for the performance of body stiffness and interior security

PC12. Analyse the Electrical/Electronic (E/E) SMT's safety goals for the functioning of electrical loads & wiring, electronic systems & communication (navigation, GPS, autonomous driving, LIDAR, ECUs in Chassis/PT/Body/Interior/HVAC, sensors, software and onboard computer)

Understand the latest trends of technology deployment to ensure functional safety effectively - swiftly - cost-effectively

To be competent, the user/individual on the job must be able to:

PC13. Understand the technology space applicable for the vehicle as per VDP guidelines for Quality-Cost-Time

PC14. Study the market trends, industry specifications and governmental controls that are applicable for the technologies shortlisted for the VPD

PC15. Review the VDP budget and VPD gates timelines to select the set of apt technologies to meet the quality standards of functional safety

PC16. Examine the safety guidelines for the design and development of E/E systems (AUTOSAR, ISO 26262, etc) as well as Diagnostics and Servicing (MRO)

PC17. Explore the safety stipulations for the design and development of mechanical systems – Crash/collision (ENCAP, BNCAP), Exhaust/pollution (Euro-6, BS-6), Energy consumption (CAFÉ, FAME), Noise (CMVR, iCAT) and Roadworthiness (TUV, ARAI)

Design the E/E systems through the stages - technology concept to prototype evaluation to vehicle assembly to manufacturing drawing release

To be competent, the user/individual on the job must be able to:

PC18. Examine the definition of functional safety and review the elicited safety requirements

PC19. Identify the areas of functioning - operating - automating of E/E system where safety consideration is crucial

PC20. Follow Q-C-T imperative of VDP at all times including change of technology schemes adopted for the vehicle

PC21. Integrate the V-model MBSE (Model Based Systems Engineering) of E/E product and system design into the VPD for Fast-to-Market (FTM) / On-Time-Delivery (OTD) and First-Time-Right (FTR) approach delivery through the VVD gates from virtual concept vehicle release (VCVR) to virtual production vehicle release (VPVR)

Follow the V-model MBSE of design development by tight integration with product (hardware) and system (software) suppliers/vendors

To be competent, the user/individual on the job must be able to:

PC22. Adopt the apt supplier integration (SI) level as per the VPD plan and budget

PC23. Examine the APQP documents to detail the exchanges between software suppliers and hardware vendors

PC24. Design E/E systems for reliability - durability - repeatability

PC25. Draft Design Statement of Requirement (D-SOR) clearly for vendors and design engineers to work on

PC26. Identify the risks and hazards involved in the use-misuse-abuse conditions by following Automotive Safety Integrity Levels (ASIL)

PC27. Prepare Design & Process FMEA (Failure Mode Effects Analysis) complying with risk mitigation stipulations as per ISO 26262 & AUTOSAR and verify safety requirements compliance in the VDP of the vehicle

PC28. Plan for joint exercise by SMT-Testing-QC teams for part approval and design documentation as per PPAP (Production Part Approval Process)

Evaluate the safety functionality of E/E products and systems designed as per evolving technologies under all modes of performance validation all through the life-cycle of the vehicle – NPD to EoL

To be competent, the user/individual on the job must be able to:

PC29. Seek approval of supervisors for design finalization and PPAP at each stage of PDP

PC30. Conduct design verification and validation through the stages of MBSE (vehicle-assembly-part) – Simulation [Software-in-Loop (SIL), Hardware-in-Loop (HIL)] and Tests [Chassis-dyno, lab vehicles and field vehicles]

PC31. Perform cross-functional validation with Vehicle Integration (VI) tests and pre-production user trials of prototype vehicles

PC32. Archive and store the approved data (virtual models, physical properties/samples and documents) for easy retrieval

PC33. Follow the part/system reuse strategy through the design life-cycle of vehicle (NPD - New Product Development, CI - Continuous Improvement, VA-VE - Value-Addition – Value-Engineering, MYC – Model Year Changes, MCE – Mid-Cycle Enhancement and EoL – End of Life)

PC34. Adapt to emerging technologies for faster adoption of software & hardware development, vehicle manufacturing, automobile usage and MRO

Evaluate the safety functionality of E/E products and systems designed as per evolving technologies under all modes of performance validation all through the life-cycle of the vehicle – NPD to EoL

To be competent, the user/individual on the job must be able to:

PC35. Identify the load cases for all types of simulations

PC36. Examine the VVD scheme (budget, fidelity, security, exclusivity) to select software and server

PC37. Follow the approved VVD strategy to create unified Finite Element (FE) models for crash, durability, NVH, etc.

PC38. Devise FE modeling (pre-processing) strategy to do FE meshing of vehicle parts for safety analysis (FEA)

PC39. Check for quality of FE models after integrating BC (Boundary Conditions), parts, connections, material models

Validate CAE models of part design (CAD) by correlating with DV/PV/PPV tests

To be competent, the user/individual on the job must be able to:

PC40. Review the diverse designing processes (NPD, ECR, Re-engineering, Reverse engineering) to decide on correlation requirement

PC41. Explore the diversity of virtual vehicle models and FEM configurations

PC42. Identify the simulation load cases critical for design-for-safety

PC43. Perform simulations on Body & Chassis for Crash safety, PowerTrain, HVAC & Interiors for Fire safety, Overall vehicle for Aerodynamics, Kinematics, Mobility, Stiffness analysis

PC44. Finalise designs as per VVD gate approvals for Strength (Factor of Safety) and Performance (Ranking)

Perform CAE simulations as per approved VPD plans for each phase of Product Life-Cycle (PLC)

To be competent, the user/individual on the job must be able to:

PC45. Execute designing of parts and assemblies at each stage for development in-house or at supplier-end

PC46. Follow design statements to fulfill all requirements through all phases of PLC – new design creation, correction, improvisation and transformation

PC47. Change CAD models as per Design Manager's instruction after correlating between DV/PV test reports and FEA/CFD/MBD CAE reports in the DRBTR (Design Review based on Test Results)

PC48. Release CAD models in time for VVD's subsequent CAE simulations

PC49. Document all CAE reports and seek final approval for drawing release and archiving

Prepare Learning Analysis Design Validation (LADV) plan by adopting learning in the PDP and field usage of vehicle

To be competent, the user/individual on the job must be able to:

PC50. Finalise design of each part as per CAE-Testing-QC-PM (Program Management) reports

PC51. Include manufacturing process tolerance studies in the GD&T (Geometric Dimensioning & Tolerancing) scheme of production drawing release

PC52. Release production drawing as per Manager's direction with due priority to safety aspects

PC53. Seek the Supervisor's approval for compiling all the learning, especially on functional safety, risk mitigation procedures, performance reliability, etc

PC54. Archive the Learning Analysis Design Validation (LADV) report of the VDP for using in the next phase of PLC or the next cycles of vehicle designing

Knowledge and Understanding (KU)

The individual on the job needs to know and understand:

KU1. Country specific safety regulations for various categories of vehicles

KU2. Vehicle safety type approval standards followed by Indian automobile industry

KU3. Each function of in the vehicle PLM (product lifecycle management)

KU4. Vehicle Integration (VI) and Sub-system Management Team (SMT) safety targets for general automobiles

KU5. Field-Lab-Math (FLM)correlation procedures

KU6. Safety critical parts and sub-assemblies in the vehicle sub-systems - Chassis-PT-Body-Int.-HVAC

KU7. Technologies supporting design, analysis and testing

KU8. Government and industry control on emerging technologies

KU9. Emerging trends in safety regulations by world regions and vehicle markets

KU10. Vehicle Development Plan (VDP) approach for Fast-to-Market (FTM), Value-for-Money (FVM), Quality and Safety

KU11. Electrical/Electronic (E/E) sub-system and its hardware parts and software systems

KU12. Model Based Engineering (MBE) methodology for E/E system design and test-validation

KU13. Standard Supplier Integration (SI) schemes for vehicle development

KU14. General and specific VDP documents, APQP steps pertaining to E/E systems

KU15. Design requirements in general and safety specific for E/E systems

KU16. ISO 26262 procedures and AUTOSAR stipulations for E/E

KU17. Vehicle industry specific FMEA, DFSS, DFX

KU18. Vehicle design cycles in the product lifecycle
KU19. Typical vehicle operating conditions and extremities - use/misuse/abuse
KU20. Field and track testing procedures of prototype vehicle
KU21. Laboratory testing procedures for vehicle structural parts, engine & transmission, E/E systems
KU22. CAD-CAE softwares in the market - proprietary and free & open source (FOSS)
KU23. Emerging technologies in CAD modeling & storing and FEA meshing & High Performance Computing (HPC)
KU24. F.E techniques across automotive industry for various types of analysis and different systems - Mech & Elec, Structural & Fluid, Static & Dynamic, etc.
KU25. Geographic conditions impacting vehicle performance - Temperature, Humidity, Altitude, Corrosion, etc.
KU26. Ecosystem of CAE - Engineering Service Providers (ESP), Computing technology providers, Customised solution providers
KU27. Procedures of production drawing release and systems & practices in Product Data Management (PDM)

Generic Skills (GS)

User/individual on the job needs to know how to:

GS1. read and interpret notes, designs and instructions shared by various teams internal/external
GS2. follow instructions, guidelines, procedures, rules, and service level agreements/contracts
GS3. listen & comprehend accurately and communicate smoothly with the supervisor/team-mates
GS4. follow rule-based decision-making process and make judgments for positive business impact
GS5. imbibe the work culture, recognise workplace problems correctly and take suitable actions
GS6. analyse aptly all information gathered from observation, experience, explanation, literature
GS7. plan and organise the work to achieve targets and meet deadlines
GS8. apply problem-solving approaches to different situations appropriately
GS9. act with attention-to-detail, being first-time-right, for on-time-delivery
GS10. exchange technical information clearly using proper language and manage data per protocol

Assessment Criteria

Assessment Criteria for Outcomes	Theory Marks	Practical Marks	Project Marks	Viva Marks
Engage fully for thorough understanding of functional safety	**3**	**-**	**-**	**2**
PC1. Study the safety regulations that apply for the vehicle and its target markets	-	-	-	1
PC2. Examine the statutory compliance rules regionally applicable, homologation procedures and the industry standards pertinent to the vehicle program	1	-	-	-
PC3. Understand the functional safety goals stated in the VDP plan; and review the role of non-R&D departments (Manufacturing, Purchase, Quality) in processes linked to functional safety	-	-	-	1
PC4. Study the design targets set by the Vehicle Integration (VI) team as well as by the Sub-system Management Team (SMT) for the parts and assemblies in each of vehicle sub-systems	1	-	-	-
PC5. Learn the Virtual Product Development (VPD) stipulations for correlating simulations with safety testing in lab and field (FLM: Field-Lab-Math correlation	1	-	-	-
Align with the objectives of the Vehicle Development Program (VDP)	**7**	**-**	**-**	**4**
PC6. Explore all safety stipulations in the light of VDP imperatives (Quality-Cost-Time)	1	-	-	-
PC7. Review the vehicle safety goals by the VI team – Crash safety, Fire safety, Safety limits for Warranty (Strength, Endurance) and Performance (Stiffness, Noise-Vibration-Harshness [NVH], Fuel economy [FE]), Vehicle dynamics and Aerodynamics (Cd)	1	-	-	1
PC8. Review the sub-system level safety goals by the SMTs in line with the VI targets and the VDP objectives	1	-	-	-
PC9. Analyse the Chassis-SMT's safety goals for the functioning of Braking system, Fuel storage & distribution system, Suspension-Wheel-Axle system, Steering system and Exhaust system	1	-	-	1

Assessment Criteria for Outcomes	Theory Marks	Practical Marks	Project Marks	Viva Marks
PC10. Analyse the PowerTrain-SMT's safety goals for the functioning of IC engine (Gasoline/Diesel/LPG/CNG/LNG/H2) and EV (BEV/Solar) – combustion, ignition, cooling, lubrication and waste treatment / disposal	1	-	-	1
PC11. Analyse the Body-Interior-HVAC (Heating Ventilation Air-Conditioning) SMTs' safety goals for the performance of body stiffness and interior security	1	-	-	-
PC12. Analyse the Electrical/Electronic (E/E) SMT's safety goals for the functioning of electrical loads & wiring, electronic systems & communication (navigation, GPS, autonomous driving, LIDAR, ECUs in Chassis/PT/Body/Interior/HVAC, sensors, software and onboard computer)	1	-	-	1
Understand the latest trends of technology deployment to ensure functional safety effectively - swiftly - cost-effectively	**4**	**-**	**-**	**-**
PC13. Understand the technology space applicable for the vehicle as per VDP guidelines for Quality-Cost-Time	-	-	-	-
PC14. Study the market trends, industry specifications and governmental controls that are applicable for the technologies shortlisted for the VPD	1	-	-	-
PC15. Review the VDP budget and VPD gates timelines to select the set of apt technologies to meet the quality standards of functional safety	1	-	-	-
PC16. Examine the safety guidelines for the design and development of E/E systems (AUTOSAR, ISO 26262, etc) as well as Diagnostics and Servicing (MRO)	1	-	-	-
PC17. Explore the safety stipulations for the design and development of mechanical systems – Crash/collision (ENCAP, BNCAP), Exhaust/pollution (Euro-6, BS-6), Energy consumption (CAFÉ, FAME), Noise (CMVR, iCAT) and Roadworthiness (TUV, ARAI)	1	-	-	-
Design the E/E systems through the stages - technology concept to prototype evaluation to vehicle assembly to manufacturing drawing release	**2**	**-**	**-**	**2**
PC18. Examine the definition of functional safety and review the elicited safety requirements	1	-	-	-

Assessment Criteria for Outcomes	Theory Marks	Practical Marks	Project Marks	Viva Marks
PC19. Identify the areas of functioning - operating - automating of E/E system where safety consideration is crucial	-	-	-	1
PC20. Follow Q-C-T imperative of VDP at all times including change of technology schemes adopted for the vehicle	-	-	-	1
PC21. Integrate the V-model MBSE (Model Based Systems Engineering) of E/E product and system design into the VPD for Fast-to-Market (FTM) / On-Time-Delivery (OTD) and First-Time-Right (FTR) approach delivery through the VVD gates from virtual concept vehicle release (VCVR) to virtual production vehicle release (VPVR)	1	-	-	-
Follow the V-model MBSE of design development by tight integration with product (hardware) and system (software) suppliers/vendors	**6**	**11**	**-**	**3**
PC22. Adopt the apt supplier integration (SI) level as per the VPD plan and budget	-	-	-	1
PC23. Examine the APQP documents to detail the exchanges between software suppliers and hardware vendors	1	-	-	-
PC24. Design E/E systems for reliability - durability - repeatability	1	-	-	1
PC25. Draft Design Statement of Requirement (D-SOR) clearly for vendors and design engineers to work on	1	5	-	-
PC26. Identify the risks and hazards involved in the use-misuse-abuse conditions by following Automotive Safety Integrity Levels (ASIL)	1	-	-	-
PC27. Prepare Design & Process FMEA (Failure Mode Effects Analysis) complying with risk mitigation stipulations as per ISO 26262 & AUTOSAR and verify safety requirements compliance in the VDP of the vehicle	1	3	-	-
PC28. Plan for joint exercise by SMT-Testing-QC teams for part approval and design documentation as per PPAP (Production Part Approval Process)	1	3	-	1

Assessment Criteria for Outcomes	Theory Marks	Practical Marks	Project Marks	Viva Marks
Evaluate the safety functionality of E/E products and systems designed as per evolving technologies under all modes of performance validation all through the life-cycle of the vehicle – NPD to EoL	**4**	**9**	**-**	**1**
PC29. Seek approval of supervisors for design finalization and PPAP at each stage of PDP	-	-	-	-
PC30. Conduct design verification and validation through the stages of MBSE (vehicle-assembly-part) – Simulation [Software-in-Loop (SIL), Hardware-in-Loop (HIL)] and Tests [Chassis-dyno, lab vehicles and field vehicles]	1	5	-	1
PC31. Perform cross-functional validation with Vehicle Integration (VI) tests and pre-production user trials of prototype vehicles	1	4	-	-
PC32. Archive and store the approved data (virtual models, physical properties/samples and documents) for easy retrieval	-	-	-	-
PC33. Follow the part/system reuse strategy through the design life-cycle of vehicle (NPD - New Product Development, CI - Continuous Improvement, VA-VE - Value-Addition – Value-Engineering, MYC – Model Year Changes, MCE – Mid-Cycle Enhancement and EoL – End of Life)	1	-	-	-
PC34. Adapt to emerging technologies for faster adoption of software & hardware development, vehicle manufacturing, automobile usage and MRO	1	-	-	-
Evaluate the safety functionality of E/E products and systems designed as per evolving technologies under all modes of performance validation all through the life-cycle of the vehicle – NPD to EoL	**1**	**5**	**-**	**2**
PC35. Identify the load cases for all types of simulations	-	-	-	1
PC36. Examine the VVD scheme (budget, fidelity, security, exclusivity) to select software and server	-	-	-	-
PC37. Follow the approved VVD strategy to create unified Finite Element (FE) models for crash, durability, NVH, etc.	-	2	-	-

Assessment Criteria for Outcomes	Theory Marks	Practical Marks	Project Marks	Viva Marks
PC38. Devise FE modeling (pre-processing) strategy to do FE meshing of vehicle parts for safety analysis (FEA)	-	-	-	1
PC39. Check for quality of FE models after integrating BC (Boundary Conditions), parts, connections, material models	1	3	-	-
Validate CAE models of part design (CAD) by correlating with DV/PV/PPV tests	**2**	**13**	**-**	**2**
PC40. Review the diverse designing processes (NPD, ECR, Re-engineering, Reverse engineering) to decide on correlation requirement	-	-	-	-
PC41. Explore the diversity of virtual vehicle models and FEM configurations	-	-	-	1
PC42. Identify the simulation load cases critical for design-for-safety	1	3	-	-
PC43. Perform simulations on Body & Chassis for Crash safety, PowerTrain, HVAC & Interiors for Fire safety, Overall vehicle for Aerodynamics, Kinematics, Mobility, Stiffness analysis	-	5	-	1
PC44. Finalise designs as per VVD gate approvals for Strength (Factor of Safety) and Performance (Ranking)	1	5	-	-
Perform CAE simulations as per approved VPD plans for each phase of Product Life-Cycle (PLC)	**1**	**5**	**-**	**2**
PC45. Execute designing of parts and assemblies at each stage for development in-house or at supplier-end	1	-	-	-
PC46. Follow design statements to fulfill all requirements through all phases of PLC – new design creation, correction, improvisation and transformation	-	-	-	1
PC47. Change CAD models as per Design Manager's instruction after correlating between DV/PV test reports and FEA/CFD/MBD CAE reports in the DRBTR (Design Review based on Test Results)	-	5	-	-
PC48. Release CAD models in time for VVD's subsequent CAE simulations	-	-	-	1
PC49. Document all CAE reports and seek final approval for drawing release and archiving	-	-	-	-

Assessment Criteria for Outcomes	Theory Marks	Practical Marks	Project Marks	Viva Marks
Prepare Learning Analysis Design Validation (LADV) plan by adopting learning in the PDP and field usage of vehicle	**-**	**7**	**-**	**2**
PC50. Finalise design of each part as per CAE-Testing-QC-PM (Program Management) reports	-	5	-	-
PC51. Include manufacturing process tolerance studies in the GD&T (Geometric Dimensioning & Tolerancing) scheme of production drawing release	-	2	-	-
PC52. Release production drawing as per Manager's direction with due priority to safety aspects	-	-	-	1
PC53. Seek the Supervisor's approval for compiling all the learning, especially on functional safety, risk mitigation procedures, performance reliability, etc	-	-	-	1
PC54. Archive the Learning Analysis Design Validation (LADV) report of the VDP for using in the next phase of PLC or the next cycles of vehicle designing	-	-	-	-
NOS Total	**30**	**50**	**-**	**20**

National Occupational Standards (NOS) Parameters

NOS Code	ASC/N8116
NOS Name	Fundamentals of Automotive Functional Safety Design
Sector	Automotive
Sub-Sector	Research & Development
Occupation	Automotive Product Designing
NSQF Level	5.5
Credits	2
Minimum Educational Qualification & Experience	Completed 2nd year of UG (UG Diploma) (In trades: Manufacturing/Mechanical/Automobile/Electrical/Electronics or relevant) with 1-2 Years of experience OR Pursuing 3rd year of UG (In trades: Manufacturing/Mechanical/Automobile/Electrical/Electronics or relevant)
Version	1.0
Last Reviewed Date	NA
Next Review Date	NA
CCN Category	1