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Physical integration of hybrid and electric vehicle batteries at pack level aiming at increased energy density and efficiency Innovation Action (IA)

Grant Agreement — 770019

GHOST

InteGrated and PHysically Optimised Battery System

for Plug-in Vehicles Technologies

D1.2
Risk and data management plan

DOCUMENT INFORMATION

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3.0	29.05.2018	Final version	David Storer

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Acronyms

DMP: Data Management Plan

RMP: Risk Management Plan

DoW: Description of Work

KPI: Key Performance Indicators

WP: Work Package

WPL: Work Package Leader

ESS: Energy Storage System

BMS: Battery Management System

EV: Electric Vehicle

PHEV: Pluggable Hybrid Electric Vehicle

BEV: Battery Electric Vehicle

BS: Battery System

SoH: State of Health

SoC: State of Charge

SIL: Simulation in the Loop

EoL: End of Life

BoL: Beginning of Life

HP: High-power

HE: High-energy

HV: High Voltage

BMU: Battery Management Unit

VMU: Vehicle Management Unit

1 Introduction

1.1 Executive summary

The Project Coordinator (CRF) is responsible for technical coordination and scientific quality assurance throughout the project. This task involves monitoring of the technical progress, coordinating data management, the various work packages and tasks, and risk monitoring. When necessary corrective actions will be taken including potential work reallocation which will be coordinated by the Project Coordinator and agreed by the Executive Board consisting of all WP leaders. An approval procedure was defined during the kick-off meeting and it has been agreed that the Executive Board is the body for quality assurance in line with the Consortium Agreement. D1.1 the Quality Assurance Guideline contains more information on the related internal roles, rules and procedures.

This Deliverable report addresses both the risk and data management plans and includes definitions and details of the processes being implemented with respect to the GHOST project.

The Risk Management Plan (RMP) is an on-going process which is continuously updated throughout the lifetime of the project to monitor known risks, identify emerging risks, and where necessary to respond to them. As part of the risk management plan, a risk register is compiled from risks identified in the GHOST Grant Agreement, Deliverables to date, and from risks which are identified during the course of the project. This register is monitored and discussed during the Executive Board meetings and adjusted when necessary.

The Data Management Plan (DMP), which is also an on-going process, defines how different project data will be handled during the project and aims to ensure the appropriate level of access to and re-use of data generated by the GHOST project in particular with respect to the public domain Deliverable reports. The Project Coordinator (CRF) is responsible for the implementation of the DMP and its coordination is assisted by the Executive Board.

Both the RMP and DMP should be considered to be complimentary with respect to the other Deliverable reports and in particular Deliverable D1.1 “Quality Assurance Guidelines” and D9.2 “Dissemination and communication plan”. Furthermore, all the partners have signed a Consortium Agreement, in which all relevant issues necessary for the proper execution of the project are described in detail including: the responsibilities (General Assembly, Project Coordinator and individual parties), liabilities, voting rules, intellectual property rights (IPR), knowledge management, rules for publishing information, conflict resolution, etc.

2 Overview of the GHOST Project

2.1 Objectives and Scope

The aim of the GHOST project is to develop an InteGrated and PHysically Optimised Battery System for Plug-in Vehicles Technologies.

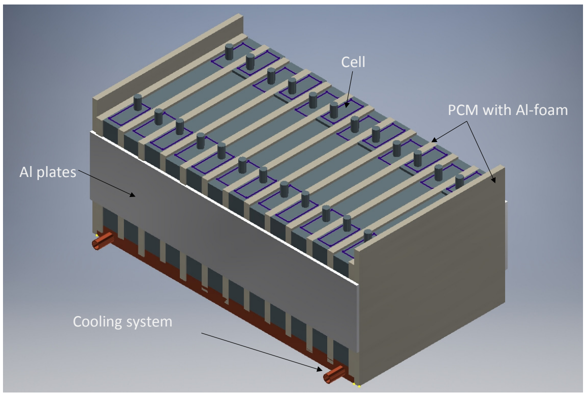
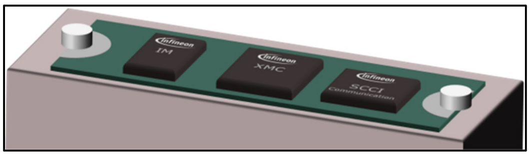
The overall objectives of the GHOST project, looking at both the existing Li-ion battery technologies and the future commercial post-lithium-ion ones, are:

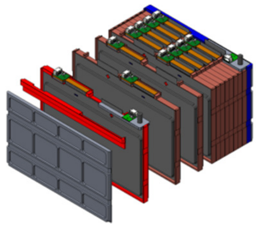
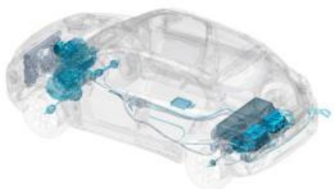
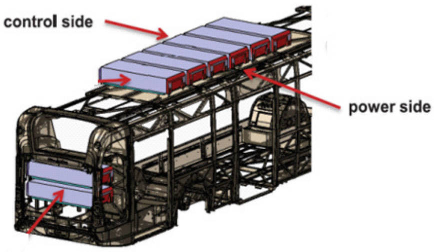
- Design of a novel and modular battery system with higher energy density (in weight) up to 20% based on the state- of-the-art of lithium-ion battery cell technologies through:
  - Implementation of advanced light and functionalized battery system (BS) housing material;
  - Innovative, modular, energy and cost efficient thermal management architectures & strategies;
  - Optimal selection of the right battery cell technology for different applications and use-cases that will be demonstrated in the proposed project;
- Increase of the energy density of the battery system up to 30% based on novel Dual Battery System concept based on new emerging battery technologies and high power lithium-ion battery;
- Development of mass producible innovative and integrated design solutions to reduce the battery integration cost at least by 30% through smart design: starting from cell up to recycling, testing and modelling approaches;
- Definition of new test methodologies and procedures to evaluate reliability, safety and lifetime of different Battery Systems;
- Design of novel prototyping, manufacturing and dismantling techniques for next generation of lithium-ion BS;
  - Evaluation of 2nd life battery potential, applications and markets starting from requirements and specifications;
  - Demonstration of GHOST solutions in two demonstrators (BEV bus with ultrafast partial charge capability and P-HEV) and one lab demonstrator (module level) for the post Lithium-Ion technology.

The aim is to achieve these key innovations at affordable cost in order to strengthen Europe's competitive position in terms of Battery System, a crucial field for electrified vehicles.

Technologies developed in the frame of the project will aim for first market introduction between 2023 and 2024.

Importantly, the technology devised will have a strong impact on the electrically chargeable vehicles (BEVs and P-HEVs) performance increase (including range and related battery lifetime and reliability).

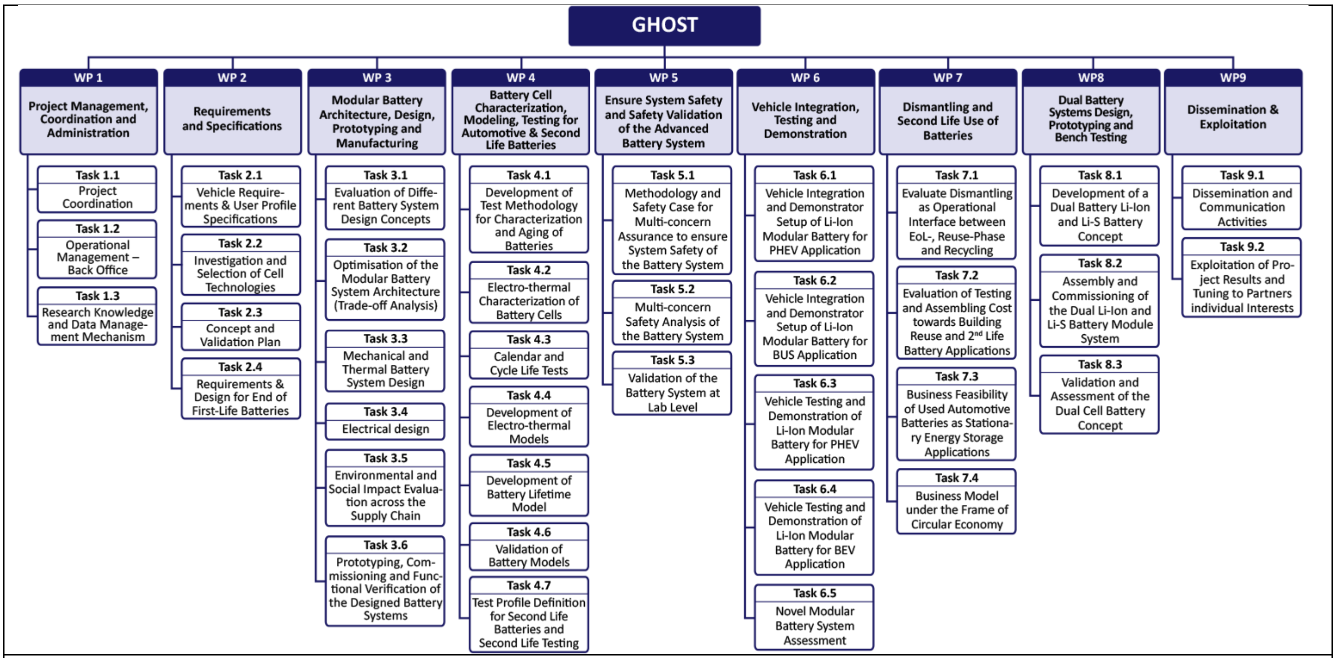
Aim	GHOST Objective
Thermal, electrical and mechanical design of battery systems based on lithium and post lithium cells aiming at highly increased energy density and modularity	Mechanical design: ➢ Replacement of bulky and heavy housings that are used in the current conventional BS by reliable and functionalized lightweight materials, contributing up to 30% weight reduction and provide improved safety by higher specific energies; ➢ Redesign of the BS by using novel materials at module level to reduce further the weight up to 20% and to maintain the required mechanical stability and safety.  Thermal design: ➢ Development of a module level novel and modular thermal management through advanced thermal concepts, which is independent of the cooling concept and selected media; ➢ Adaptive and smart active control of the cooling circuit pumps/fans; ➢ Thermal management design for bus and future BEVs fast charging (up to 350-450 kW). Electrical design: ➢ Development of a modular battery module architecture (i.e. 48V), which can be easily scaled up to 400-800 V with full commonalities in the field of used mechanical connections between the cells, fuses, safety, and battery controller unit concept; ➢ Novel Dual-Cell-Battery architecture
Battery cost reduction	➢ Implementation of intelligent more integrated and simplified harness sensing and communications (i.e. for temperature and state of heath estimation) with high reliability;  ➢ Complete redesign of the BS by taking into account the dismantling and recycling aspects (reduction of integration cost up to 20% and reduction time up to 30-40%); ➢ Standardized and innovative parameterization test protocols, models and state functions which can speed up the battery module and system development process by 20% compared to SoA contributing to reduce the integration cost as a consequence; ➢ Defining the needs to be taken into account to obtain a modular balancing concept solution suitable for automotive and second life applications; ➢ Improved modelling and simulation tools for BS improvement/development using virtual modelling approach, which is mainly based on the concept of Simulation-In-Loop (SIL), addressed through the application of the knowledge that will be generated in the project on thoroughly insight ageing mechanisms, SoH, SoC, SoF and electro-thermal modelling.

Aim	GHOST Objective
Design for manufacturing, recycling and second use	➢ In the GHOST Project, efficient manufacturing processes will be applied for the BS that will be designed taking into account the best experiences in the field. In addition, the manufacturing will be processed in such way towards recycling in a cost efficient way thanks to the innovative solution of the physical integration of battery modules. 
Prototyping and mass-production technologies for battery systems	➢ New environmental friendly design of prototyping and manufacturing processes of BS for automotive will be considered and analysed; ➢ Identification of the cost efficient BS solution for mass-production.
Demonstration of performance, lifetime and safety behaviour including lab testing and demonstration under real life conditions in vehicles	➢ Demonstration of GHOST BS solutions at lab level (TRL 5) and within 2 demonstrators (PHEV 500X and BEV bus) under real life conditions based on performances and operational/functional safety.  
Advanced physical integration technologies for high energy/power density battery packs should take into account safety and modularity	➢ Development of a Novel Dual-Cell-Battery architecture for next generation BS that comprises high-power (HP) battery and next generation high-energy battery technologies (HE) with highly integrated and efficient physical integration thanks to advanced DC/DC converter based on newest semiconductors technologies (Si and WBG technologies). This concept will be demonstrated at lab level (TRL 4). ➢ The integration, manufacturing and safety methodology aspects considered for lithium-ion technology will be transferred for the Dual-Cell-Battery architecture.
Demonstration of performance, lifetime and safety behaviour including bench testing and demonstration under real life conditions in	Test methodologies and procedures to evaluate the functional safety and lifetime of the battery from cells, modules to system levels: ➢ Advanced and reliable standardized test procedure focusing on lifetime, safety, reliability for Li-ion and post Li-ion as well. New technologies may need new accurate and reliable testing methods and evaluation procedures to reflect real-life scenarios, because different C-rates, operation temperatures, safety limits, etc. are required to verify the operational BS. More realistic test methods can decrease testing time and enhance safety and competitiveness; ➢ Moreover, the novel BS architecture will require devoted new procedures for the experimental evaluation to be applied in the validation phase;

Aim	GHOST Objective
vehicles	Reliability enhancement due to: ➢ BS with less external and internal connections (i.e. advanced harness sensing for temperature), cabling, components and also for the vehicle protection relays architecture; ➢ Innovative simplified connection methods between BS and battery controller unit. Safety improvement thanks to: ➢ In GHOST project, novel thermal-management architectures and strategies will be implemented to increase the safety and to guarantee insulation protection; ➢ Battery state function will be implemented to detect possible failure mechanisms; ➢ The battery system will be investigated in depth based on the functional safety during the verification, validation and integration within the vehicle.

2.2 Workplan Overview

- PHASE I: Define the specifications starting from the requirements and constraints (WP2);
- PHASE II: Define the modular novel BS architecture for lithium based technology (WP3):
  - ➢ New functionalized lightweight materials for reducing the weight/volume of the BS;
  - ➢ Novel and cost efficient modular Thermal Management at battery module level that can be used for different types of vehicles (i.e. 400 or 800V) through refrigerant direct cooling or liquid cooling, depending of the application requirements;
  - ➢ Advanced modular electric design which can guarantee higher level of safety and simplification of the battery system;
  - ➢ Modular battery system approach for current and midterm lithium-ion battery technology;
  - ➢ Recycle and reuse design approach for cost reduction;
  - ➢ Eco-design analysis of the selected material.
- PHASE III: Advanced prototyping and manufacturing of processing of BS and verification (WP3 & WP4):
  - ➢ Integration of the developed state functions and harness sensing in the battery controller unit; Prototyping battery systems towards manufacturing processes;
- PHASE IV: Evaluation of the safety requirements of the battery system at controlled environment (WP5);
- PHASE V: Integration within the vehicle and demonstration in real environment (WP6);
- PHASE VI: Analysis of recycling and second use of batteries at end of first life in the vehicle (WP4, WP7); Implementation and exploitation of the results and disseminate the findings (WP9).



GHOST Work Breakdown Structure

2.3 Expected Impacts of the GHOST Project

Expected impact	GHOST Contribution	Related Deliverables
Battery integration costs (excluding cell cost) reduced by 20 to 30%	➢ Implementation of intelligent harness sensing (i.e. for temperature and state of heath estimation) with high reliability and safety; ➢ Complete redesign of the battery system by taking into account the dismantling and recycling aspects (like reduction of integration cost up to 20% and dismantling time by 30-40%); ➢ Standardised and innovative parameterization test protocols and models that work with existing and next generation cell technologies (such as lithium sulphur or next generation) and which can speed up the battery model development process by 20% compared to state of the art models. Thus, the proposed solution will contribute to reduce the integration cost and the development time; ➢ Defining the needs to be taken into account in order to obtain a modular balancing concept solution suitable for automotive and second life applications; ➢ Improved modelling and simulation tools for battery system improvement/development thanks to the use of virtual modelling approach, which is mainly based on the concept of Simulation-in-Loop (SiL), addressed through the application of the knowledge that will be generated in the project on thoroughly insight ageing mechanisms, SoH, SoC, SoF and electro-thermal modelling.	D3.4 D3.1 D4.1 D4.5 D4.5
Strengthening the EU value chain, from design and manufacturing to dismantling and recycling.	▪ Efficient manufacturing processes will be considered for the BS that will be designed taking into account the best experiences in the field. In addition, the manufacturing will be processed in such way towards recycling in a cost efficient way thanks to the innovative solution of the physical integration of battery modules; ▪ New design of prototyping and manufacturing processes of battery system for automotive will be considered and analysed; ▪ Identification of new cost-efficient BS for mass production.	D3.6 D3.7 D8.2
Contributing to climate action and sustainable development objectives	▪ A modular battery system will be designed that targets weight reduction. The newly integrated battery system will not only be more efficient on pack level; the increased total energy density will also yield a significant improvement of the overall vehicular energy efficiency and the upstream CO_2 emissions linked to the generation of the electricity used during charging of the vehicles.	D3.5 D7.1 D7.2

Contributing to climate action and sustainable development objectives	▪ The GHOST proposal will investigate how reusing and refurbishing second-life batteries can be enabled (reducing barriers and gaining leverages) in order to meet specific sustainability goals. The dismantling process of a module will be simplified to decrease the handling cost for second life usage. The manufacturing of components and the mining of materials of the battery system have an important environmental and social impact. Optimizing the usage and need of these materials and components with a circular approach has the potential to reduce the environmental and social impacts significantly.	D3.5 D7.1 D7.2

Expected Impact	GHOST Contribution	Related deliverables
Energy density improvement of battery packs in the order of 15 to 20%	**Mechanical design:** ➢ Replacement of bulky metallic housing of battery system that are used in the current or conventional battery systems (i.e. BMW i3 or TESLA) by reliable and lightweight materials, which will contribute up to 30% weight reduction; ➢ Redesign of battery system by using novel materials such as Al-foam at module level to reduce further the weight up to 20% and to maintain the required mechanical stability and safety according to the standards of on-road vehicles. **Thermal design:** ➢ Optimization of thermal management through efficient integration of phase change materials (PCM) into Al-foam to increase the thermal buffer on one hand and to simplify the thermal architecture on another hand. The incorporated PCM inside Al-foam will be coupled with refrigerant or liquid cooling at the bottom of the battery module to achieve an efficient cooling concept; ➢ Adaptive and smart active control of the cooling circuit pumps/fans; ➢ Design of thermal management applicable for fast charging opportunities. **Electrical design:** ➢ Development of a modular battery module architecture (i.e. 48V), which can be easily scaled up to 400-800V or high capacity applications with full commonalities in the field of used mechanical connections between the cells, fuses, safety, and optimised electrical integration and control thanks to battery control system (BCS); ➢ Novel Modular Dual Battery System architecture composed by one high-power (Li-Ion) and one high-energy (Li-Sulphur) battery modules, combined by a DC/DC converter with integrated control unit.	D3.1 D3.2 D3.3 D3.4 D8.1 D8.2 D8.3

3 Risk Management

3.1 Introduction

Risk is defined as an event that has a likelihood of occurring, and could have a negative impact on a project. A risk may have one or more causes and, if it occurs, one or more impacts. All projects assume some element of risk, and it's through risk management to monitor and track those events that have the potential to impact the outcome of a project.

Risk management has four stages: risk identification, analysis, evaluation and mitigation underpinned by continuous monitoring and control. These stages are described below in more detail as well as the roles and responsibilities connected to the risk management.

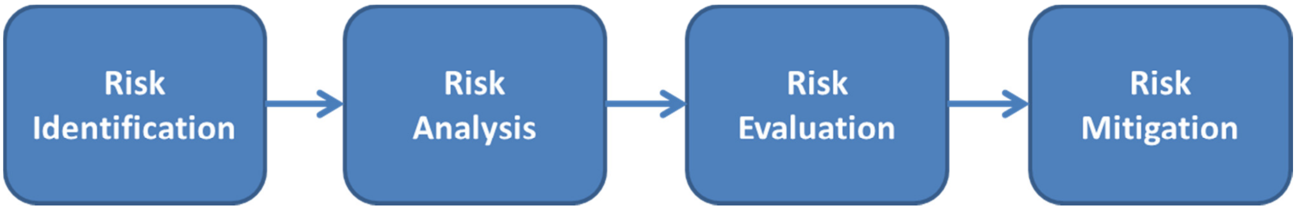


Figure 1: Stages of risk management

Risk management is an on-going process that continues throughout the life of a project. It includes processes for risk management planning, identification, analysis, monitoring and control. It is the objective of risk management to decrease the likelihood and impact of events averse to the project. On the other hand, any event that could have a positive impact should be exploited.

3.2 Types of Risk

Typically the risks in a technical research and innovation project of this type include:

- Technological risks
- Partnership risks
- Market risks
- Legal risks
- Management risks
- Environmental/regulation /safety risks

The purpose of this document is to describe the procedures being implemented within the GHOST project for identifying and handling risks. This risk management plan applies to all partners in the project.

3.3 Risk likelihood

The risk likelihood is the chance that a risk will occur in the life time of the project. The following chart shows the risk likelihood definitions. For each of the identified risks the potential likelihood that a given risk will occur must be assessed, and appropriate risk likelihood is selected from the chart below.

Likelihood Category	Description
Certain	Risk event expected to occur
Likely	Risk event more likely than not to occur
Moderate	Risk event may or may not occur
Unlikely	Risk event less likely than not to occur
Rare	Risk event not expected to occur

Table A: Risk Likelihood

3.4 Risk impact

The risk impact is the cause or effect of the risk in the project's progress. It is classified in five levels:

- Very serious: The risk would jeopardize the project's continuity or would significantly affect the projects outcomes. A very serious impact would be that the project needs to stop.
- Serious: The risk would jeopardize the project's continuity or would significantly affect the project outcomes. Usually, when a serious impact risk occurs, there is a need of changing the project contract, eg. one of the partners abandons the project.
- Moderate: the risk has a significant impact on the project, but it is perceived that the objectives will be still achieved eg. difficulties of defining RTD specifications lead to 6 months delay.
- Slight: the effect on the project is minor e.g. a task leader drops out the project.
- Low: the effect on the project is negligible, e.g. Shift of budget between partners.

The complexity, the technical challenges and the size of GHOST require an adequate risk management. It is therefore necessary that potential risks are clearly identified, assessed, and that possible recovery actions be prepared. Potential risks can be related to delays, performance, collaboration and management. Risk is by definition the product of Probability and Impact. A preliminary analysis of GHOST risks associated with the work plan and using a Risk Probability-Impact Matrix approach is presented by a sequential step-approach:

- Identify potential impacts of risks;
- Evaluate Probability Impact Scores;
- Prioritize Risks for Management Action;
- Determine risk mitigation measures into actions.

		IMPACT				
		TRIVIAL	MINOR	MODERATE	MAJOR	EXTREME
PROBABILITY	RARE	LOW	LOW	LOW	MEDIUM	MEDIUM
	UNLIKELY	LOW	LOW	MEDIUM	MEDIUM	MEDIUM
	MODERATE	LOW	MEDIUM	MEDIUM	MEDIUM	HIGH
	LIKELY	MEDIUM	MEDIUM	MEDIUM	HIGH	HIGH
	VERY LIKELY	MEDIUM	MEDIUM	HIGH	HIGH	HIGH

Table B: Probability-impact matrix

3.5 Specific aspects of the GHOST Risk Management Plan

3.5.1 Roles and responsibilities

All project partners should identify the project risks and give input to the reports concerning those risks. The risks must be defined and reported through the progress report template, indicating its risk likelihood, impact, contingency plan, and responsible partner and in what period of the project the risk is valid and should be monitored.

The Project Coordinator (CRF) with the support of the Back Office (VUB) will review and assess the identified risks. If necessary, feedback will be provided to the identified responsible partner. If the risk exposure is critical or there is a need for further discussion, the Project Coordinator is responsible for raising the issue during the Executive Board and Consortium meetings (i.e. General Assembly's and/or Progress Meetings). In that case, the mitigation plan must be established through a consensus decision process, and it may require the involvement of the Project Officer and all the partners.

3.5.2 Reporting and monitoring

The risks must be identified and reported as part of the progress reports which are scheduled at nominally 6-month intervals in conjunction with the General Assembly meetings. All project partners are required to participate in the identification of the project risks and give input to the progress reports regarding those risks.

Updates of the RMP

Version number	Project month	Nature
1	M8	Original version
2	M12	Update
3	M18 – RP1	Update
4	M24	Update
5	M30	Update
6	M36 – RP2	Update
7	M42 – RP3	Update

3.5.3 The Risk Management register

The risks are registered in a repository that is presented below.

The Risk Management register is available on EMDESK, on the online management platform used for GHOST. Work Package leaders are expected to collect feedback from the partners involved in

their Work Packages, revise and if necessary update the register at the end of each bi-annual internal reporting period.

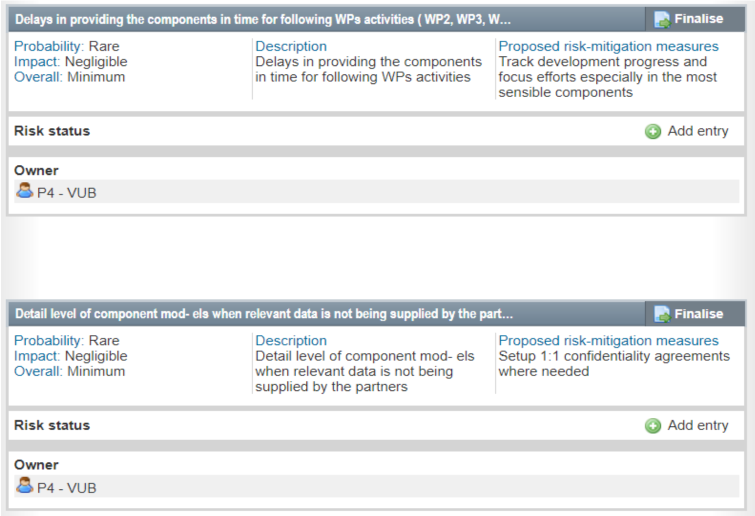


Figure 2: Risk register on EMDESK

3.5.4 Foreseen risks

An overview on significant risks and associated contingency plans is given in the Table below. The project management approach provides mechanisms to identify and resolve potential risks, such as continuous controls of the project plan with its milestones and key deliverables. The progress and resource reporting will enable the Project Management team (i.e. Coordinator, Back-office and Executive Board) to be continuously aware of potential problems. Hence, the team can initiate countermeasures in a timely fashion before a problem becomes jeopardizing and fall-back solutions can be defined and implemented in time.

No.	Description of risk	WP	Risk-mitigation measures	Probability	Effect
Delays					
1	Delays in providing the components in time for following WPs activities	All	Track development progress and focus efforts especially in the most sensible components.	Medium	High
Performance					
2	Detail level of component models when relevant data is not being supplied by the partners	All	Setup 1:1 confidentiality agreements where needed.	Medium	Medium
3	Integration effort of the components higher than expected	WP3, WP7	Upfront virtual design validation need to be applied where possible.	Medium	Medium
4	Final assessment does not show expected target	WP3, WP7, WP8	Re-evaluation of specification and recommendations for future improvement.	Medium	Medium
5	Component failure during	WP3,	Since from the proposal phase,	Medium	Medium

No.	Description of risk	WP	Risk-mitigation measures	Probability	Effect
	testing	WP4, WP7, WP8	the potential component failure critical pathways have been identified and the availability of a proper number of spare parts to avoid delays on the Project timing have been planned.		
6	Bench devices failure during testing	WP3, WP7, WP8	Back-up plan for alternative test capabilities.	Low	Low
7	Availability of high quality li-ion cells	WP3, WP4	Back-up suppliers involvement.	Low	High
8	Availability of high quality Li-S cells proto	WP8	Contact with different possible Projects, organisations able to supply proto cells.	Medium	Medium
Collaboration					
9	Poor cooperation between partners	ALL	In the monthly WP leader phone calls, the effectiveness of the partner interactions will be continuously monitored. If this problem happens, it will be managed identifying the reasons why and solving them at WP level or at Project level depending on which are the involved partners and the nature of the problem.	Low	High
Management					
10	Partners leave or Partners become insolvent	ALL	Back-up partners list or inside Consortium solution.	Low	High

Table C: List of foreseen risks and associated mitigation measures

3.5.5 Preliminary Identification of Risks

As indicated in the Grant Agreement, the GHOST Project consortium has identified at a preliminary stage some of the main barriers, obstacles and framework conditions that may limit and/or reduce the level of achievement of the previously described expected impacts.

The achievement of the potential impacts that will be demonstrated via the GHOST project is dependent upon the market adoption of the technologies. Therefore, anything putting at risk their cost effective realization can be considered as potential barrier or obstacle. In particular there are foreseen to be:

- The lack of industrial and international standards for the investigated architecture solution to set certain technical specifications, dimensions, and mechanical, electrical, and communication interfaces. Without a standard, OEMs and suppliers will be cautious in their development programs because of the financial risks associated with the risk not to be able to achieve economy of scale advantages;
- Uncertain deployment of the European Energy Taxation regulation (COM/2011/169 and COM/2011/168) and a modification of the directive 96/53/EC on weight and dimensions of commercial vehicles will result in planning uncertainty in the automotive supply chain for electrified commercial vehicles;
- The lack of homogeneous, and in some case adequate, government incentives in the different European Member States in order to stimulate the deployment of, in particular, electrified vehicles.

3.5.6 International Standards

As is documented in the APPENDIX to this report, a preliminary survey of the type approval regulatory body has been performed in order to identify any possible hindrance to a future homologation of the developed enhanced vehicle, taking into account those specifications and requirements which might be affected by the introduced advanced technologies; special attention has been paid to the hazardous aspects of the changes planned to the battery pack with a particular focus on crashworthiness, and the protection of occupants and vulnerable road users.

4 Data Management

4.1 Introduction

According to the H2020 Programme Guidelines on FAIR Data Management in Horizon 2020:

"Data Management Plans (DMPs) are a key element of good data management. A DMP describes the data management life cycle for the data to be collected, processed and/or generated by a Horizon 2020 project. As part of making research data findable, accessible, interoperable and re-usable (FAIR), a DMP should include information on: the handling of research data during and after the end of the project, what data will be collected, processed and/or generated, which methodology and standards will be applied, whether data will be shared/made open access and how data will be curated and preserved (including after the end of the project).

The DMP is a living document to be updated over the course of the project whenever significant changes arise and as a minimum in time with the periodic evaluation/assessment of the project. The consortium will, at the time of the bi-annual internal progress reporting assess whether the DMP needs to be updated.

The aim of the initial version of the GHOST DMP is to provide a general overview of data types collected and/or created by different project partners and on the usage of such data in line with the project objectives. The Horizon 2020 FAIR DMP template has been used and as the project proceeds, more questions will be addressed in detail, if needed.

Updates of the DMP		
Version number	**Project month**	**Nature**
1	M8	Original version
2	M12	Assessment whether update is needed
3	M18 – RP1	Update
4	M24	Assessment whether update is needed
5	M30	Assessment whether update is needed
6	M36 – RP2	Update
7	M42 – RP3	Update

4.2 The GHOST DMP

Component	Issues to be addressed	GHOST Project DMP
1. Data summary	State the purpose of the data collection/generation	A wide variety of technical data will be collected, primarily via simulation and experimental testing during the activities of the project primarily to enable direct comparison, in order to validate the simulation models, and to evaluate the performance of the technical solutions developed.
	Explain the relation to the objectives of the project	The generation of data through the testing and simulation activities will focus on evaluating the performance of the innovative battery systems developed during the project. In this context, the generation of data is directly relevant to the objectives of the project.
	Specify the types and formats of data generated/collected	The exact types and formats of the data generated/collected, whether any existing data is being re-used, the origin of the data, and the expected size of specific databases, will be defined in due course as a result of the testing and simulation activities which are planned to be conducted throughout the project.
	Specify if existing data is being re-used (if any)	
	Specify the origin of the data	
	State the expected size of the data (if known)	
	Outline the data utility: to whom will it be useful	The data will be primarily of use to the partners within the GHOST consortium, bearing in mind that the exchange of technical information is effectively one of the fundamental and essential elements of a collaborative technical research project. Furthermore key data generated within the project, and reported within the Public (PU) Domain Deliverable reports, are likely to be useful to other stakeholders external to the GHOST consortium working in fields related to the development and deployment of battery systems for (primarily) automotive applications.

2. FAIR Data		
2.1 Making data findable, including provisions for metadata	Outline the discoverability of data (metadata provision)	
	Outline the identifiability of data and refer to standard identification mechanism. Do you make use of persistent and unique identifiers such as Digital Object Identifiers?	With respect to the provision and sharing of data, particularly those data relating to Deliverable reports classified as PU, every effort will be made to ensure that the data are easily identifiable and that standard identification mechanisms will be used.
	Outline naming conventions used	Together with the creation and making available of data generated within the project, the naming conventions used will be specified. At this stage, the approaches being adopted for keyword searching and versioning will be specified if appropriate.
	Outline the approach towards search keyword	
	Outline the approach for clear versioning	
	Specify standards for metadata creation (if any). If there are no standards in your discipline describe what type of metadata will be created and how	In this context it is assumed that the term metadata refers to "data [information] that provides information about other data". With respect to this specific project, no specific existing standards are known. Nevertheless, if and when metadata are created, the approach adopted will be specified.
2.2 Making data openly accessible	Specify which data will be made openly available? If some data is kept closed provide rationale for doing so	The data which will be made openly available will correspond to the Deliverables that are classified as PU and hence will be in the Public Domain.
	Specify how the data will be made	The data will be made available using the EMDESK platform (https://www.emdesk.com/en/) which is the instrument

	available	selected for the storage and exchange of all key documents and information within the project.
	Specify what methods or software tools are needed to access the data? Is documentation about the software needed to access the data included? Is it possible to include the relevant software (e.g. in open source code)?	The EMDESK platform which will be used for data storage and exchange is a standard instrument which can be accessed directly. Should any specific instructions be required to facilitate data access, such as information relating to the nature and origin of the data, then these will be provided when the data is deposited.
	Specify where the data and associated metadata, documentation and code are deposited	All relevant documentation, codes, etc. relating to the data to be made openly accessible will be made available also within the EMDESK platform via public links that are accesible by those external users with whom the URL has been shared.
	Specify how access will be provided in case there are any restrictions	The data selected for open access relating to public-domain Deliverable reports will be made available without restrictions. Conversely data relating to Deliverables which are classified at Consortium-level will be stored within the EMDESK platform with access restricted to the partners in the consortium.
2.3 Making data interoperable	Assess the interoperability of your data. Specify what data and metadata vocabularies, standards or methodologies you will follow to facilitate interoperability.	Due to the nature of the data which will be generated, primarily from the simulation and testing of the battery systems to be developed in the project, the data will be strictly linked to the specific system or component under investigation. Full details of the respective system/component and test/simulation will be provided in the corresponding public-domain Deliverable report relating to the data made available.
	Specify whether you will be using standard vocabulary for all data types present in your data set, to allow inter-	Standard and conventional vocabulary, nomenclature, measurement units will be used throughout the project. A full glossary of abbreviations and acronyms will also be provided if and when necessary.

	disciplinary interoperability? If not, will you provide mapping to more commonly used ontologies?	
2.4 Increase data re-use (through clarifying licences)	Specify how the data will be licenced to permit the widest reuse possible	Currently there are no plans to license the use of key data related to public-domain Deliverables, but instead to allow open access to permit wide re-use during and after the project. Should it instead become necessary to alter this policy, and license the use of data, this will be specified in subsequent version of the GHOST Data Management Plan.
	Specify when the data will be made available for re-use. If applicable, specify why and for what period a data embargo is needed	In general, the data for open access will be made available for re-use once deposited on the EMDESK platform, the timing of which would nominally correspond to the delivery date of the public-domain Deliverable reports to which the data is related. Should it become necessary, during the course of the project, to alter this process, eg. delay the release of key data with respect to when the Deliverable report is deposited, then this will be specified in a subsequent release of the GHOST DMP.
	Specify whether the data produced and/or used in the project is useable by third parties, in particular after the end of the project? If the re-use of some data is restricted, explain why	The key data which will be made publically available and hence useable by third parties during the course of the project will be made available for between 12 months and 36 months following project completion.
	Describe data quality assurance processes	The data quality assurance process is outlined below.
	Specify the length of time for which the data will remain re-usable	Typically data will remain usable for 24 months after project completion.

3. Allocation of resources	Estimate the costs for making your data FAIR. Describe how you intend to cover these costs	The task of making key data from the project FAIR was envisaged from the outset and are therefore covered by the project budget.
	Clearly identify responsibilities for data management in your project	The responsibilities for data management are described below.
	Describe costs and potential value of long term preservation	The cost of long-term preservation (ie. for longer than 36 months) will be estimated if and when the need become apparent. Currently long-term preservation is not planned since it is likely that data will become obsolete within a 2-3 year timeframe following completion of the project due to new technical developments and innovations.
4. Data security	Address data recovery as well as secure storage and transfer of sensitive data	It is foreseen that none of the data to be stored and made available will be of a sensitive nature.
5. Ethical aspects	To be covered in the context of the ethics review, ethics section of DoA and ethics deliverables. Include references and related technical aspects if not covered by the former	No aspects which may be considered to be sensitive from an ethical perspective will be addressed during this project.
6. Other	Refer to other national/funder/sectorial/departmental procedures for data management that you are using (if any)	References to other national/funder/sectorial/departmental procedures for data management will be made in due course if used during the project.

Table D: Overview of the GHOST DMP at project launch

4.3 Overview of individual WPs with respect to the generation of data

WP2 (Requirements & Specifications) collects requirements from the application point of view, related to the vehicle demonstrators to define the Battery System complete specification both for P-HEV and BEV applications. At the same time, the available cell technologies to target the most suitable for the application will be investigated in order to have the most promising tested within WP4. In parallel, in WP2 the test typologies need to assess the technology development of GHOST versus the requirements previously listed.

In WP3 (Modular Battery Architecture, Design, Prototyping and Manufacturing), first an investigation and an evaluation of the best suited battery module architecture will be performed followed by a detailed design of the modular battery modules for the targeted P-HEV and BEV battery systems. The outcome will contain data relating to detailed mechanical, electrical and thermal design of two battery systems based on the same flexible and scalable battery modules that enable thermally optimized ultra-fast charging at up to 350kW (for the BEV system).

WP4 (Battery Cell Characterization, Modelling and Testing for Automotive & Second Life Batteries) focuses on developing a good understanding of the behaviour of the battery cells considered in the project. In this work package the cells will be characterized experimentally for the development of electrical, thermal and lifetime models, hence generating data from measurements. Furthermore, WP4 will provide the required information and technical background regarding the thermal behaviour of the battery cells, which in WP3 will be extended to module and battery system level. In addition, in this Work Package dedicated analysis will be carried out on advanced battery technologies e.g. Li-S and on considered lithium-ion battery cells during second life.

WP5 (System Safety Validation of the Advanced Battery System) a methodology to build-up a multi-aspect system assurance case of the novel battery system will be developed in order to demonstrate system safety for different system environments (e.g. P-HEV, BEV) and different use cases (e.g. 1st life as battery in the vehicle, 2nd life as storage system). A multi-concern safety analysis approach will be then applied to perform the battery system safety analysis; the ISO 26262 will be considered as initial base to start the analysis, using methods, like the hazard analysis and risk assessment, suggested by ISO 26262. The outcomes of these analyses will provide the baseline data for performing appropriate safety analysis such as FMEA in order to identify the safety critical elements of the general concepts. The analysis will consider, in an integrated approach, electrical, thermal and functional safety aspects of the battery system. A comparative analysis and impact evaluation of installing the battery system in different system environments on achieving system safety in different contexts will be also performed. Once the multi-concern safety of the general concepts have been analysed, the defined safety measures will be verified under lab conditions but with realistic build-in and operational conditions.

WP6 (Vehicle Integration, Testing and Demonstration) focuses on the in-vehicle integration of the previously developed and commissioned battery systems for Li-ion applications. In WP6, actual vehicle testing activities in real conditions, either on road or on rolling bench, will be performed and hence measurement data will be generated.

Finally, a comprehensive assessment of the battery system versus the specifications defined in WP2 will take place, considering all the tests performed in WP4, WP5 and WP6 and also the outcomes of the second life testing and analysis performed in WP7.

In WP7 (Dismantling and Second life use of batteries), dismantling studies on existing batteries will provide data regarding how to improve battery design of the new battery pack with the target to reduce efforts and cost at the EoL-management including getting the new packs optimized for remanufacturing, reparation, reuse and second life. This finally will be demonstrated by a design approval based on dismantling studies. Furthermore a future oriented concept for reuse and 2nd life application will be developed, technically and commercially evaluated to show beneficial solutions for the expanded usage of battery packs and/or valuable components after the first life.

In WP8 (Dual Battery System Design, Prototyping and Bench Testing), high power Li-Ion and Li-S technology dual battery concept will be studied with the aim of incrementing the energy density and efficiency of current Li-Ion-based battery systems. The modular concept for Li-Ion technology developed in WP3 is used and adapted for the design of a dual battery system together with the development of a DC/DC converter that emerges in this novel system. A validation and assessment of the novel dual battery system will be investigated with a scaled-down prototype to carry out a quantitative comparison between the scope of the dual battery system concept and the Li-Ion modular one.

Number	Title	Type	WP	Lead partner	Due
D1.2	Risk and data management plan	Report	WP1	CRF	M6
D2.2	Cells specification report for battery system prototype	Report	WP2	VUB	M6
D2.3	Concept validation plan report	Report	WP2	CRF	M8
D3.3	Prototyping, commissioning and functional verification of the designed battery systems	Demonstrator	WP3	AVL	M28
D4.1	Metholodology test, characterisation test and electro-thermal battery model report	Report	WP4	VUB	M12
D8.2	Assembly, commissioning of the dual cell Li-ion, Li-S battery module and validation & assessment of the dual battery system concept	Demonstrator	WP8	IKERLAN	M40
D9.1	Public website	Website	WP9	VUB	M3
D9.2	Dissemination and communication plan	Report	WP9	VUB	M6
D9.4	Report on liaison with ongoing relevant EU projects in the field of battery system development and testing	Report	WP9	VUB	M42

Table E: List of GHOST deliverables with Public dissemination level

4.4 Quality Assurance and Responsibilities

4.4.1 Scientific and Technical Quality

The quality of the overall outcome of the project is primarily dependent upon the quality of the execution of the innovation and demonstration activities. Formally, the quality of the work is monitored throughout the project by the General Assembly, the Executive Board and the Project Coordination team. Informally, each and every project team member, including the WP leaders and the Coordinator, has the responsibility to critically consider the quality of the work and strive for the best possible results. Potential deviations from the project plan must be anticipated and identified in a timely manner to allow mitigating actions to be developed and planned. In this way, quality can subsequently be maintained by taking suitable corrective actions to recover the deficiency in output or time delay. In this process, particular attention will be paid to monitoring, and supporting good communication and cooperation between work packages in order to avoid a fragmentation of the activities, which could lead to a mismatch between interrelated work packages.

4.4.2 Quality of Results

The formal deliverables of the GHOST project are the output of the research and innovation activities and, as such, should be high-quality representations of the activities undertaken. The quality of the deliverables will be managed through a straightforward review process, which was agreed during the Kick-off meeting, in the Consortium Agreement and described in D1.1.

The quality assurance mainly aims at the quality of deliverables by ensuring smooth cooperation within the consortium and defining the process of decision making and knowledge sharing. The deliverables primarily shall deliver all the initially agreed information which is required by partners to carry out their own work and to fulfil their obligations in the project. Furthermore, the deliverables must be in line with the project targets.

During the Kick-off Meeting it was agreed that the Executive Board is the main body for quality assurance. The procedure rests on the premise that the author of the deliverable is the technical expert on the topic of the deliverable and as such is responsible for the technical content. The work package leader should check the deliverable, with a focus on the check with the objectives of the work package and its fit with the overall work within the work package (consistency check). Furthermore, all deliverables are reviewed by at least one and ideally by two reviewer who is not directly involved in the preparation of the deliverable. The Project Coordinator performs the final review of the deliverable, focusing on general fit with the project objectives. If the deliverable serves as input for other work packages, focus should be put on whether the deliverable serves this purpose, both an a qualitative as well as quantitative level. Subsequently, the Project Coordinator is responsible for the delivery of the report to the EC.

Another important aspect of quality management is the administrative processes of a project. The Project Coordinator, CRF, complies with the procedures indicated by the ISO 9001 certified Quality System. The Project Coordinator, strongly supported by VUB, will regularly monitor administrative processes in such matters as finances and any legal issues which may arise. Key points to be monitored such that the administration of the project is traceable and justifiable include, finances, risks and risk mitigation, changes which may affect the Grant Agreement, timing and reporting.

The Project Coordinator, CRF, with the support of the Back-Office, VUB, coordinates the periodic management reports and the final report. In this task, the H2020 Tool, which was specifically designed for the collection of detailed use of resources and the technical status of projects, will be used. The Coordinator will collect, check and send to the EC the required cost statements, on the basis of the scheduled plan. The Project Coordinator with the support of the Back-Office will monitor progress through the nominally monthly Executive Board meetings, bi-annual Work Progress reports and annual General Assembly meetings.

All finalised deliverables will be stored at the internal EMDESK platform for partners. All public deliverables with a public (PU) dissemination level will be made available on EMDESK via public sharing links also for external users and will also be placed on the GHOST public website. Instead, if the deliverable has a dissemination level of confidential (CO) only the publishable executive summary will be placed on the public website. Furthermore, the key data relating to the public deliverables which will be made available according to the GHOST DMP (see Table D) will be made available on the EMDESK platform and accessible for those who possesses the public link.

EMDESK, the GHOST platform serves as central data storage and secure repository for document management and sharing. It allows the project partners to define specific permissions for folders or documents, to track document versions, share large documents or datasets, to share direct document link e.g. via email, to make documents accessible to public via public sharing link, to assign documents to related project items for easy and quick document retrieval and to receive email digests on activities in the document manager.

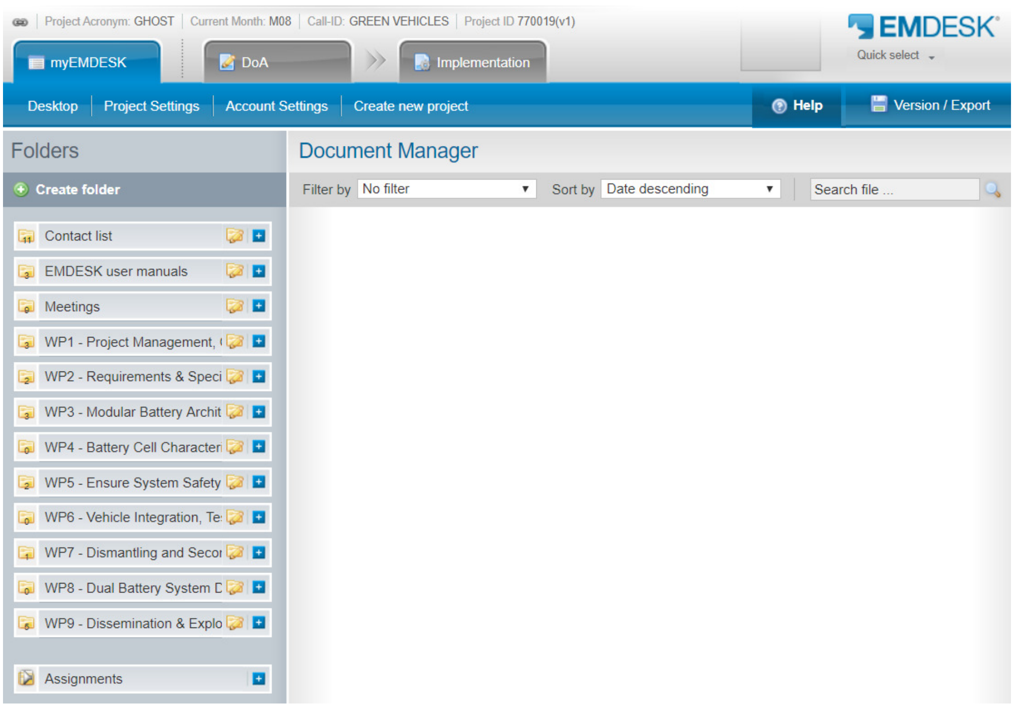


Figure 3: Data management and storage on EMDESK

Within the project, document templates have been developed for deliverables. These templates can be found on EMDESK. As outlined in D1.1, documents shall be named in a way that makes them easily identifiable and findable. Suggested process to be used for giving titles to project documents: [Project] - [WP] - [Document] - [Owner] - [Version].

For every deliverable the author will take the review comments into account. A motivated explanation is required if it is not possible to process the comments as requested by the reviewer, or if the author(s) disagree with the comments received.

In case of remaining disagreement, the Project Coordinator will guide the process and will ensure a convergence of the process towards a final result.

4.5 IPR: handling of intellectual property rights and data access

All the partners have signed a Consortium Agreement. This agreement addresses the exploitation of the results and the patent and licensing issues as well as procedures with respect to the dissemination of results. A guiding rule is that partners investing in research should have an advantage compared to those who do not. This means that knowledge created during projects that offer commercial interest must be safeguarded and protected for exploitation by the owner. On the other hand, partners of this project need to come together in order to collaborate and benefit from their respective resources and competencies. Thus, added value through the sharing of knowledge and promoting exploitation represents a clear objective and driving forces of this collaborative project. This approach to knowledge management and IPR is detailed and regulated in the Consortium Agreement, which has been signed by all partners at the start of the project.

Some of the major aspects covered are indicated below:

- Background knowledge, specific limitations and/or conditions for implementation and for exploitation; Project Results, their (joint) ownership and the transfer of Results;
- Access rights to Background and Results, for consortium partners and their affiliates;
- Publications, procedures for dissemination of results and research data and open access hereto.

Background (= existing know how or pre-existing intellectual property) of a specific partner shall be made available to the Partner (or Partners) within the consortium that needs this information for the proper execution of their tasks within the scope of the project. The use of Background is strictly limited for use to the achievement of the project goals and for the duration of the project. The receiving partner or partners will sign appropriate non-disclosure agreements with the providing partner. An overview of the Background was included as an annex to the consortium agreement. All partners shall be entitled to license their Background. Licensing of Background to third parties will be done on commercial conditions whereas licensing of Background to partners of the consortium will be done on fair and reasonable conditions. Results (e.g. results, including intellectual property generated in the project) shall be owned by the partner or partners who developed the results.

Each partner is responsible for taking the appropriate steps for securing intellectual property of the knowledge or results created in the project (e.g. filing of patent applications). Each partner is obligated to fully inform the project coordinator of the filing of patent applications of knowledge or results created in the field of the project within two weeks of the date of filing. Each partner that owns a specific Result shall be free to exploit their Result as it sees fit. Appropriate joint ownership agreements will be drawn up. The participating research institutes/universities are entitled to use knowledge or results from the project, which either have been published or have been declassified, for research and teaching purposes. The project's website will also contain an overview/archive of all published information and/or links hereto.

Access Rights to Background and Results shall be free of charge to partners of the consortium for research and development purposes within the scope and the duration of the project. Access Rights to Background and/or Results that are owned by one or more of the partners shall be granted on fair and reasonable conditions and to the extent necessary to enable these partners to exploit their own results. For this purpose, the involved partners are entitled to conclude appropriate (bi, tri or multi-lateral) license, supply, product and/or service agreements.

APPENDIX Overview of Relevant International Safety Standards

The international standards concerning type-approval requirements for the general safety of motor vehicles have been reviewed and analyzed with reference to the technical innovations in the framework of the GHOST project.

Within the European Union, two systems of type approval are in force. The first is based on the European Commission directives and regulations, and targets the entire vehicle system as well the subsystems and components. The second is based on the UN regulation, and targets subsystems and components of the vehicle, but not the whole vehicle.

The main directive for the vehicle type approval in the EU is the 2007/46/EC of the European parliament and of the council. The directive establishes a framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles. This Framework poses requirements for the different subsystem constituting the vehicle. Hence, to gain the whole approval of the vehicle, the various subsystems shall be verified against their compliance.

The above mentioned directive provides a list of Regulatory acts for EC type-approval of vehicles produced in unlimited series and includes, for example:

- General Safety — Regulation (EC) No 661/2009
- Electric safety — Regulation (EC) No 661/2009 UNECE Regulation No 100

The main directive for the vehicle type approval with respect to the General safety is the Regulation (EC) No 661/2009. It sets out requirements regarding both the general safety of motor vehicles and the environmental performance of tires.

The subsystems reported in Annex 1 of the regulation are in scope of the requirements expressed in Article 5 (1) and (2), e.g.:

1. Manufacturers shall ensure that vehicles are designed, constructed and assembled so as to minimize the risk of injury to vehicle occupants and other road users,
2. Manufacturers shall ensure that vehicles, systems, components and separate technical units comply with the relevant requirements set out in this Regulation and its implementing measures, including among other the requirements relating to:
   - vehicle structure integrity, including impact tests;
   - systems to provide the driver with visibility and information on the state of the vehicle and the surrounding area, including glazing, mirrors and driver information systems;
   - electromagnetic compatibility;
   - heating system
   - electrical safety

In general, pursuant with par. 7 of UNECE Regulation No. 94, any increase in mass of the vehicle greater than 8 per cent might imply a bigger testing effort in order to demonstrate compliance with the regulation provisions, depending on the judgement of the Type Approval Authority.

Product certification is a fundamental precondition to establish a product at the market. The certification comprises the tests regarding required standards and robustness. Generally, depending on the mission profile the vehicle manufacturer specifies the requirements on the electrical and electronic equipment. The supplier of the Battery System is liable to observe these requirements and to perform the appropriate tests to ensure functionality, reliability and safety.

The Battery System as an electric device have to undergo through various tests and likewise its electrical and electronic components have to meet various requirements and standards. Such components are for example, circuit boards, sensors, actuators, integrated circuits (ICs), semiconductors, active and passive components etc.

An important standard for qualification of electrical and electronic equipment in road vehicles is the ISO 16750, Road vehicles - Environmental conditions and electrical testing for electrical and electronic equipment. The ISO 16750 [4-8] applies to electric and electronic systems and components for vehicles. It describes the potential environmental stresses and specifies tests and requirements recommended for the specific mounting location on or in the vehicle. The ISO 16750 consists of the following 5 parts:

- ISO 16750-1: General
- ISO 16750-2: Electrical loads
- ISO 16750-3: Mechanical loads
- ISO 16750-4: Climatic loads
- ISO 16750-5: Chemical loads

Similarly to device level, the electrical and electronic components that build up the Battery System have to undergo tests before assembling. In general, the responsible international standardization organisations for electrotechnical and electronic applications are:

- IEC -International Electrotechnical Commission
- CENELEC -European Committee for Electrotechnical Standardization
- JEDEC Solid State Technology Association

In the automotive field, the Automotive Electronics Council (AEC) based in the United States was established for the purpose of setting common part qualification and quality-system standards for the supply of components in the automotive electronics industry. The AEC Component Technical Committee is the standardization body for establishing standards for reliable, high quality electronic components. Components meeting these specifications are suitable for use in the harsh automotive environment without additional component-level qualification testing.

The quantity, value and complexity of electronics in passenger vehicles continue to rise. Therefore, it is suggested to ensure to the vehicle manufacturer that the supplier of the meets the following standards of the AEC - Q100 norm which in turn refers to many JEDEC standards.

JEDEC has been the global leader in developing open standards and publications for the microelectronics industry. JEDEC brings manufacturers and suppliers together to participate in more than 50 committees and subcommittees, with the mission to create standards to meet the diverse

technical and developmental needs of the industry. JEDEC's collaborative efforts ensure product interoperability, benefiting the industry and ultimately consumers by decreasing time-to-market and reducing product development costs. The JEDEC Automotive Electronics Forum is going to bring together experts from the worldwide automotive electronics industry to evaluate current standardization efforts and future industry needs.

- AEC - Q101 - Failure mechanism based stress test qualification for discrete semiconductors
- AEC - Q200 - Stress test qualification for passive components

The AEC standard is well-known to customers of electrical and electronic components. The application and compliance with AEC standards, respectively, create clarity in reliability and standardization issues and save time in communication between supplier and customer.

The signal integrity is also an important issue to consider regarding electrical requirements. Generally, signal integrity is closely related to the EMC. If a design was implemented under consideration of its physical requirements, both fields achieve best results. As far as the enquiry resulted in there is no particular standard respective to the signal integrity. The signal integrity is a set of measures describing the quality of an electric signal. Some of the main issues of concern for signal integrity are ringing, crosstalk, ground bounce, distortion, signal loss, and power supply noise. Today's transfer rates require a combination of simulation, modeling and measurement in order to already avoid signal integrity issues in the design. When integrating fast data lines, signal integrity is one of the most important parameters at all levels of electronics packaging and assembly (from internal connections of an IC, through the package, the printed circuit board (PCB), the backplane, and inter-system connections) because various effects can degrade the electrical signal to the point where errors occur and the system or device fails.

The design of a new battery module with integrated thermal management requires that attention is given to the safety requirements regarding the vehicles equipped with electric power train in the event of frontal or lateral collision, pursuant UNECE Regulations No. 94 and No. 95; thus following the test conducted in accordance with the procedure defined in Annex 3 to Regulation No. 94 and in Annex 4 to Regulation No. 95, the electrical power train operating on high voltage, and the high voltage components and systems, which are galvanically connected to the high voltage bus of the electric power train, shall ensure that the vehicle passengers are not exposed to voltages higher than 30 VAC or 60 VDC, or alternatively the total energy (TE) on the high voltage buses shall be in the limits established in Annex 11 of UNECE Regulation No. 94 or Annex 9 of UNECE Regulation No. 95.

Until 30 minutes after the impact no electrolyte from the Rechargeable Energy Storage Systems (REESS) shall spill into the passenger compartment and no more than 7 per cent of electrolyte shall spill from the REESS.

REESS located inside the passenger compartment shall remain in the location in which they are installed and REESS components shall remain inside REESS boundaries.

No part of any REESS that is located outside the passenger compartment for electric safety reasons shall enter the passenger compartment during or after the impact test.

Complying also with regulation No. 100 Uniform provisions concerning the approval of vehicles with regard to specific requirements for the electric power train, the protection DEGREE IPXXD against direct contact with high voltage live parts should be provided and the resistance between all exposed conductive parts and the electrical chassis shall be lower than 0.1 ohm when there is current flow of at least 0.2 ampere.

Isolation resistance should meet the prescriptions of regulation No. 100, besides those exposed in regulation 94, where it is measured as indicated in Annex 4A of such abovementioned regulation.

The REESS shall overcome the tests established in Annex 8 to regulation No. 100, such as vibration test, thermal shock and cycling test; moreover, fire resistance shall also be granted complying with regulation No. 100.

Besides, since the employment of battery cells other than those used in the current vehicle has been planned for the prototypal battery module, external short circuit protection, overcharge/over-discharge protection and over-temperature protection shall also be ensured pursuant regulation No. 100.