Supporting the deployment of safe Li-ion stationary batteries for large-scale grid applications

# Introduction

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# Context

- Li-ion technology is developing widely to answer the needs of various fields of applications thanks to its huge energy density and long life.
- Implementation of large Li-ion batteries in stationary applications is in its starting phase with only demonstration units installed
- Safety behavior is a key driver for industrial implementation and a dedicated standard is mandatory to :
  - compare on the same basis battery systems provided by different manufacturers
  - promote a safe commercial design and use
  - develop a level of confidence in the technology for the various stakeholders (authorities, insurances, operators, public)
  - stabilize business and avoid introduction of poor quality products
  - develop world trade exchange in this sector on a fair basis
  - support the development of RES by enabling the deployment of a safe and well-designed technology

# Context

» Safety mechanisms have been studied ever since Li-ion cells have been sold

» Tests and standards mainly developed for cells and small batteries

» Introduction of automotive batteries based on Li-ion technology have also followed the same strategy

» Tests not necessarily meaningful to reproduced the battery behavior for large systems

**Table 1: Existing standards in various sectors**

| | UL | | | | | NEMA | SAE | IEEE | | BATSO | Telcordia | JIS | INERIS | UN | IEC | | | ISO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Test Criteria Standard** | UL 1642 | UL2054 | UL Subject 2271 | UL Subject 2580 | UL2575 | C18.2M | J2464 | IEEE 1625 | IEEE 1725 | BATSO 01 | GR-3150 | JIS C8714 | ELLICERT D | Part II S38.3 | IEC 62133 | IEC 62281 | IEC 62660-2 | 12405-1 & 12405-2 |
| Applications* | C, A, I | C | A | A | C | C | A | C | C | A | C | C | A | C,A,I | C | C,A,I | A | A |
| External short circuit | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| Abnormal charge | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| Forced discharge | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • |
| Crush | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | | • | |
| Impact | • | • | • | • | | • | | • | • | | | | | • | | • | | |
| Shock | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| Vibration | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| Heating | • | • | • | • | • | • | • | • | • | | | • | • | | • | | • | • |
| Temperature cycling | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • |
| Low pressure (altitude) | • | | • | • | • | • | | • | • | • | | • | • | • | • | • | | |
| Projectile | • | • | • | • | | | | • | • | | | | | | | | | |
| Drop | | | • | • | | • | | | | • | | • | • | | • | • | | |
| Continuous low rate charging | | | | | | | | | | | | • | | | • | | | |
| Molded casing heating test | | | | | | • | | | | | | | | | | | | |
| Open circuit voltage | | | | | | • | | | | | | | | | | | | |
| Insulation resistance | | | | • | | • | | | | | | | | | | | | |
| Reverse charge | | | • | • | | | | | | | | | | | | | | |
| Penetration | | | • | • | | | • | | | | | | • | | | | | |
| Internal short cicuit | • | | | • | | | | | | | | • | | | • | | | |
| Immersion | | | | | | | | | | | | | • | | | | | |
| Fire | | | | | | | | | | | • | | • | | | | | |

*Automotive: A; Consumer (Mobile phone; Laptop etc.): C; Industry: I

# Context

- For large batteries, this methodology shows its limitation since:
  - it is difficult to model a MWh system based on cell tests,
  - the behavior of full system needs to be considered,
  - the link with the application needs to be considered.
- It is preferred to use of a methodology generally implemented in the industry for risk analysis: e.g. Preliminary Hazard Analysis
- First example of this strategy has been implemented for residential systems Li-ion batteries (8-10 kWh batteries developed in Sol-ion program)

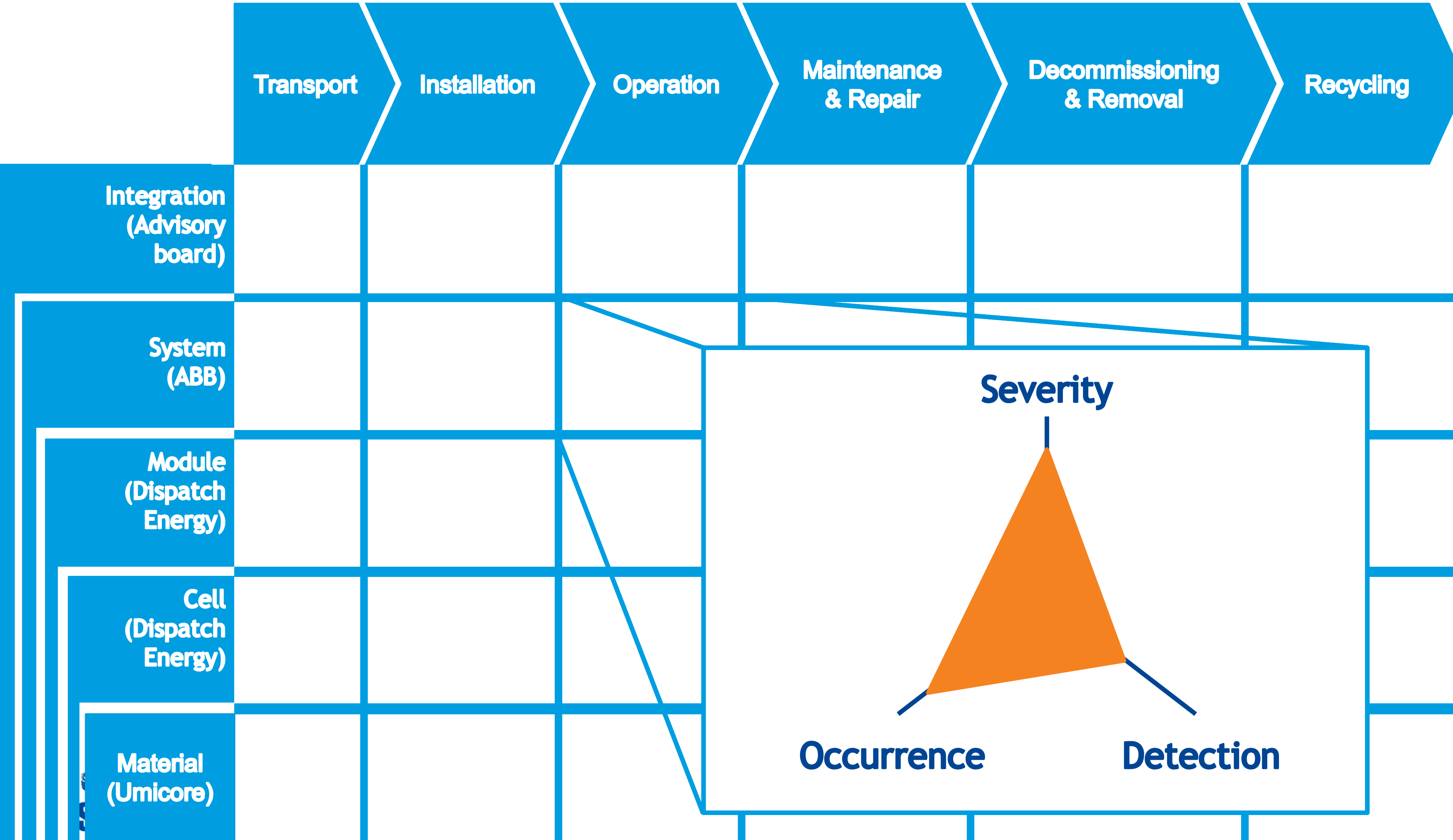
# Objective of the call

- Thematic priority:ENERGY.2012.7.3.2: *Facilitating the deployment of safe stationary batteries*

- Propose, through the use of recognised risk assessment and a robust validation, improved methodologies and protocols for safety testing in several or all of the following sub-areas: transport, installation/commissioning, operation, periodic inspection, maintenance, decommissioning, and removal phase.

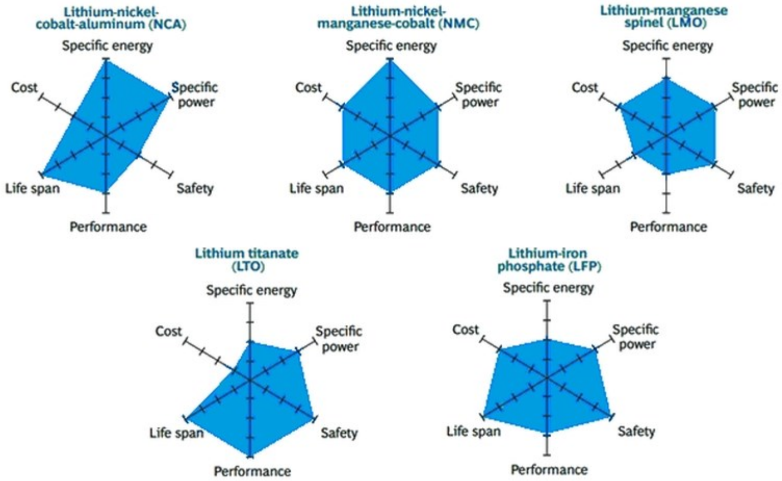
- Relevant environmental aspects should be considered in the proposal. The work should include modelling, measurement and testing development with robust validation.

# STALLION project approach
# 1. Two-axis experience-based risk assessment

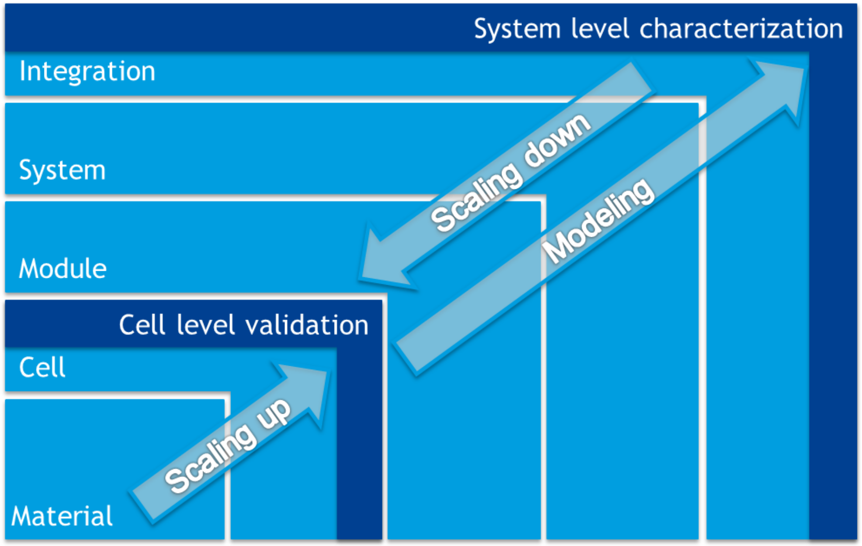


# STALLION project approach

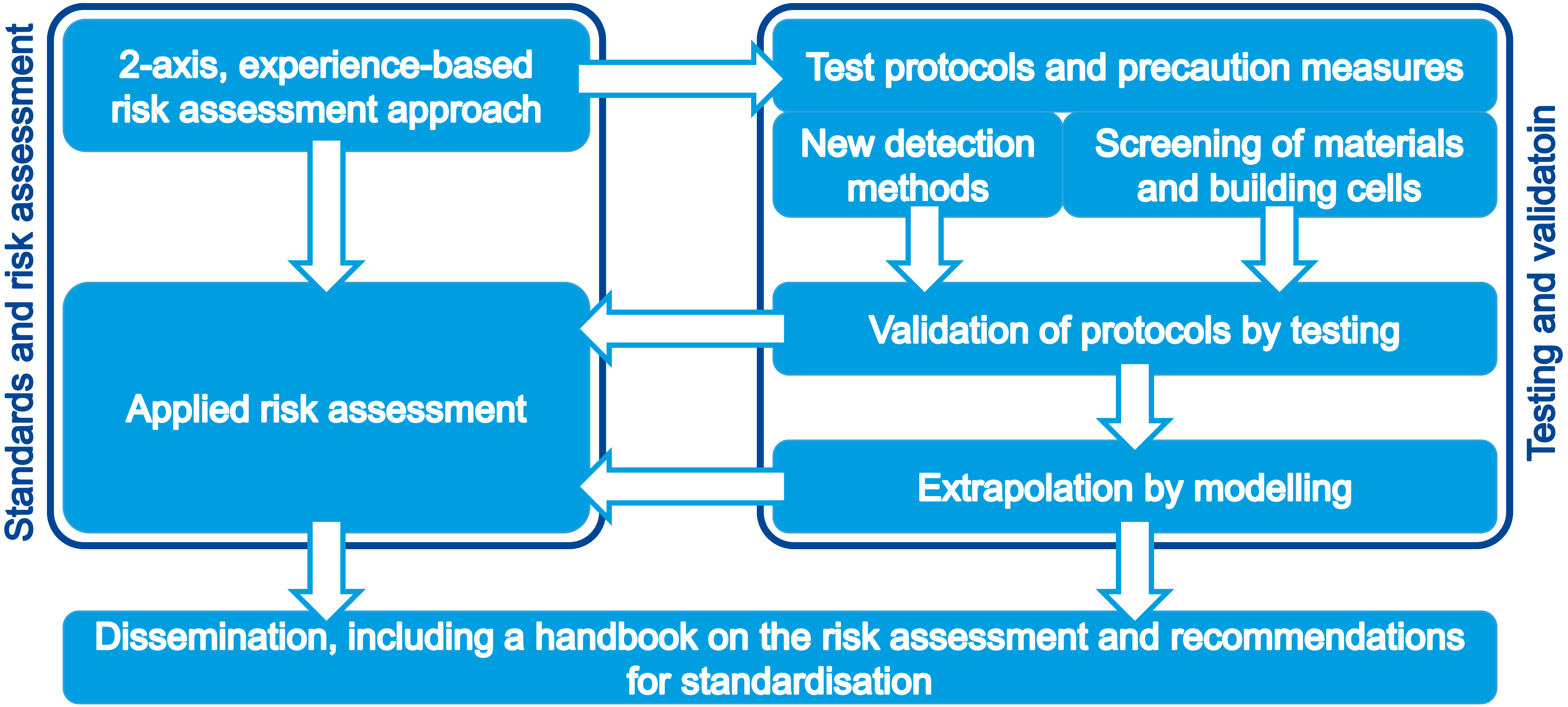
## 2. Establishing the state of the art




## 3. Validating defined risk mitigation measures



# STALLION Work packages



# STABALID

» Title: **STA**tionary **Ba**tteries **LI**-ion safe **D**eployment

» Start: October 1$^{st}$, 2012 (duration: 30 months)

**Old approach**

- Tests at the cell level
- A priori tests

NEW

**Innovative STABALID approach**

**Risk assessment**
- Main steps of the life cycle
- Various environments
- End user in the consortium

**Test procedures**
- based on the risk assess.
- 2 certification companies

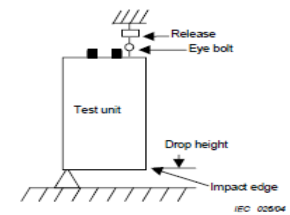
**Input existing standard committees**

# STABALID

| Dangerous Situation | Undesirable Event | P | S | RA | RMM | $P_{RMM}$ | $S_{RMM}$ | $RA_{RMM}$ |
|---|---|---|---|---|---|---|---|---|
| Loss of protection | External aggressions | 2 | 2 | Acceptable | RMM23 | 2 | 2 | Acceptable |
| People in proximity | Intoxication | 4 | 1 | Tolerable | RMM12 | 2 | 1 | Acceptable |
| Equipment in proximity | Corrosion | 4 | 2 | Intolerable | RMM17 RMM33 | 2 | 2 | Acceptable |
| People in proximity | Asphyxia | 4 | 2 | Intolerable | RMM02 | 2 | 2 | Acceptable |
| | Intoxication | 4 | 2 | Intolerable | RMM03 | 2 | 2 | Acceptable |
| Equipment in proximity | Pollution surr. equip. | 4 | 2 | Intolerable | RMM17 | 2 | 2 | Acceptable |
| People in proximity | Burnt | 4 | 3 | Intolerable | RMM04 | 1 | 3 | Acceptable |
| Equipment in proximity | Fire propagation | 4 | 4 | Intolerable | RMM05 RMM17 | 1 | 3 | Acceptable |

**WP 1: Definition of safety testing procedures:**
Based on a specific risk assessment and the review of existing protocols for safety testing, test protocols for safety assessment have been drafted.

**WP 2: Validation of stationary battery safety tests**
86 modules have been produced and are being tested according to the draft safety protocols from WP1. The test protocols have been further improved to take into account the experience of the performance of the tests.





**WP3: Standardization and dissemination activities**
The test protocols from WP2 have been transformed into standards and disseminated to the standardization committee working on the safety of stationary batteries (IEC 62619-1, IEC 62619-2 and IEC 62620).

**WP4: Regulatory environmental harmonized framework**
The European environmental regulations dealing with stationary batteries were identified and a proposal for a harmonized framework, based on the standards from WP3, has been prepared.

# Specificities of STABALID

- **Modeling of accidental consequences and thermal effects**
  - To evaluate potentially dangerous consequences of large Li-ion batteries for grid applications under extreme events
  - Based on the well-known FCD FDS fire code
  - Small scale consequences prediction by comparison with experiments before large scale extrapolation
- **Regulatory environmental harmonized framework**
  - To identify the relevant regulations in EU and in Japan defining the safety requirements for stationary batteries and to propose a harmonized regulatory framework
  - Survey of existing regulations
  - Analysis of the existing regulations
  - Strategy and roadmap to establish a harmonized regulatory framework

# Joint activities

» Joint Workshops:
  - Risk assessment – April 24, 2013 – Paris
  - Test procedures review – October 2, 2013 – Antwerp
  - Test procedures review – January 29, 2014 – Arnhem

» Regular alignement telephone meetings

» Risk assessment

» Test procedures

**Supporting the deployment of safe Li-ion stationary batteries for large-scale grid applications**

## Thank you!

## Introduction

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