Technische Herausforderungen bei Entwicklung, Integration und Betrieb von Batteriesystemen für Hybrid- und Elektrofahrzeuge

Holger Schuh

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Agenda

1. Saft in a nut shell
2. Saft experience in electric and hybrid vehicles
3. Market Challenge: Diversity of commercial vehicles
4. Technical Challenges
   - Challenge 1: What is the customer need?
   - Challenge 2: Development of the battery system
   - Challenge 3: Integration, Commissioning and Maintenance
5. Conclusion
1. Saft in a nutshell
SAFT Group in 2013 - Key figures

Sales 2013: €624.2m

Specialty Battery Group
- €256.3m (41%)
- High performance primary and rechargeable lithium and silver batteries for the electronics, defense and space industries.

Industrial Battery Group
- €367.9m (59%)
- Rechargeable nickel and lithium-based batteries for demanding industrial applications.

Joint-Ventures:
- ASB Group Thermal batteries
- Equity accounted

Applications:
- Defence
- Space
- Railway
- Rail and Mass Transit
- Industrial standby
- Telecommunication
- Clean energy storage
- Emergency Lighting
- Vehicles
- Aviation
- Metering and Professional Electronics
- Industrial Battery Group
- Space
2. Saft experience in electric and hybrid vehicles
Key accomplishments over the last 20 years in EV’s

- **Ni-Cd – STM5-100 (1995-2005)**
  - More than 11,000 e-Cars + 3,000 e-Scooters on the road in Europe equipped with Saft batteries (PSA Peugeot-Citroën + Renault + Th!nk (Ford)

- **Ni-MH technology (1995-2005)**
  - Chrysler EPIC Minivan EV development and fleet (200 Ev’s)

- **Li-ion - Demo cars & Fleet vehicles since 2000**
  - Various EV fleet programs with major European & US car manufacturers
  - More military hybrid energy storage programs than any other company
A true serial automotive experience from 2009

1.5 millions Lithium-Ion cells manufactured with Saft technology used in serial vehicle programs in Europe and US
Racing Applications – Extreme Performances

- **Formula 1 – KERS “Kinetic Energy Recovery System”**
  - Very High Power – Weight Critical
  - Supplying major teams since 2009

- **ANDROS ice racing series**
  - First World wide EV race
  - With Saft energy storage since 2009

- **European Electric F3 Championships**

- **High Class Sport GT EV**

**INNOVATION AWARD 2012**

Saft has received the 2012 Innovation Award from the Scuderia Ferrari for its highest overall contribution to innovation during the last five years, thereby helping to maximize the team’s results in the Formula One Championship.
Saft Strategy
Focus on some major electric and hybrid applications

- Buses and public transportation vehicles
- Commercial delivery trucks
- Industrial and Special vehicles
  - Material handling
  - Construction and mining
  - Airport GSE, Seaport
  - Agriculture and forest
An industrial Li-ion footprint in EU and USA

**Bordeaux (France)**
- Pilot line in operation for more than 12 years
- Research & Development Center for Europe

**Nersac (France)**
- World’s 1st facility for Li-ion automotive batteries
- Large volume, automotive ISO/TS 16949 Qualified
- Capacity installed: ½ million energy cells

**Cockeysville (MD)**
- Research & Development Center for North America
- Multi technology cells and systems manufacturing

**Jacksonville (FL)**
- Opened since September 2011, eligible to BAA requirements
- Large volume, include manufacturing line for prismatic cells
- Capacity installed: 2 millions energy cells
3. Market Challenge
Diversity of commercial vehicles
## Electric/Hybrid configuration

<table>
<thead>
<tr>
<th>Main attribute</th>
<th>Vehicle category</th>
<th>Micro HEV (µHEV)</th>
<th>Mild HEV (MHEV)</th>
<th>Strong HEV</th>
<th>Plug-in Hybrid (PHEV)</th>
<th>EV</th>
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<tbody>
<tr>
<td>Stop/Start</td>
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<td>Electric Drive</td>
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<td>Operating Voltage</td>
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<td>Energy level</td>
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</table>

### Electrical specifications

- **Operating Voltage**: 12V to 750V
- **Energy level**: 0.3kWh to 200kWh

### 4 main voltage ranges for industrial and commercial vehicles

<table>
<thead>
<tr>
<th>Voltage Range</th>
<th>Description</th>
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<tr>
<td>12-48V</td>
<td>Light duty vehicle</td>
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<tr>
<td>72-96V</td>
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<tr>
<td>300-400V</td>
<td>Medium and Heavy duty vehicle</td>
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<tr>
<td>600-750V</td>
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</table>
Technical Application Mapping: 300V to 750V
4. Technical challenges

What is the customer’s real need
Customer inputs

« Automotive » RFQ process / Very detailed specification

Said or not, always needs or constraints for:

- Energy level
- Voltage range
- Power level
  - Continuous
  - Peak
- Charging constraints
- Mechanical integration
- Safety & Reliability
- Life duration
- Operating conditions

Energy or autonomy
Customer inputs

Weight & Volume

Efficiency & usage ratio

Lower...

Lower...

Lower...

Higher...

Higher...

Higher...
Battery Sizing Strategy

What customer wants...

To what battery manufacturer can offer...

« State of the art » of battery design

To what battery manufacturer can offer...
4. Technical challenges

Development of the battery system
The technical choice

Energy → Power → Physics → Aging → Budget

Sizing the battery

Techno & Cell → Cooling Need → Basis Module → BMS → Housing
Cell & Technology

- Several available technologies
  - SLFP™ « Super Phosphate »
  - NMC
  - NCA / Small Cells

- Several form factors
  - Cylindrical
  - Prismatic « VDA » or others

- Wide range of cells
  - From 3Ah...
  - To 41Ah

- Several abilities
  - « E » as Energy
  - « M » as medium
  - « P » as Power
  - « H » as High Power

SLFP is Saft patented technology

NCA: Nickel Cobalt Aluminum
NMC: Nickel Manganese Cobalt
The Duty Cycle

- Can be determined
  - from a rough estimation
  - power recording on real vehicles

- Is the basis to any battery design
  - significant influence on sizing
  - will impact the business case
Using simulation tool

It requires:

- Knowledge of Cell performance research, tests & field experience
- Duty cycle as relevant as possible
- Choice of battery configuration and cooling parameters

It has realized models based on more than 15 years of Li-ion experience.
Simulation Output

- Power in/out of the battery
- Current in/out of the battery
- State of Charge evolution during cycle
  *Here correctly balanced*
- Battery behavior for temperature
  *Here significant rise...*
- Batt voltage range during cycle
- Cell voltage range during cycle
The Sizing process

Define cycle and battery typical use

More than « I need a battery for my bus »...

Size battery xSyP Cell
Cooling efficiency

Run simulations
Extract results

Development Project Starts...

OK
Performance &
Business Case?

OK!

Specification can be fixed

NO!

YES!!

More than « I need a battery for my bus »...
Additional Requirements

Some additional parameters

- Green Requirement
- Industrial potential
- Standards (IEC, ISO)
- EMC’s
- Test means
- Operating condition
## Structured Development Process

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<th>Milestones</th>
<th>Q1</th>
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### Design

- **Rational arrangement of components**

### Procurement

### Industrialization

- **Full Performance Management**

### Production

### Quality

- **Fully Operational System**

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*SAFT - MobiliTec Forum, Hannover 2015 - SAFT PROPRIETARY INFORMATION*
4. Technical challenges
Integration, Commissioning and Maintenance
Battery System Integration and Commissioning

- Needs to be a structured and detailed activity
- Has already to be part of the system specification
  => Should result in an **Integration and Commissioning Plan**

**Several Steps**
- Functional and Safety test of the Battery System
- Integration of the Battery System inside the Vehicle Test Bench
- Integration and commissioning inside the real vehicle

**Several activity levels**
- Check of electrical, mechanical and communication interfaces
- Validation of basic performances
- Expansion of the functional operation range
- Test and validation of failure effects

- May need several optimizations cycles
Battery System Maintenance

- Needs to be a structured and detailed activity
- Has already to be part of the system specification
  => Should result in a Maintenance Concept Plan

Questions to be asked
- Which preventive and corrective maintenance activities are necessary?
- Which of those maintenance activities should be performed by whom?
- Which kind of technical qualification of the service technicians is required?
- What are the training and service documentation requirements?
- What is the resulting spare part concept?

Implementation of the necessary service actions
5. Conclusion
Conclusions

Saft does have:

- Experience with Automotive programs
- Automotive Development and Production capabilities
  > From the cell to the complete system
- Products for vehicle applications
- Commercial successes
  > On-road vehicles
  > Off-road vehicles
  > Forklift
  > Sport vehicles
  > ....

Saft: the partner of choice for your vehicle program