Supporting Role of IT for Lithium Ion Batteries Transportation and SOH monitoring
BIO - 15 years executive managerial experience in automotive and electric scooters industry where he has been in charge to build and implement purchasing, logistics and manufacturing strategy within 2 startups. Within GOVECS group he is responsible for oversight of the company’s manufacturing operations and supplier management functions, including implementation of advanced manufacturing technologies and global supply chain strategies. Prior to electric 2 wheelers business he held managerial positions in logistics and worldwide purchasing department in DELPHI Automotive. Przemek holds Master of Science in Mechanical Engineering form the University of Technology in Poznan. He studied Industrial Management and Engineering at Technical University in Porto. He holds as well Master of Business Administration from Georgia State University in Atlanta.
Supporting Role of IT for Lithium Ion Batteries Transportation and SOH monitoring

Agenda:

- GOVECS GROUP introduction
- Information about Lithium Ion batteries
- Safety regulations for Lithium Ion batteries transportation
- Supporting role of IT for Lithium Ion batteries transportation. ERP and cloud base system
- Data analysis
- End
“You believe in what you see and it is our objective to let you experience a new way of intelligent and sustainable mobility, which offers solutions to the world rather than complaining about our problems.”

Thomas Grübel, CEO

5.5 B
HOURS SPENT IN TRAFFIC JAMS ONLY IN U.S. CITIES PER YEAR

3.7 M
DEATHS WORLDWIDE DUE TO RESPIRABLE DUST PER YEAR

5.5 B tons
17% OF WORLDWIDE CO2 EMISSION IS CAUSED BY ROAD TRAFFIC

6.3 B
PEOPLE LIVING IN „Mega-Cities“ IN 2050
OUR MISSION

GOVECS - as a pioneer within the fast growing electric mobility sector, understands the market and consumers' needs and offers customized solutions.

While electric drivetrains for cars are still facing major difficulties and restrictions, new vehicle concepts within the “L” category segment are the only existing solutions so far.

Know-how and service portfolio are the core competences of GOVECS GROUP and the secret of the company’s success.

By constantly developing our competences, we were able to prevail over our competitors and establish our name and products in the fast-growing market.

60% of the world’s population will live in urban areas by 2030.
GROUP STRUCTURE

GOVECS GROUP

GOVECS Business Solution GmbH
Munich, Germany
Platform service offerings for delivery and sharing market

GOVECS Inc.
USA
US market entry planned for 2018

GOVECS Sp. z o.o.
Wroclaw, Poland
R&D, supply chain, project management, production & assembly, technical service, field support, quality, HR, finance & accounting

B2C Sales
In foundation: Operating shops and retail - starting with flagship store in Berlin 2017

International sales
International marketing & PR
Finance & accounting
Retail & business development
Legal affairs, M&A
HEADQUARTERS, MUNICH/GERMANY

• Hub for all national and international sales activities (direct and indirect)
• In-house development, roll out and coordination of all national and international marketing, trade fairs & press activities
• Own department for retail (on- and offline)
• Business Development
• Finance & Administration
EUROPE'S LARGEST PRODUCTION FACILITY FOR ELECTRIC VEHICLES

- 4,000 sq m production area with actual 2 production lines
- Capacity: Up to 20,000 vehicles per year
- In-house R&D department
- In-house project management team
DESIGNING MOBILITY

B2B – Renting, Sharing & Delivery
The growing population and concentration of urban areas, causes a need for delivery services and transportation solutions which are efficient and sustainable. The demand for those solutions will grow rapidly till 2030.

OEM
With its unique set-up, GOVECS is already a appreciated OEM partner. Five OEM products are ready for mass production - the first product will still be launched in Q4 2016.

Further, the Group paves the way for intelligent vehicles and self-propelled mobility solutions, including 4-wheelers in the L7E category.

B2C
In 2017, GOVECS will launch a lifestyle oriented consumer product – a step closer to conquer the B2C segment and become the European market leader.
HISTORY

- **1999**: Founding of GOVECS
- **06/01/2009**: Homologation of the first electric scooter in Europe by Thomas Grübel
- **2009**: Cargo Scooter
- **2010**: H1
- **2011** – 2013: Start of the OEM cooperation
- **2011 - 2013**: First Li-ION powered Scooter in Europe
- **2011**: European e-scooter of the Year Award won by GOVECS in 2011, 2012 and 2013
- **2012**: eCarTec Award* won by GOVECS in 2011 and 2012
- **Q3 2014**: Development start of Sway (OEM project)
- **Q4 2014**: MBO supported by German Family Office
- **Q3 2015**: Production start of a cargo postal mobility solution
- **Q4 2015**: Take-over of efw-Suhl and Vectrix – both via asset deal
- **2016**: Enter the consumer market with the SCHWALBE and further exciting products
- **Q2 2015**: 2 new OEM contracts signed
  - Introduction of GO! Rent
  - Entry to sharing market
- **Q3 2016**: 2017/2018
- **2018**: Enter the consumer market
  - Elly
  - Take-over of efw-Suhl and Vectrix – both via asset deal

**GOVECS GROUP**
PRODUCTS & BRANDS

GOVECS GO! T Series

SCHWALBE

B2C Product

NON DISCLOSURE

GOVECS GO! S Series
MARKET PORTFOLIO

DELIVERY & TRANSPORT
- Special developed transport vehicles secure an enormous payload compared to competitors due to smoothest acceleration and best maneuverability
- GOVECS GO! scooters are especially designed for heavy usage (more than 20,000 km/year)
- Efficient drivetrain for low variable costs
- Reference clients: Joey’s Pizza, Domino’s Pizza, Takeaway.com (NL), Burger King, Green Guru’s, Post NL, Securitas

SHARING & RENTING
- Strongest growing market
- Preferred partner in the leading international two-wheeler projects: eCooltra: Barcelona, Madrid, Rome, Milan
  Scoot Networks: San Francisco
  Cityscoot: Paris
  Emmy: Berlin – Negotiations
- Market leadership and deep business knowledge
- Customized adjustments and hardware integrations are part of GOVECS’ DNA

B2C (from 2017 on)
- World-class driving experience and acceleration set new standards in the two-wheel industry
- The first lifestyle consumer product to be launched in Q4 2016
- Further electric motorized vehicles and concepts are in planning
- Reference product: SCHWALBE
GOVECS GO! T SERIES

- Designed for the purposes in the delivery sector
- Special frame construction for direct fixation of any cargo box. This leads to perfect driving conditions even with maximum payload
- The only scooters homologated for a maximum payload up to 180 kgs
- Flexible battery solutions with distance range up to 130 kilometers per charge
- More then 50,000 km estimated battery lifetime
- Low maintenance solution thanks to mono-frame construction and usage of high-quality components
GO! RENT

• Innovative renting model for delivery services

• Available w/o maintenance, service inspections and insurance (comprehensive coverage or battery insurance)

• Unique mobility solution and most cost-efficient alternative to extending the fleet

• Flexible contract periods and transparent costs

• GOVECS takes over fleet management

• Full transparency of costs

• Daily fee starting from 5,90 €
GOVECS GO! S SERIES

• New state-of-the-art batteries and high torque for more driving fun

• Flexible battery solutions with distance range up to 130 kilometers per charge

• Available as L1E and L3E version

• Integrated charger allows easy charging on every household plug

• 2 passengers / 150 kgs permissible maximum weight

• Preferred model for sharing projects
- A cult item is back as the first GOVECS consumer lifestyle product. Market entry summer 2017
- Features the most cutting-edge drivetrain system in the world
- In cooperation with technology partner BOSCH
- Extremely dynamic and agile driving characteristics
- Innovative service concept: Own on-site service instead of local workshops
- Individual configuration with online configurator
- Distance range higher than 100 kilometers*
- Distribution by own online and offline channels

* Depending on weather conditions and size/weight of the load

GOVECS GROUP
SHARING – THE KEY FOR URBAN MOBILITY
Actually 5.9 mio people worldwide are using vehicle sharing projects. Thereof 36% only in Europa. The market is expected to grow by factor 6 until 2021.

ADVANTAGES OF SCOOTERS VS. CARS:
• The key to success for e-scooter sharing is the simplicity of the operations
• Municipals do not dedicate special parking areas for car sharing operators
• 50-60% of booking time in car sharing is spent for searching parking slots
• Less operative cost for service and maintenance
Informations about Lithium Ion batteries

Why Lithium Ion?

All about Energy density

Energy density size and weight

Source: www.epectec.com
Informations about Lithium Ion batteries

Cell types

COIN

CYLINDRICAL

POUCH

PRISMATIC

Source: www.epectec.com
Informations about Lithium Ion batteries

Chemistry (6 most common types)

1. Lithium Cobalt Oxide (*popular choice for mobiles, laptops*)
2. Lithium Manganese Oxide (*power tools, medical instrument*)
3. Lithium Nickel Manganese Cobalt Oxide (*power tools, e-bikes*)
4. Lithium Iron Phosphate (*portable and stationary with high load*)
5. Lithium Nickel Cobalt Aluminum Oxide (*Medical devices, industrial, electric powertrain (Tesla)*)
6. Lithium Titanate (*UPS, electric powertrain*)

Source: batteryuniversity.eu
Informations about Lithium Ion batteries

Battery pack – Energy management

- 2 or more cells connected together

- Connected parallel and in series ie: 20s10P

- Connecting cells into the battery pack in series and parallel, batteries voltage and its capacity goes up

- For example 36V, 48V, 72V....capacity depends on cell specification
Informations about Lithium Ion batteries

Battery pack – Energy management

- Increasing battery pack size (number of cells) - stored Energy goes up

GOVECS battery 72V 4.2kWh 400 cells

TESLA 85; battery 400V 85kWh 7104 cells

- Cells are grouped in modules

Source: wikipedia.com
Informations about Lithium Ion batteries

Battery pack – Energy management

• By increasing battery size (amount of Energy) we are increasing as well complexity of Energy management

• BMS – battery management system responsible for State of Health of the battery
Informations about Lithium Ion batteries

Battery pack – Energy management

• One of the key role of Battery Management System is balancing battery pack

• Balancing battery pack usually is done on the level of the sections
Informations about Lithium Ion batteries

Battery pack – Energy management

- The condition of the battery pack, its Quality and lifetime depends on well/equally ballanced cells

- Properly designed BMS makes this happen and BMS monitors battery State of Health (SOH)
Informations about Lithium Ion batteries

Battery pack – Unbalanced cells/Safety

- Unbalanced cells means Voltage difference between cells/sections
- Unbalanced cells decreases lifetime of the battery pack and battery health (Quality)
- In extreme, unbalanced cells due to the current flow heats up the cells and might create fire
- It happens to big brands too 😞
Informations about Lithium Ion batteries

Battery pack – Energy management

• Key parameter to control battery SOH is monitoring delta voltage in between the cells/sections

• Delta Voltage monitoring helps to understand battery Quality and provides key information for a preventive action

• Battery should be taken from the market (scrapped)
Safety regulations for Lithium Ion batteries transportation

Lithium Ion as a Dangerous Goods

• Dangerous Goods called by abbreviation of DG are these one which under specific conditions can create harm to human health and life.

• Any company whose activities includes DG transportation, packing, filling, unpacking or handling should appoint one or more trained safety advisor for supporting and preventing risk of harm/damage to human health/life or environment.
Safety regulations for Lithium Ion batteries transportation

What are the regulations?

• United Nations recommendations on the test criteria for Lithium Ion batteries transportation

• Manual of Tests and Criteria, Part III, Sub-section 38.3 ST/SG/AC.10/11/Rev.5, Amend. 2

• All batteries transportation should comply with UN transport test for air (ICAO-TI/IATA-DGR), road (ADR), rail (RID) and maritime transport (IMDG Code)
Safety regulations for Lithium Ion batteries transportation

UN tests. Long lasting test, usually minimum 16 weeks

<table>
<thead>
<tr>
<th>Test Criteria/Standard</th>
<th>UL 1642</th>
<th>UL 2054</th>
<th>UL Subject 2271</th>
<th>UL Subject 2580</th>
<th>UL 2575</th>
<th>IEC 62133</th>
<th>IEC 62281</th>
<th>C18.2M, P12</th>
<th>SAE J2464</th>
<th>UN</th>
<th>IEC 168</th>
<th>IEEE 1725</th>
<th>JIS CB 4012</th>
<th>BATSO 01</th>
</tr>
</thead>
<tbody>
<tr>
<td>External short circuit</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abnormal charge</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forced discharge</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crush</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shock</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature cycling</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low pressure (altitude)</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Projectile</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drop</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous low rate charging</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Molded casing heating test</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open circuit voltage</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation resistance</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse charge</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Penetration</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal short circuit test</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Safety regulations for Lithium Ion batteries transportation

UN Regulation

- Lithium Ion batteries are classified as class 9 in the transport sector under the Miscellaneous sector

UN 3480 LITHIUM-ION BATTERIES
UN 3481 LITHIUM-BATTERIES INSTALLED IN EQUIPMENT

Labeling change from 2017
Safety regulations for Lithium Ion batteries transportation

UN Regulation - Labels

\[ \text{SOC} \leq 30\% \]
Supporting role of IT for Lithium Ion batteries transportation. ERP and cloud base system

How do we utilise ERP and cloud for battery safety monitoring?

- EDI connection between GOVECS and its supplier
Supporting role of IT for Lithium Ion batteries transportation. ERP and cloud base system

How do we utilise ERP and cloud for battery safety monitoring?

<table>
<thead>
<tr>
<th>Device name: BMS</th>
<th>Hardware version: V2.10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software version: 0.37</td>
<td></td>
</tr>
<tr>
<td>Cell 1: 4147mV</td>
<td>coeffa: 2,124774 coeftb: 1469,736328</td>
</tr>
<tr>
<td>Cell 2: 4138mV</td>
<td>coeffa: 2,100940 coeftb: -0,486552</td>
</tr>
<tr>
<td>Cell 3: 4141mV</td>
<td>coeffa: 2,107495 coeftb: 6,810513</td>
</tr>
<tr>
<td>Cell 4: 4142mV</td>
<td>coeffa: 2,112100 coeftb: 5,307435</td>
</tr>
<tr>
<td>Cell 5: 4138mV</td>
<td>coeffa: 2,102642 coeftb: 6,820329</td>
</tr>
<tr>
<td>Cell 6: 4140mV</td>
<td>coeffa: 2,107062 coeftb: 11,071412</td>
</tr>
<tr>
<td>Cell 7: 4140mV</td>
<td>coeffa: 2,109071 coeftb: 7,505012</td>
</tr>
<tr>
<td>Cell 8: 4140mV</td>
<td>coeffa: 2,110458 coeftb: 8,406975</td>
</tr>
<tr>
<td>Cell 9: 4142mV</td>
<td>coeffa: 2,104781 coeftb: 6,765154</td>
</tr>
<tr>
<td>Cell 10: 4144mV</td>
<td>coeffa: 2,114978 coeftb: 7,215586</td>
</tr>
<tr>
<td>Cell 11: 4142mV</td>
<td>coeffa: 2,117379 coeftb: 7,291262</td>
</tr>
<tr>
<td>Cell 12: 4141mV</td>
<td>coeffa: 2,105220 coeftb: 4,811733</td>
</tr>
<tr>
<td>Cell 13: 4142mV</td>
<td>coeffa: 2,104203 coeftb: 3,937625</td>
</tr>
<tr>
<td>Cell 14: 4138mV</td>
<td>coeffa: 2,108959 coeftb: 0,791144</td>
</tr>
<tr>
<td>Cell 15: 4142mV</td>
<td>coeffa: 2,117750 coeftb: 10,594744</td>
</tr>
<tr>
<td>Cell 16: 4138mV</td>
<td>coeffa: 2,109874 coeftb: 9,061022</td>
</tr>
<tr>
<td>Cell 17: 4143mV</td>
<td>coeffa: 2,112989 coeftb: 3,042330</td>
</tr>
<tr>
<td>Cell 18: 4139mV</td>
<td>coeffa: 2,105187 coeftb: 8,700367</td>
</tr>
<tr>
<td>Cell 19: 4143mV</td>
<td>coeffa: 2,102972 coeftb: 9,244531</td>
</tr>
<tr>
<td>Cell 20: 4142mV</td>
<td>coeffa: 2,111763 coeftb: 7,519598</td>
</tr>
</tbody>
</table>

Delta monitoring 9mV
Supporting role of IT for Lithium Ion batteries transportation. ERP and cloud base system

How do we utilise ERP and cloud for battery safety monitoring?

• After battery delivery to GOVECS there is supplier’s initial battery SOH notification compared to GOVECS incoming warehouse check. All potential discrepancies are notified.
Supporting role of IT for Lithium Ion batteries transportation. ERP and cloud base system

How do we utilise ERP and cloud for battery safety monitoring?

• During entire production system battery SOH is monitored in a different stage of vehicle assembly

<table>
<thead>
<tr>
<th>SOH Check</th>
<th>SOH check</th>
<th>SOH check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier and GOVECS incoming</td>
<td>Manufacturing proces</td>
<td>Final inspection and shipping Data storage</td>
</tr>
</tbody>
</table>
Supporting role of IT for Lithium Ion batteries transportation. ERP and cloud base system

How do we utilise ERP and cloud for battery safety monitoring?

- During entire production system battery SOH is monitored in a different stage of vehicle assembly, battery delta is stored in the ERP system

- VIN – as a scooter reference number
Supporting role of IT for Lithium Ion batteries transportation. ERP and cloud base system

How do we utilise ERP and cloud for battery safety monitoring?

• Next step in a battery health monitoring is to merge battery serial number and its SOH with Scooter VIN number

• Battery is treated like critical components in the scooter
Supporting role of IT for Lithium Ion batteries transportation. ERP and cloud base system

How do we utilise ERP and cloud for battery safety monitoring?

• Battery serial number and SOH merged with a VIN
Supporting role of IT for Lithium Ion batteries transportation. ERP and cloud base system

How do we utilise ERP and cloud for battery safety monitoring?

- All informations about batteries, stored in the system, are analysed before Scooters shipment
Supporting role of IT for Lithium Ion batteries transportation. ERP and cloud base system

How do we utilise ERP and cloud for battery safety monitoring?

Scooters are shipped and what is next?
Supporting role of IT for Lithium Ion batteries transportation. ERP and cloud base system

Live market scooters’s battery SOH monitoring

- Connectivity
Supporting role of IT for Lithium Ion batteries transportation. ERP and cloud base system.

Live market scooters’s battery SOH monitoring

- SOH Monitoring through battery CAN communication with connectivity BOX
Supporting role of IT for Lithium Ion batteries transportation. ERP and cloud base system

Live market scooters’s battery SOH monitoring

• Back end system control
Supporting role of IT for Lithium Ion batteries transportation. ERP and cloud base system

Live market scooters’s battery SOH monitoring

• Data analysis
• With a continuous information flow we are able to monitor battery SOH in every scooter which is on the market and take preventive action
CONTACT:
Przemek Kasiński
pkasinski@govecs.com
+48605377100