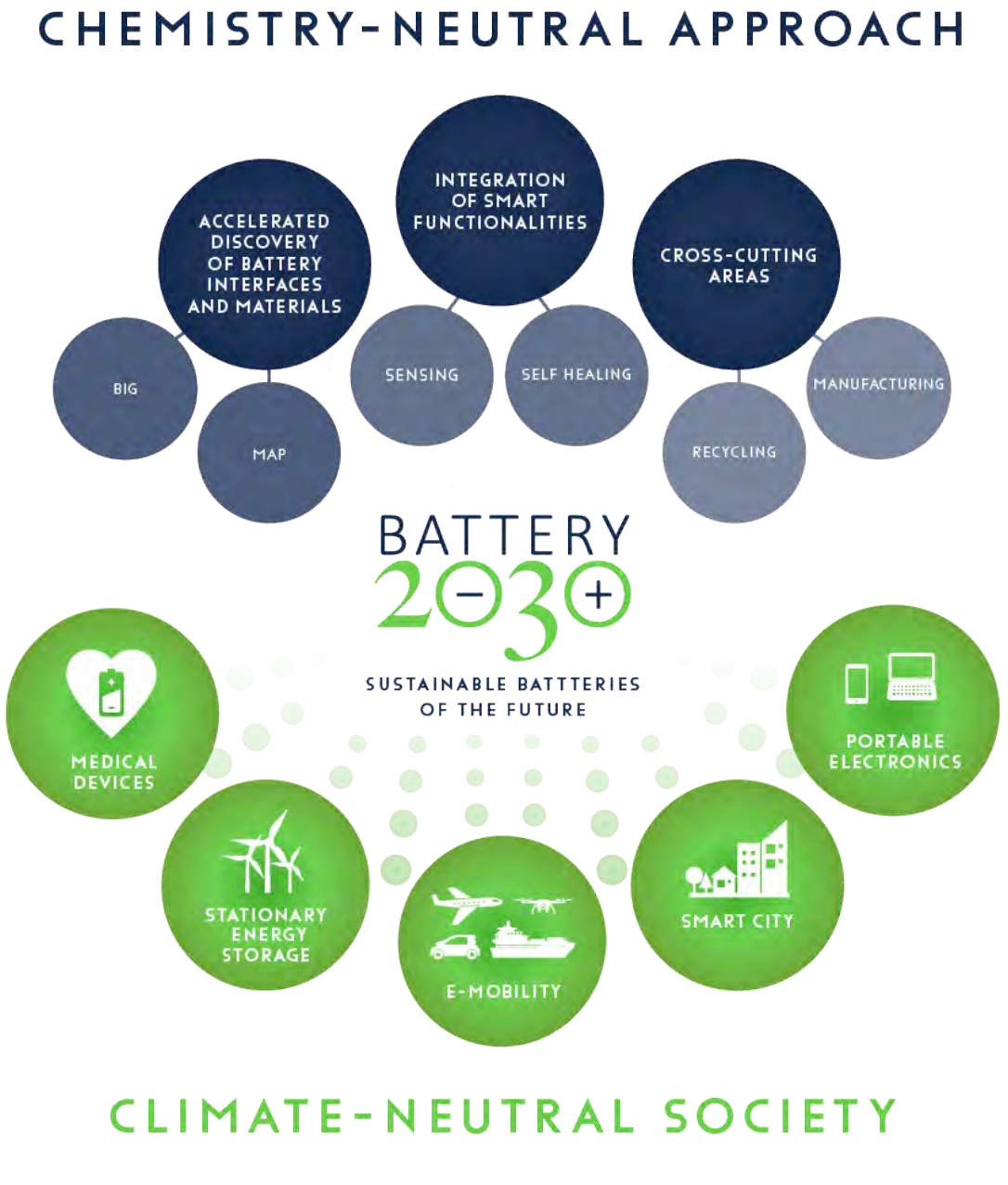
# Kick-off meeting
# BATTERY 2030+
# *LC-BAT-13 - INSTABAT*

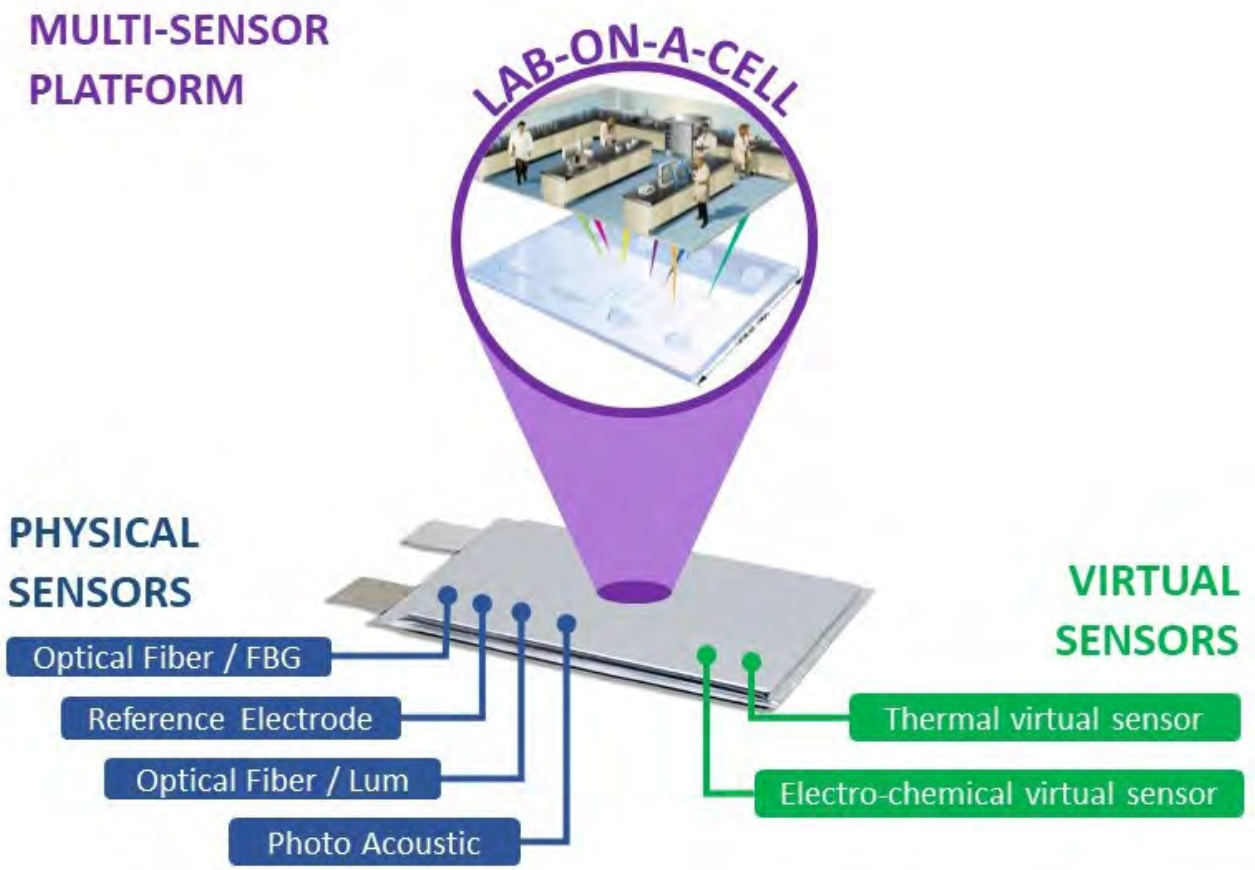
M. Priour / F. Rive




This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957213.

# PROJECT PRESENTATION

**Development of a proof of concept of**
**smart sensing technologies and functionalities, integrated into a battery cell**

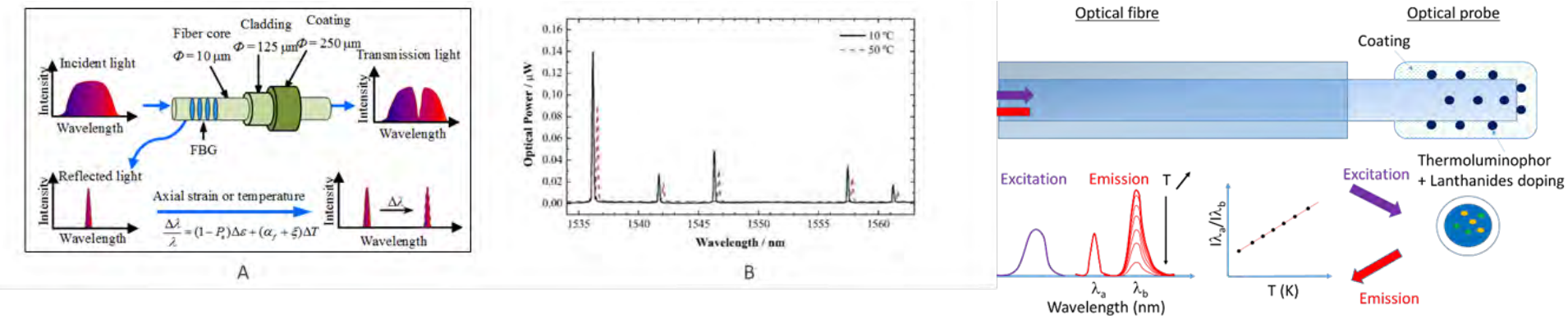


# PROJECT PRESENTATION

INSTABAT multi-sensor platform (or “lab-on-a-cell”) will be capable of:

- **performing reliable in operando monitoring of key parameters**
  *Temperature and heat flow; pressure; strain; $Li^+$ concentration and distribution; $CO_2$ concentration; “absolute” impedance, potential and polarization*

  - **four embedded physical sensors** (optical fibers with Fiber Bragg Grating and luminescence probes, reference electrode and photo-acoustic gas sensor),




  - **two virtual sensors** (based on electro-chemical and thermal reduced models).

# PROJECT PRESENTATION

INSTABAT multi-sensor platform will also be capable of:

- **correlating the evolution of these parameters with the physico-chemical degradation phenomena** occurring at the heart of the battery cell

| Sensor | Measured/estimated parameters | Physico-chemical phenomena |
|---|---|---|
| OF/ FBG | Temperature, strain, pressure | Solid Electrolyte Interphase (SEI) growth, internal resistance increase, capacity loss |
| RE | "Absolute" electro-chemical potential, impedance and polarization | Lithium plating<br>SEI/CEI growth on each electrode<br>Electrolyte degradation |
| OF/ LumT | Temperature | SEI growth, internal resistance increase |
| OF/ LumL | $Li^+$ concentration | Electrolyte degradation<br>Lithium plating<br>Loss of active material |
| PA | $CO_2$ concentration | $CO_2$ gas released from electrolyte decomposition |
| E-BASE | $Li^+$ concentration, "absolute" potential and polarization | Electrolyte polarization, lithium plating and irreversible electro-chemical reactions |
| T-BASE | Temperature | Electrolyte degradation, capacity fade, ageing and thermal runaway |

# INSTABAT PROJECT PRESENTATION

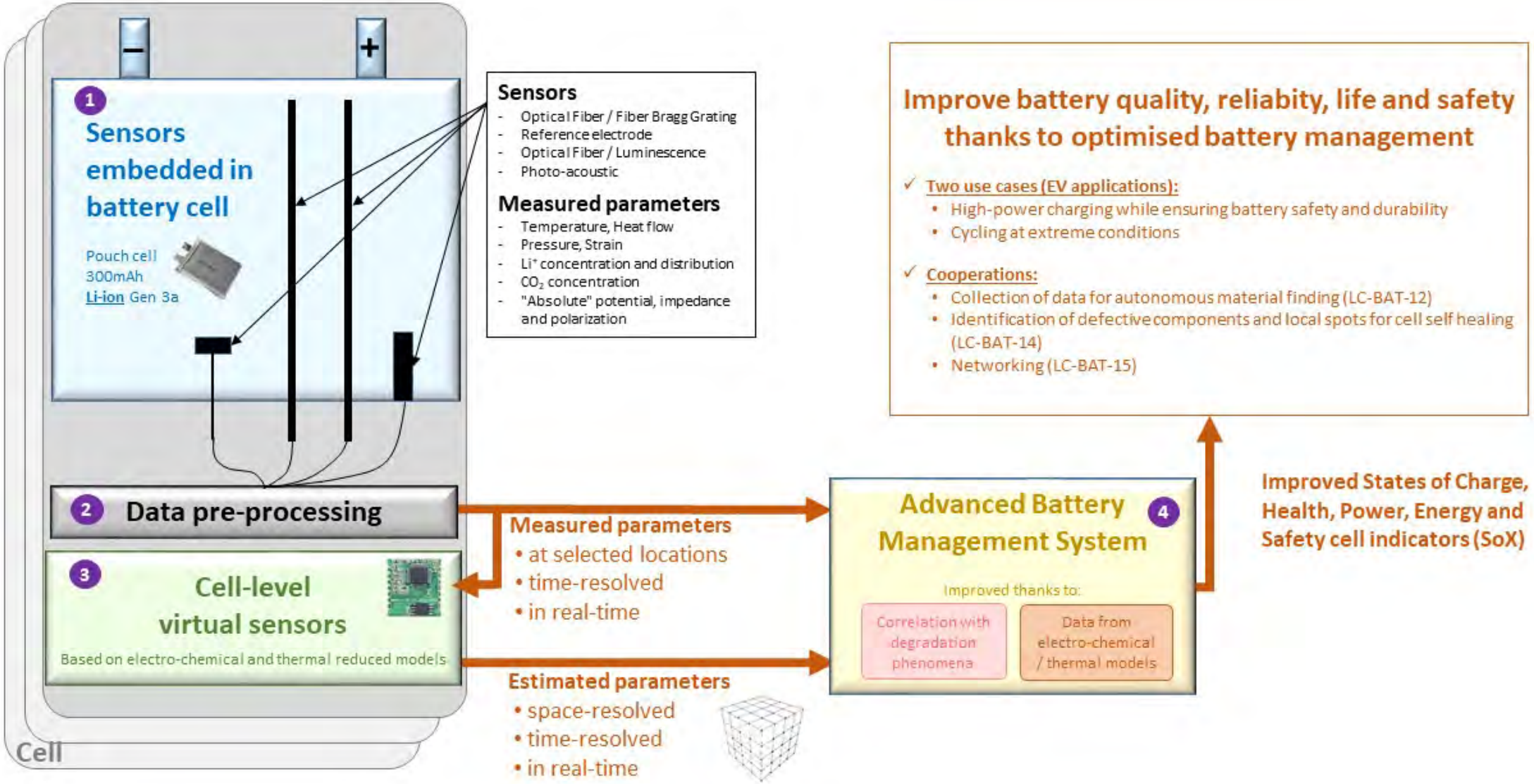
INSTABAT multi-sensor platform will also allow:

- **improving the battery functional performance and safety**,
  thanks to **BMS algorithms providing in real-time higher accuracy States of Charge, Health, Power, Energy and Safety** (taking the measured and estimated parameters into consideration)

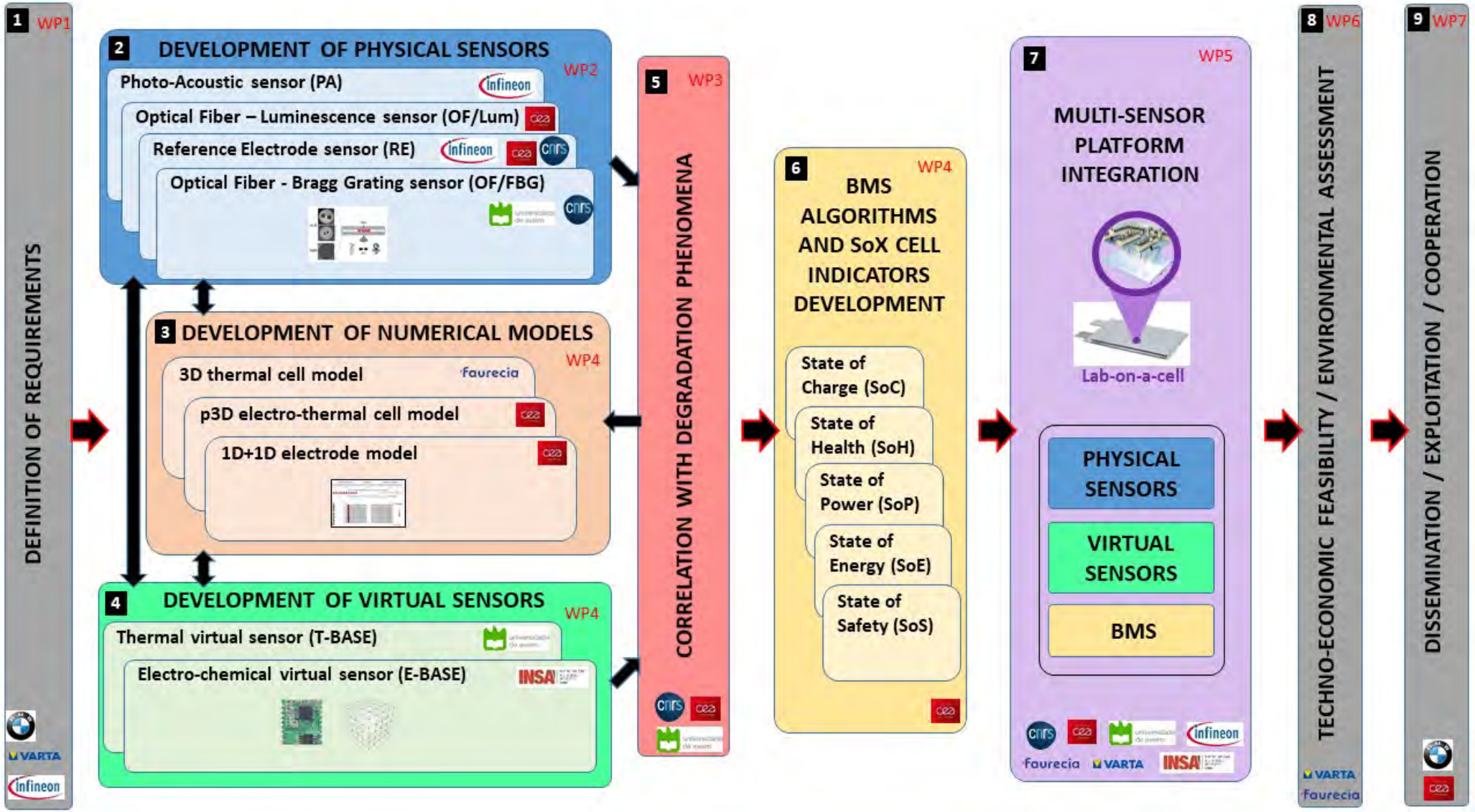
Two **use cases:**

- **cycling at extreme conditions**
- **high-power charging for Electric Vehicles (EV) applications**

# CONCEPT


1
Sensors embedded in battery cell
Pouch cell
300mAh
Li-ion Gen 3a
Sensors
- Optical Fiber / Fiber Bragg Grating
- Reference electrode
- Optical Fiber / Luminescence
- Photo-acoustic
Measured parameters
- Temperature, Heat flow
- Pressure, Strain
- Li+ concentration and distribution
- $CO_2$ concentration
- "Absolute" potential, impedance and polarization
2 Data pre-processing
3 Cell-level virtual sensors
Based on electro-chemical and thermal reduced models
Measured parameters
• at selected locations
• time-resolved
• in real-time
Estimated parameters
• space-resolved
• time-resolved
• in real-time
Advanced Battery Management System
4
Improved thanks to:
Correlation with degradation phenomena
Data from electro-chemical / thermal models
Improve battery quality, reliabity, life and safety thanks to optimised battery management
✓ Two use cases (EV applications):
• High-power charging while ensuring battery safety and durability
• Cycling at extreme conditions
✓ Cooperations:
• Collection of data for autonomous material finding (LC-BAT-12)
• Identification of defective components and local spots for cell self healing (LC-BAT-14)
• Networking (LC-BAT-15)
Improved States of Charge, Health, Power, Energy and Safety cell indicators (SoX)
Cell

# METHODOLOGY



# CONSORTIUM AND ROLES

**4 academic partners:**

- CNRS Collège de France (FR)
- INSA de Lyon (FR)
- University of Aveiro (PT)
- CEA (FR)

**4 industrial partners:**

- INFINEON Technology (DE)
- Faurecia (FR)
- Varta Micro Innovation (AT)
- BMW (DE)

| | # | Physical/ Virtual sensor | Partners involved | Technology | Measured/Estimated parameters | Physico-chemical phenomena to be correlated with sensors output |
|---|---|---|---|---|---|---|
| PHYSICAL SENSORS | 1 | **OF/FBG** | CNRS, UAVR | Optical Fiber / Fiber Bragg Grating | Temperature and heat flow, pressure, strain | Solid Electrolyte Interphase (SEI) growth, internal resistance increase, capacity loss |
| | 2 | **RE** | CNRS, IFAG, CEA | Reference Electrode | "Absolute" potential, impedance and polarization | Lithium plating, internal resistance and SEI / CEI (Cathode Electrolyte Interface) growth on each electrode |
| | 3 | **OF/LumT OF/LumL** | CEA | Optical Fiber / Luminescence | Temperature, $Li^+$ concentration | SEI growth, internal resistance increase, capacity loss, lithium plating, loss of active materials |
| | 4 | **PA** | IFAG | Photo-Acoustic | $CO_2$ concentration | Ageing, $CO_2$ gas released from electrolyte decomposition giving information about the SEI formation, safety-critical situations |
| VIRTUAL SENSORS | 1 | **E-BASE** | INSA | Electro-chemical BAttery State Estimator (reduced model at electrode level) | $Li^+$ concentration and distribution, "absolute" potential and polarization | Electrolyte polarization, lithium plating, irreversible electro-chemical reactions |
| | 2 | **T-BASE** | UAVR | Thermal BAttery State Estimator (reduced model at cell level) | Temperature | Electrolyte degradation, capacity fade, ageing and thermal runaway |

| | | |
|---|---|---|
| **Models** | **1D+1D electrode model** | **CEA** |
| | p3D cell model | CEA |
| | 3D thermal cell model | Faurecia |
| **Correlation** | Correlation with degradation phenomena | CNRS |
| **BMS algos** | BMS SoX cell indicators | CEA |
| **Exploitation** | Techno-economic feasibility, adaptability to different cell markets, environmental consideration | Faurecia, BMW, Varta |

# LINKS WITH BATTERY 2030+

Main contributions from INSTABAT to Battery 2030+ are:

(1) identify **triggers for self-healing** thanks to INSTABAT multi-sensor platform

(2) facilitate **autonomous discovery of advanced battery chemistries** by two means:
- sharing battery key parameters **datasets** (e.g., from the use cases)
- designing our platform so that it can also be used as an **in operando characterisation platform for battery materials**

(3) work towards a **common strategy for results exploitation and IPR management**

(4) contribute to common education / communication / dissemination actions

Main benefits from the collaboration with Battery 2030+ are:

(1) discuss our potential difficulties with the other LC-BAT-13 projects, exchange best practices with them

(2) see beyond our project by exploring the integration of **self-healing capabilities within the INSTABAT platform**

BATTERY 2030+

# Thank you for your attention

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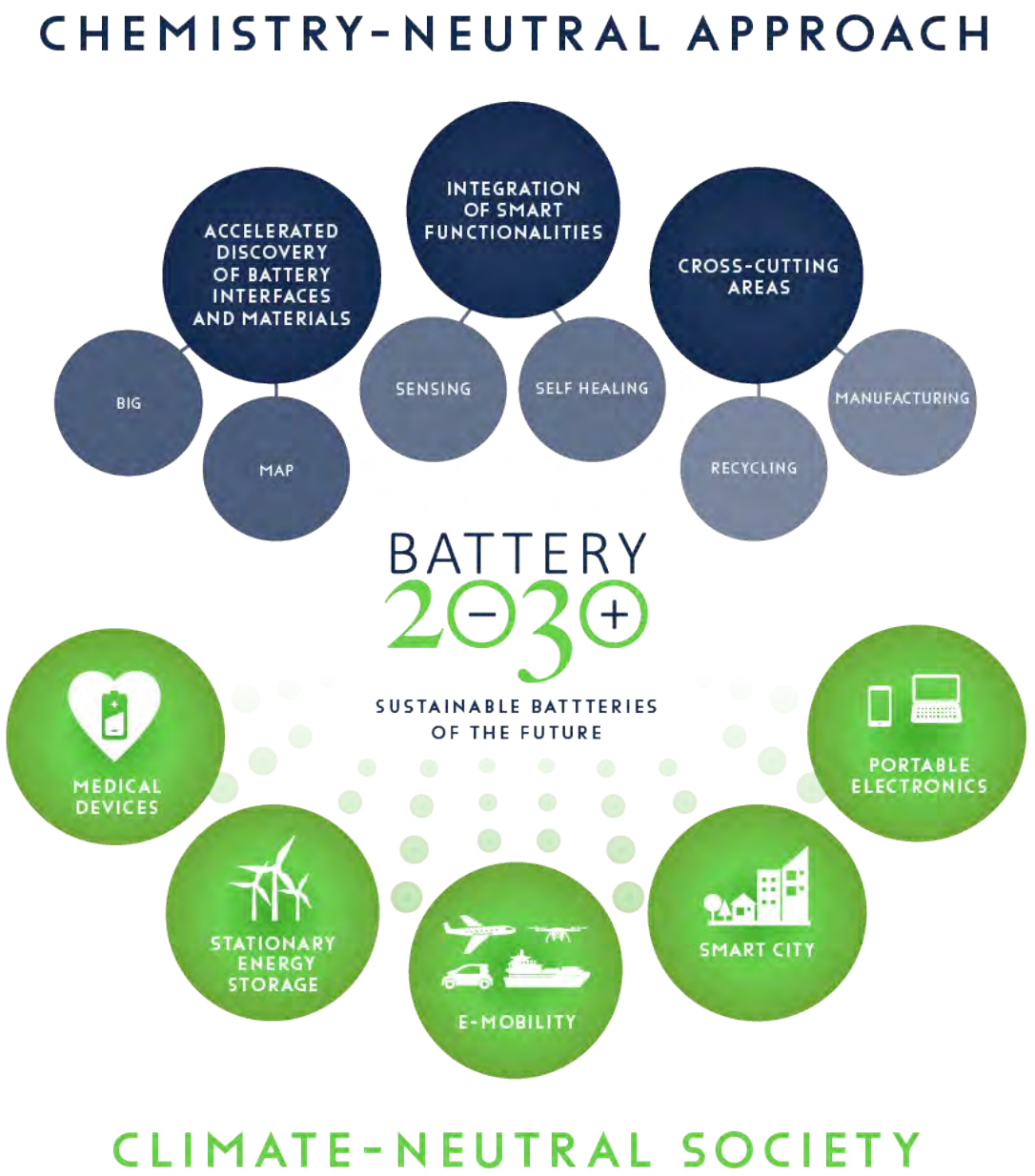


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