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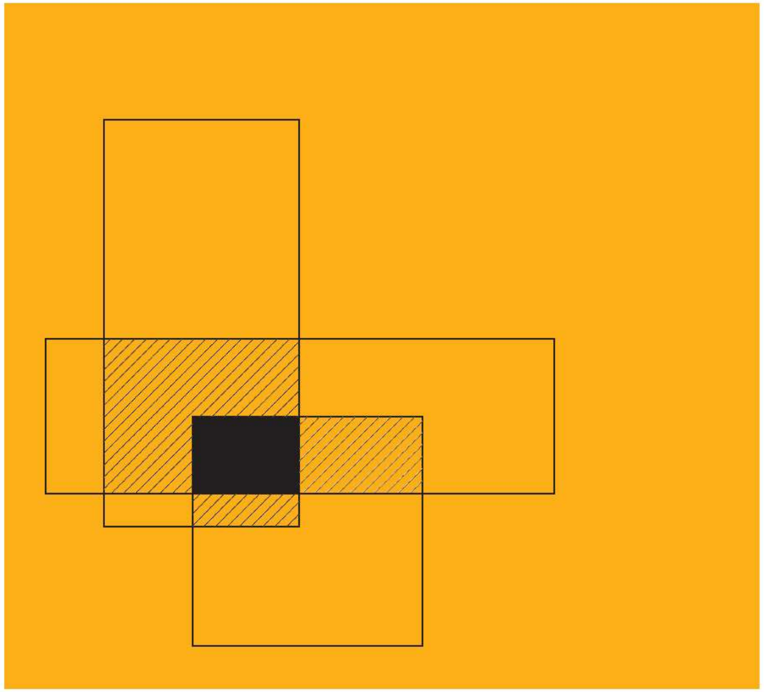
JOINT NETWORK EVENT



MEET THE PROJECT !

11:45 - 13:00

- A **Next generation e-vehicle design** // OBELICS
- B **Simulation Toolchain and Proposal for Simulation Standard** // HIFI ELEMENTS
- C **Advanced simulation tools and their use for EV battery design** // DEMOBASE
- D **Safety Concepts for batteries** // OBELICS
- E **From MiL to HiL** // HIFI ELEMENTS

C **Advanced simulation tools and their use for EV battery design,** IFPEN contributions:

- "1D modelling for module thermal safety simulation", by Martin PETIT
- "HIL tests for seamless integration of battery pack in EV", by Joseph MARTIN

1D modelling for module thermal safety simulation

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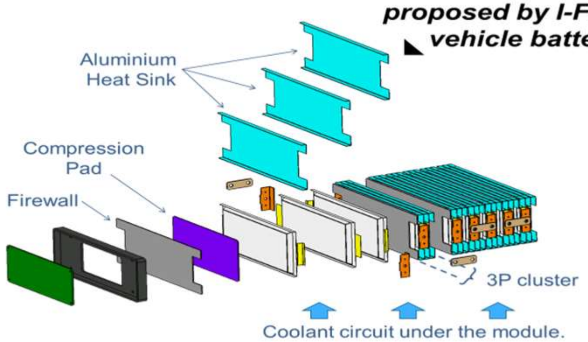
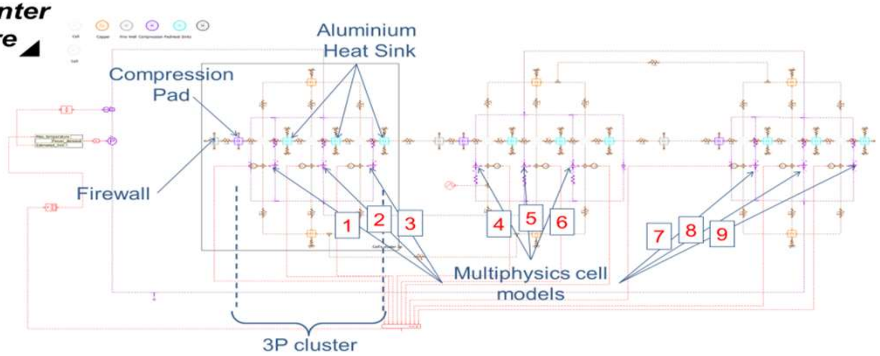
- <u>Objectives of 1D modelling:</u>
  - <u>Fast computing model</u>
    - Lumped approach
      - 1 temperature per component
  - <u>Representative of the thermal behavior of the battery pack/module</u>
    - Battery electrothermal model accounting for safety hazard
    - Each technical component is modelled and assembled in a complete system
      - Battery cells
      - Tabs
      - Heat sinks
      - Heat exchangers
      - Firewalls…

➔Such a model can be used of design or parameteric studies

3P7S module structure proposed by I-FEVS for the vehicle battery pack



IFPEN module simulator developed on Simcenter Amesim™ software



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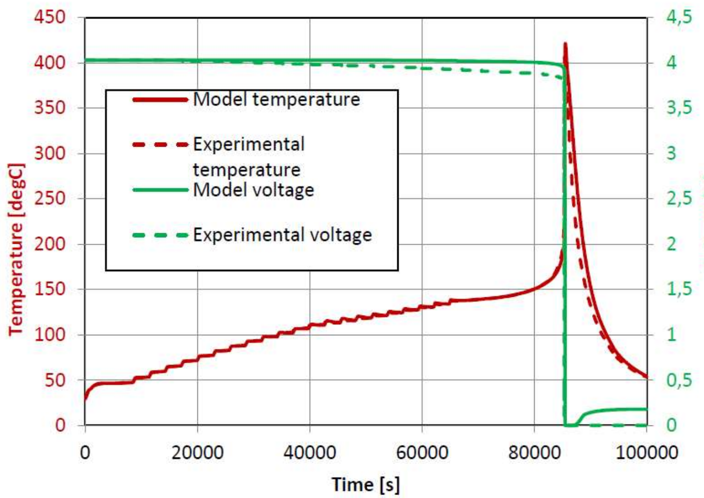
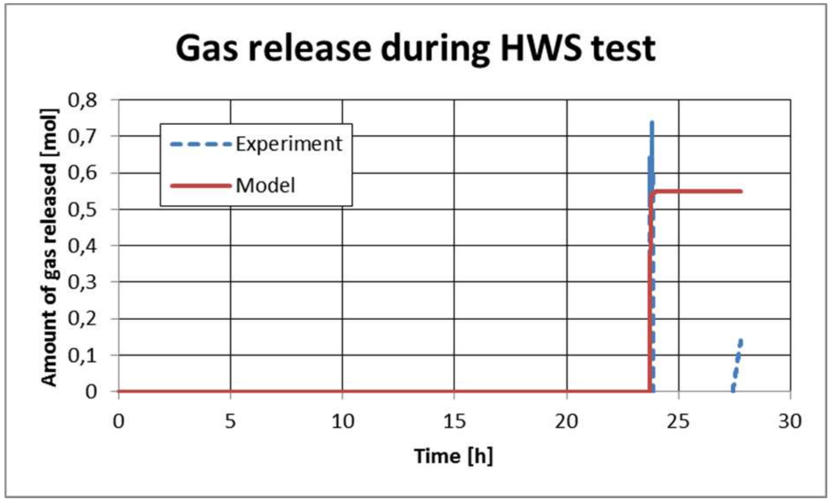
DEMOBASE

Cell safety modelling

- Need of an accurate cell model
  - Thermal/electrical behavior of the cell during thermal runaway
    - Main exothermal reactions taken into account
    - Internal short-circuit
    - Venting
- Calibration thanks to dedicated safety tests performed at INERIS
  - Evaluation of heat released from each reaction
  - Evaluation of cell electrical behavior
  - Evaluation of the amount of gases released

➔Model ready to be used in module simulator





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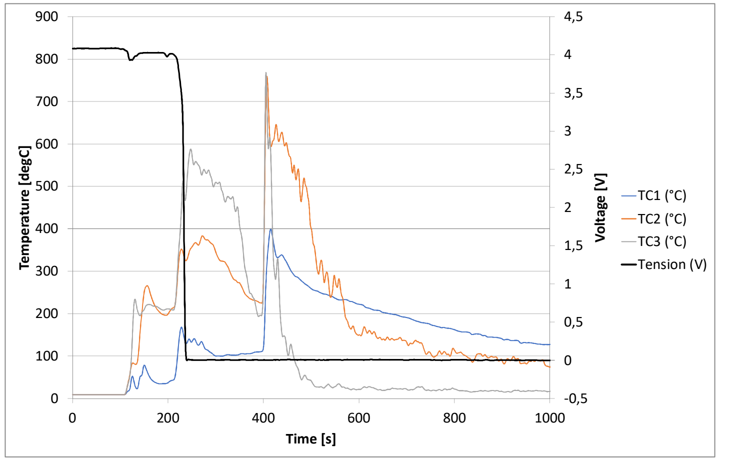
DEMOBASE

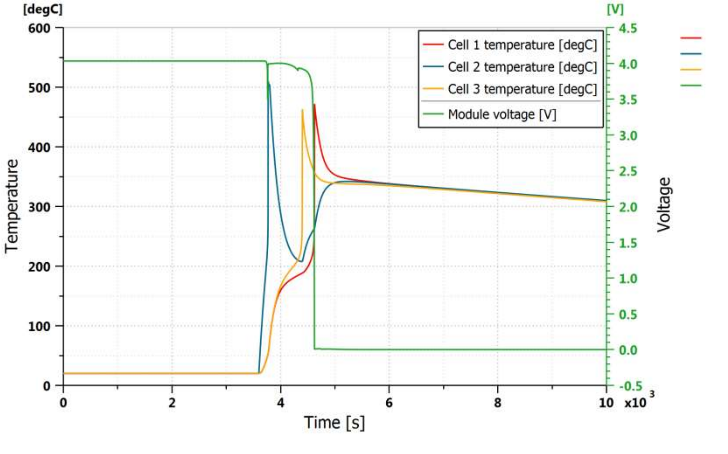
1D module simulation

- Thermal calibration
  - Test bench tests
    - Fit of materials thermal properties
    - Heat transfer coefficients
  - Validated on subsystem in INERIS test facilities
    - 3p1s cluster behavior

- Model used to evaluate technical solutions for limiting safety issues
  - Thermal behavior of the module before thermal runaway
  - Effect of water cooling
  - Effect of firewall material choice



Experimental behaviour of the module



Modelling results

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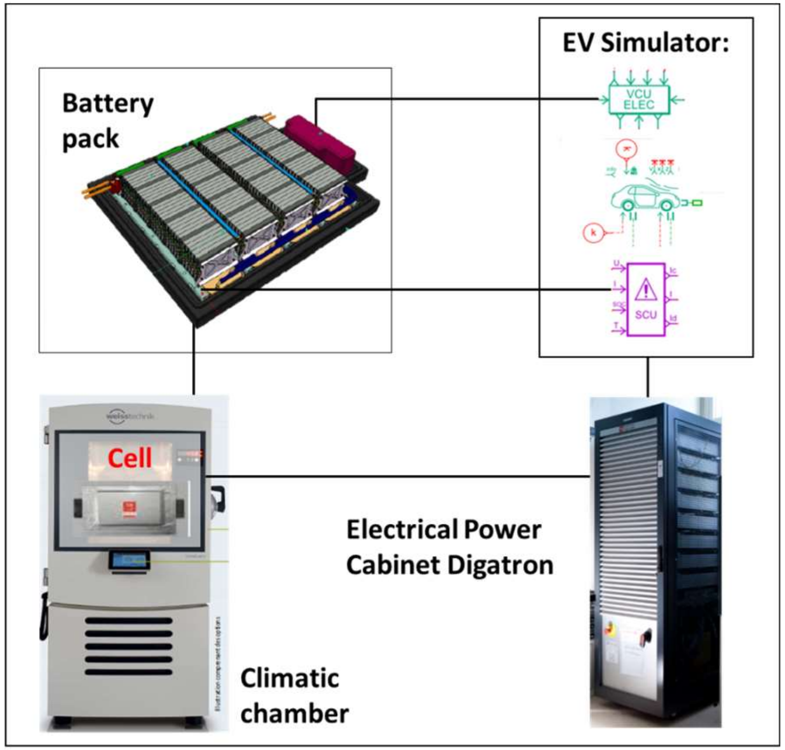
HIL tests approach for seamless integration of battery pack in light EV



- But what is a HIL test ?
  - Simulated part:
    - An Amesim™ EV model exported as a FMU
    - A Simulink™ model
  - Real part:
    - A battery **cell** placed in a climatic chamber
    - A Digatron electrical power cabinet
    - A Digatron BTS-600 battery bench manager

- Objectives of this HIL test:
  - To test a battery cell component with very close operating conditions which would be encountered in a real electric car following normalized driving cycles on the road
  - to validate new battery pack configurations quickly and with low costs.

Advanced simulation tools and their use for EV battery design

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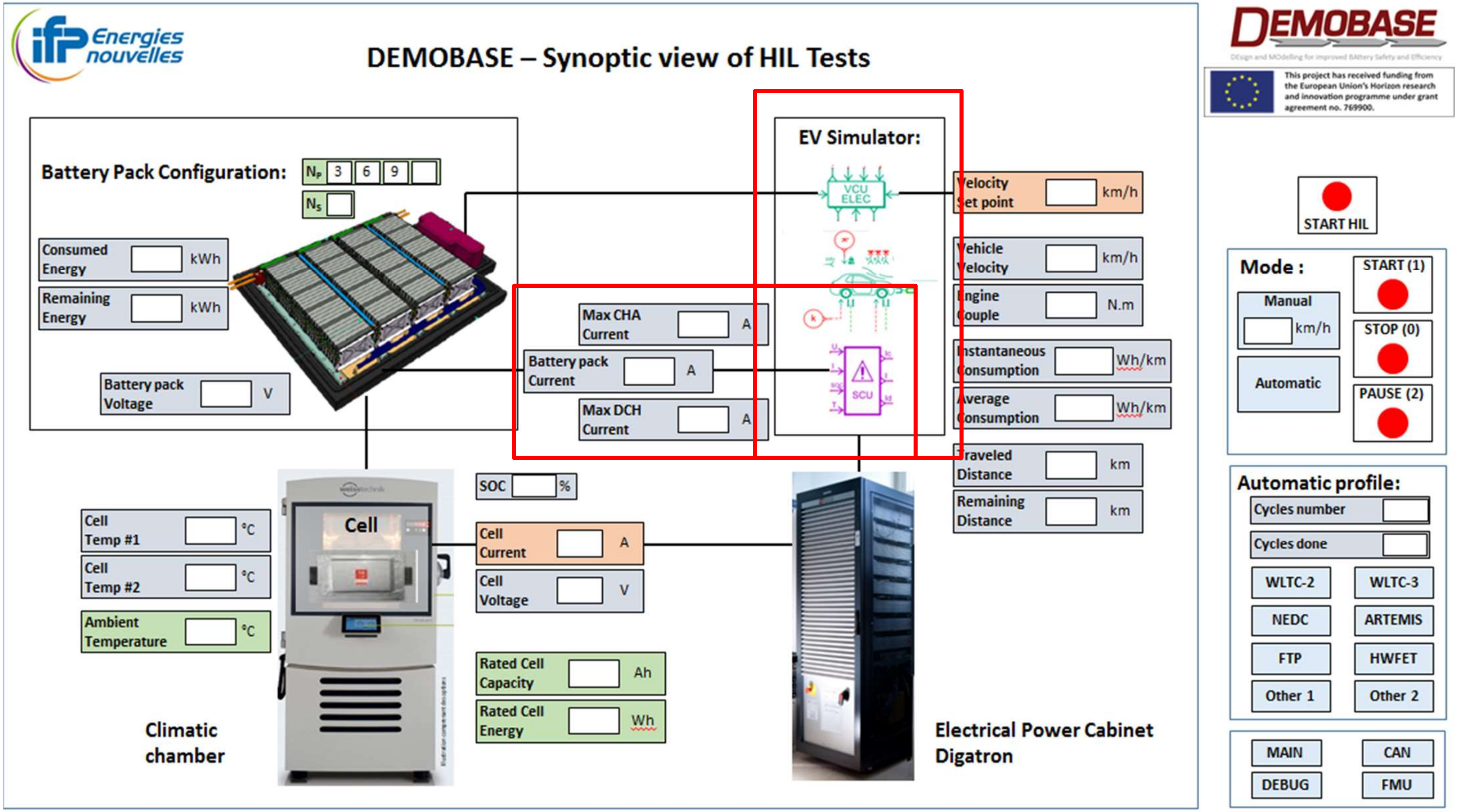
DEMOBASE



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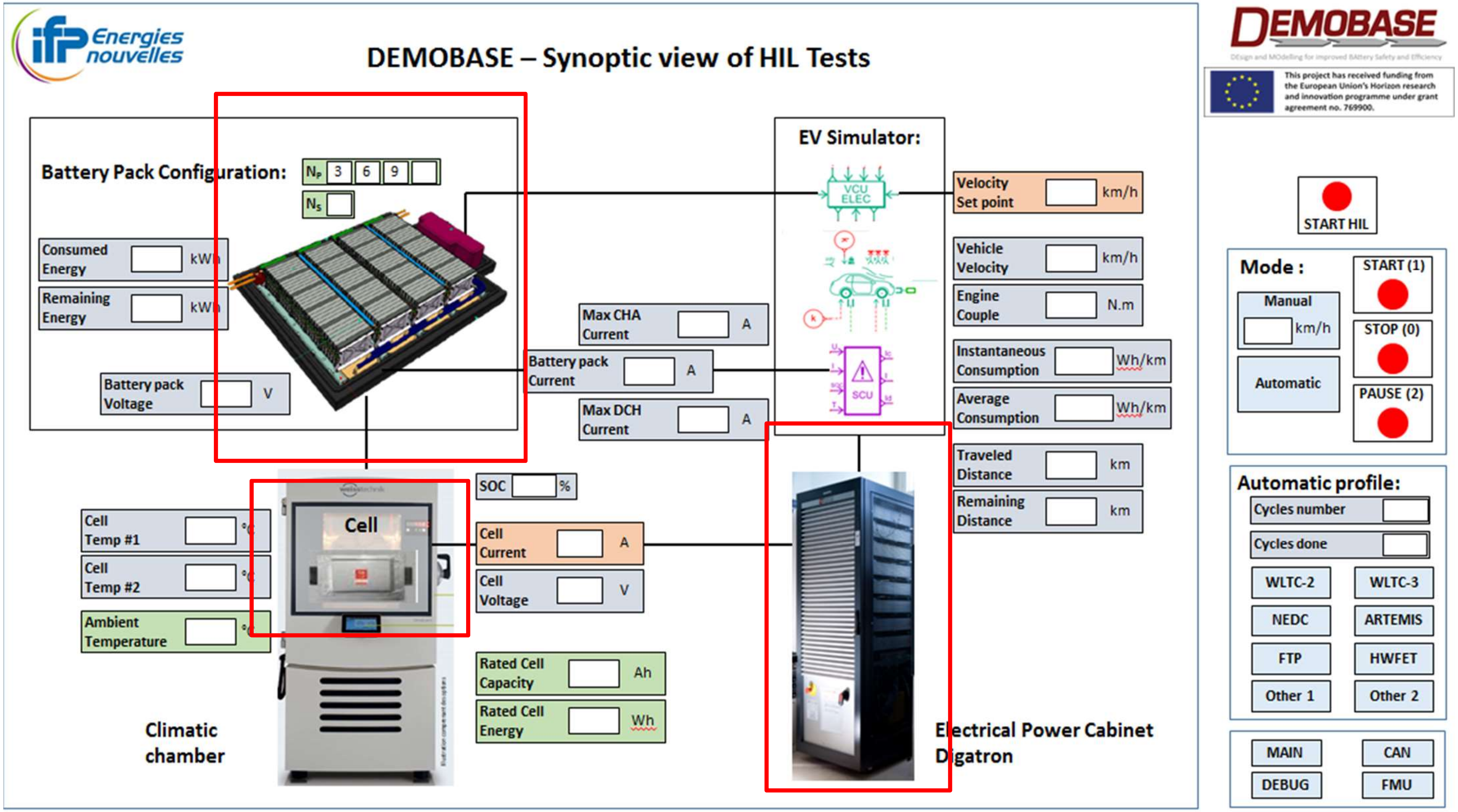

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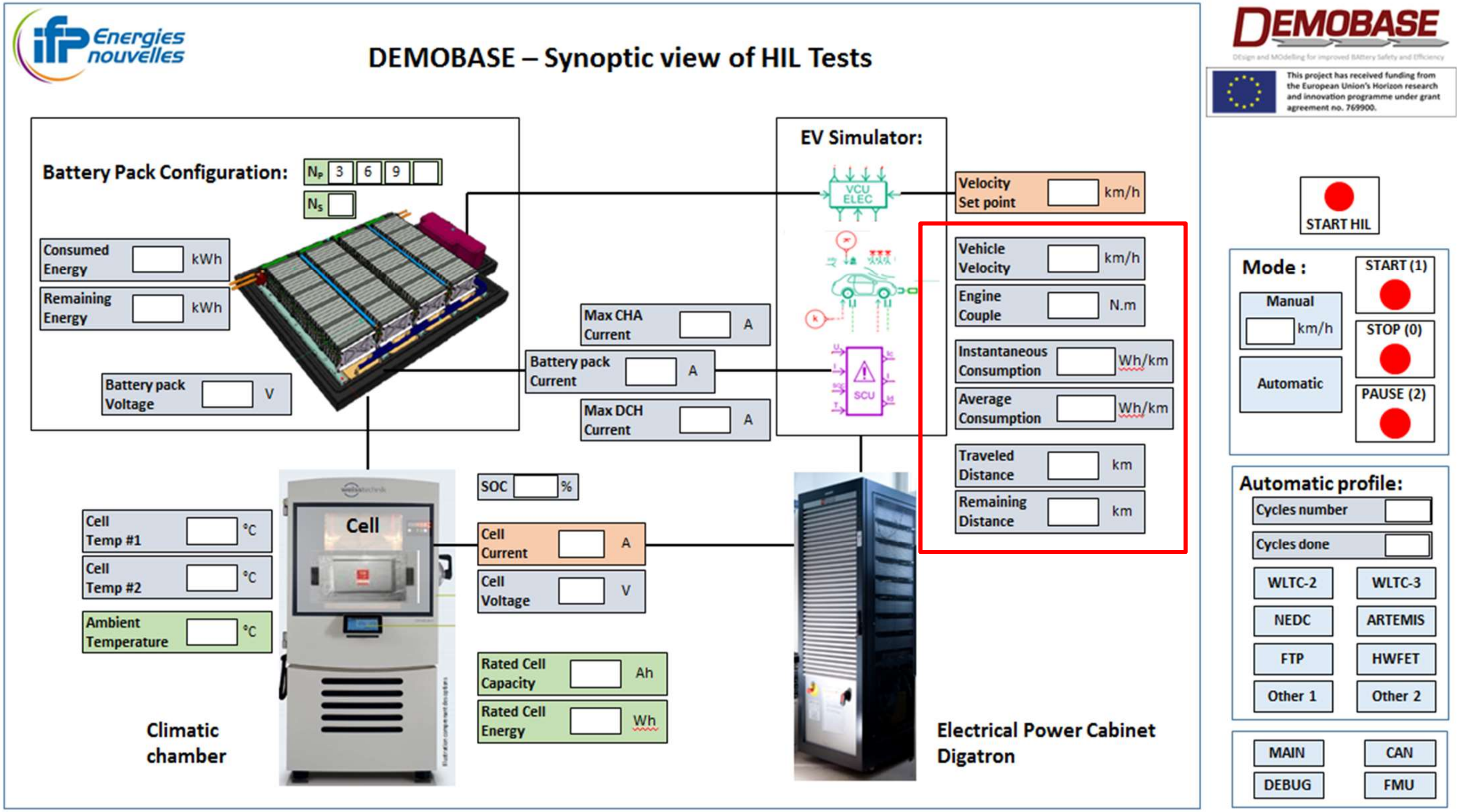

Advanced simulation tools and their use for EV battery design

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DEMOBASE

- Study parameters:
  - From the cell: specifications according to the technology, initial SOC and test temperature,
  - From the pack: number of cell in series (Ns), number of cells in parallel (Np),
  - From the EV: road speed profile (WLTC, NEDC, Artemis, …)
- Example of some results:
  - Impact of the pack configuration: number of branches in parallel

Test	Road profile	Temp.	Branches	Iterations	Range	Energy consumption	Final SOC	Remaining range
1	WLTC 3.1	25 °C	4	19	293 km	78 Wh/km	1,5 %	15 km
2	WLTC 3.1	25 °C	3	14	222 km	78 Wh/km	1,1 %	11 km
3	WLTC 3.1	25 °C	2	9	146 km	78 Wh/km	1,5 %	8 km
4	WLTC 3.1	25 °C	1	4	71 km	78 Wh/km	3,9 %	7 km

  - Impact of the road profile

Test	Road profile	Temp.	Branches	Iterations	Range	Energy consumption	Final SOC	Remaining range
2	WLTC 3.1	25 °C	3	14	222 km	78 Wh/km	1,1 %	11 km
7	NEDC	25 °C	3	17	194 km	89 Wh/km	0,3 %	8 km
9	HWFET	25 °C	3	9	160 km	107 Wh/km	0,6 %	8 km
10	ARTEMIS_Urb	25 °C	3	62	307 km	56 Wh/km	2,0 %	16 km

- Upcoming work: comparison between different cell technologies