

ELAPHE™ PROPULSION TECHNOLOGIES

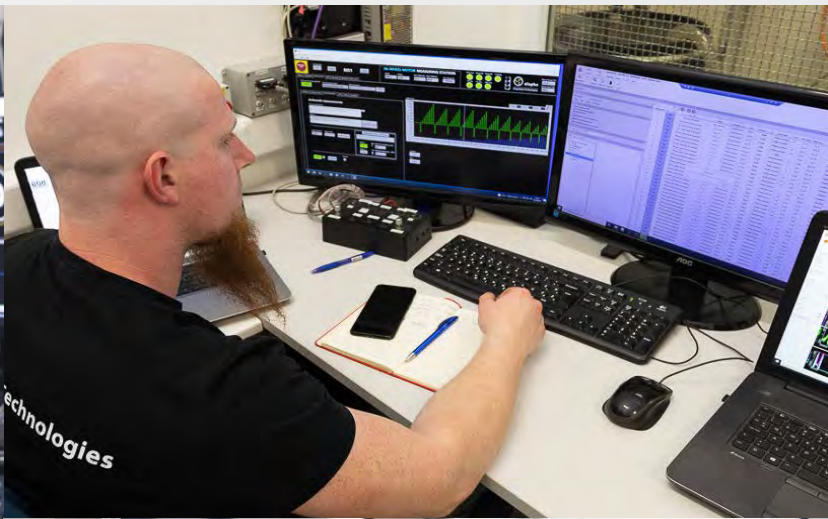
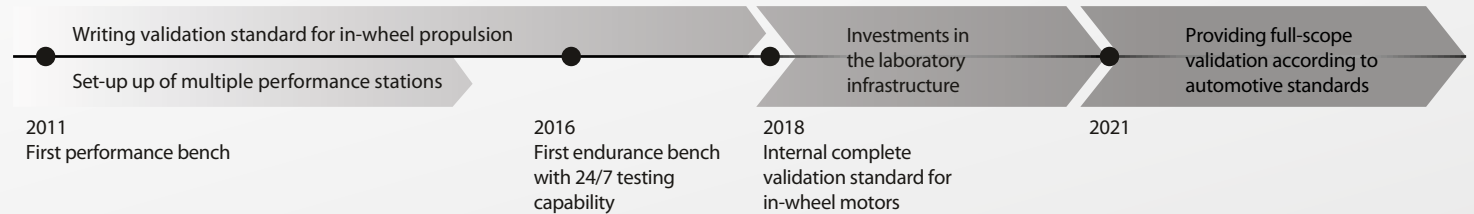
TESTING AND VALIDATION



elaphe

Propulsion Technologies

- Elaphe has a dedicated testing centre for testing high-torque/low-speed and low-torque/high-speed propulsion systems in full operating range and environmental conditions.
- Through the years, we had to learn and develop creative and effective methods to systematically adapt our processes and equipment to customer challenges and requirements, with a proper balance in cost and quality.
- We are a highly educated team with universal knowledge and more than 10 years of experience in automotive testing.
- By working with us, you get access to wider company knowledge and support of different departments (electronics HW&SW, CAE, design engineering, machining).
- We perform testing based on customer requirements, standards, legislation, failure mode and effects analysis (FMEA), previous testing experience, and simulations performed in the development phase.
- 95% of the equipment and software was developed in-house which gives us an excellent overview and flexibility to adjust to new situations and requirements.



WHAT WE OFFER

- Testing services in the scope of device under test (DUT) validation
- Support of validation plan preparation and execution according to different automotive standards (VDA, VW8000, GMW...)
- Advanced performance testing for detailed DUT characterization
- Advanced environmental/endurance testing for better insight into DUT durability
- Engineering tests based on the customer requests
- Design and preparation of dedicated testing set-ups
- Testing infrastructure rental

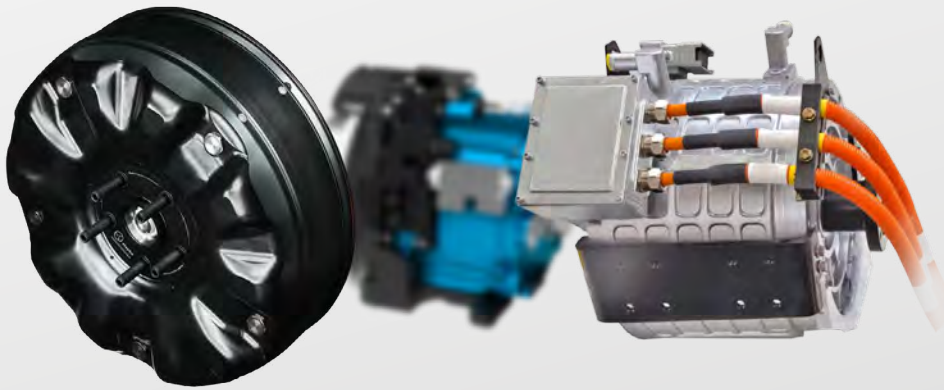


PRODUCT VALIDATION

Product development in the automotive industry generally takes 3-4 years. Individual components are tested throughout development to ensure product maturity level of the final product can be assured. There are at least three main validation phases done: concept validation (CV), design validation (DV), process validation (PV). Each validation phase consists out of 5-7 test flows that cover performance, endurance, environmental and mechanical aspects of testing.

- We offer a complete testing solution, including execution of the entire test validation plan, as well as performing individual tests.
- On-site, we have the needed capacity and equipment to run multiple parallel legs of a validation plan, ensuring optimal testing time and reliable testing data.
- Tests are performed according to automotive standards (e.g., VDA, VW, GM) and can be modified as per individual customer request.
- Based on the successful completion of several validation plans and gained know-how, we can support you with relevant test flow definition and aid you in designing product specific tests.
- We assure traceability of test procedures, execution, reports and possible deviations over the complete validation using dedicated project management tools (Jama, MS project).

E-motors



Power electronics



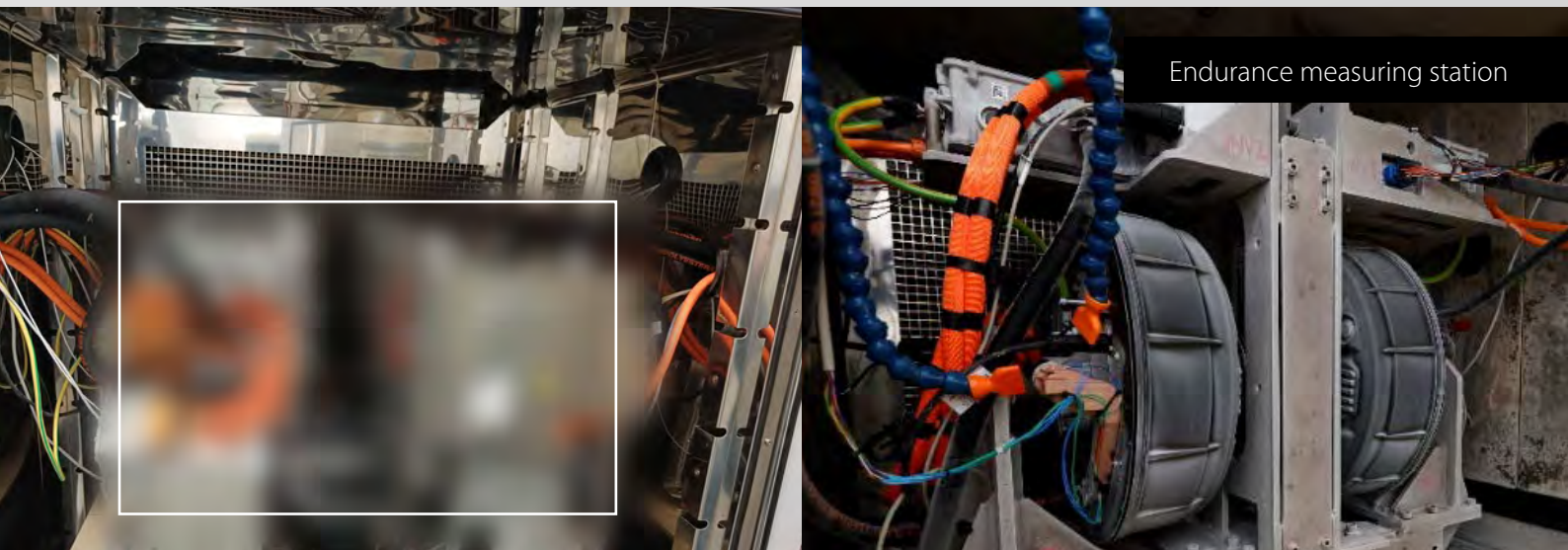
ENDURANCE TESTS



Endurance testing mainly refers to the testing of an electric power drive system using a predefined loading profile under different harsh environmental conditions. Due to necessity to validate our product for lifetime operation and a shortage of suitable testing equipment / services on the market, we internally developed a modular environmental testing measuring station.

- Standard endurance tests that we perform are PTCE, HTOE, HTHE, THC; with a possibility of a custom test prescription.
- We are confident in assisting you with a product-specific testing configuration setup. Motor loading is achieved using a so-called back-to-back arrangement, allowing us to test multiple pairs of DUTs inside a single environmental chamber.
- Power capability to test E-Systems with a supply voltage 0 to 800 V DC and a combined system consumption up to 250 kW. Motor control is achieved using customer provided inverters that are simultaneously tested, with the possibility to adapt one of our inverters.
- Achievable environmental temperature conditions range from -40 °C to +120 °C, along with selectable coolant flow and temperature.
- Tests are performed 24/7, with on-time test monitoring and selectable test discontinuation conditions. In addition to commonly used test sensorics, we can implement customer specific measurements upon request (e.g. vibration monitoring).

* Additional information about performance measuring stations is located in the INFRASTRUCTURE section (page 8).



Endurance measuring station

High-torque/low-speed performance measuring station

PERFORMANCE TESTS

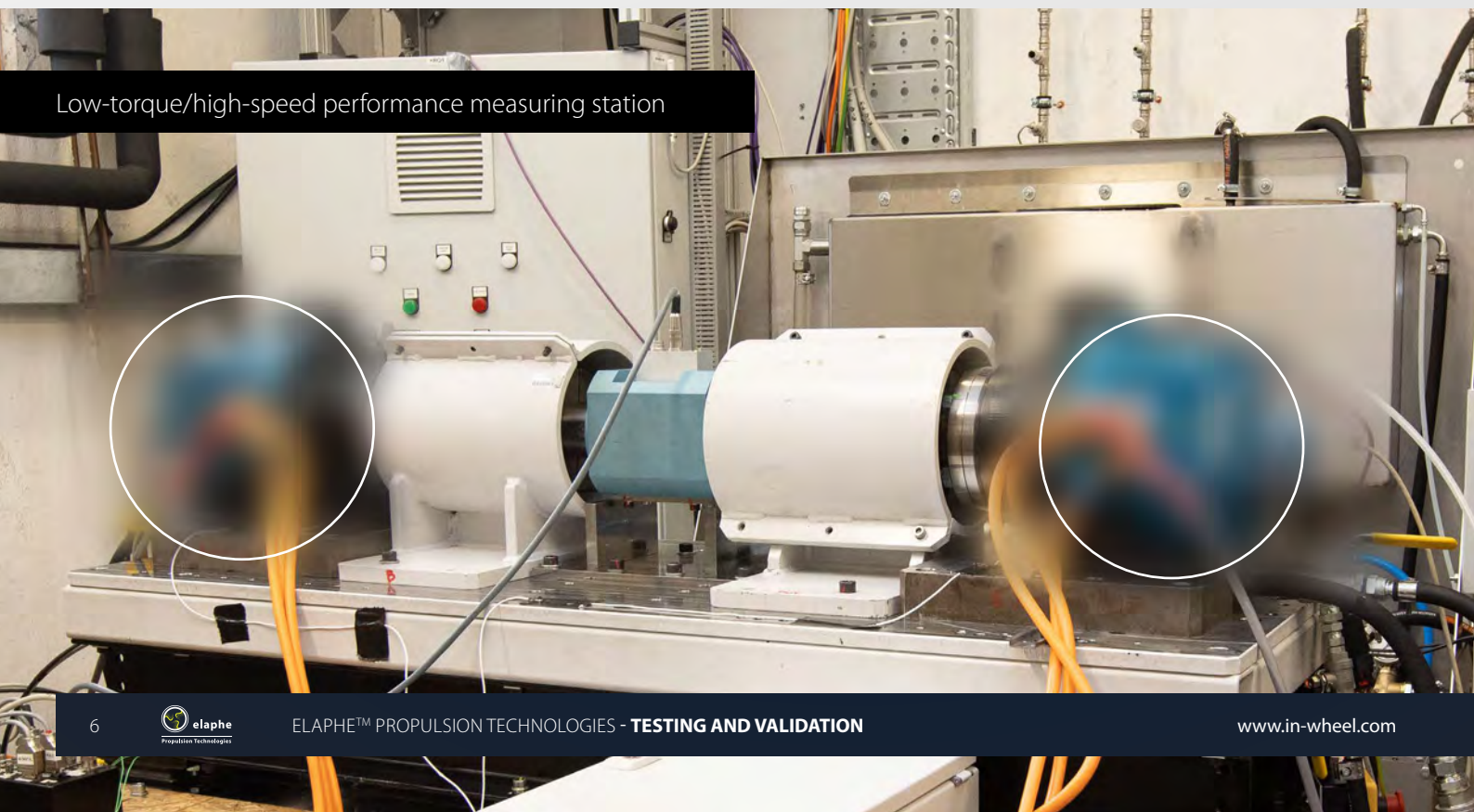
We are able to perform detailed performance measurements on the complete operating range of the tested propulsion system. Performance characterization is done for several reasons. Firstly, to test if product performance is aligned with customer requirements and secondly, to confirm simulations performed in development phase and thirdly, to obtain the required data for homologation authority.

Performance measurements give detailed insights into:

- DUT losses (bearing, windage, iron, magnet, winding)
- Operating range of DUT (torque-speed curve, net power)
- Efficiency (AC, DC)
- Energy consumption in driving cycles (WLTP, UDDS, HWFET...)
- DUT thermal behavior

* Additional information about performance measuring stations is located in the INFRASTRUCTURE section (page 8).

Low-torque/high-speed performance measuring station





Engineering validation tests have an important role in product design. For such testing we are offering a turn-key implementation in accordance with customer requests. There are two different types of engineering tests. The first type is used to confirm/reject specific solution/component during the early development phase and the second to replicate the product failure mode that was observed on the field. Both have a similar work flow.



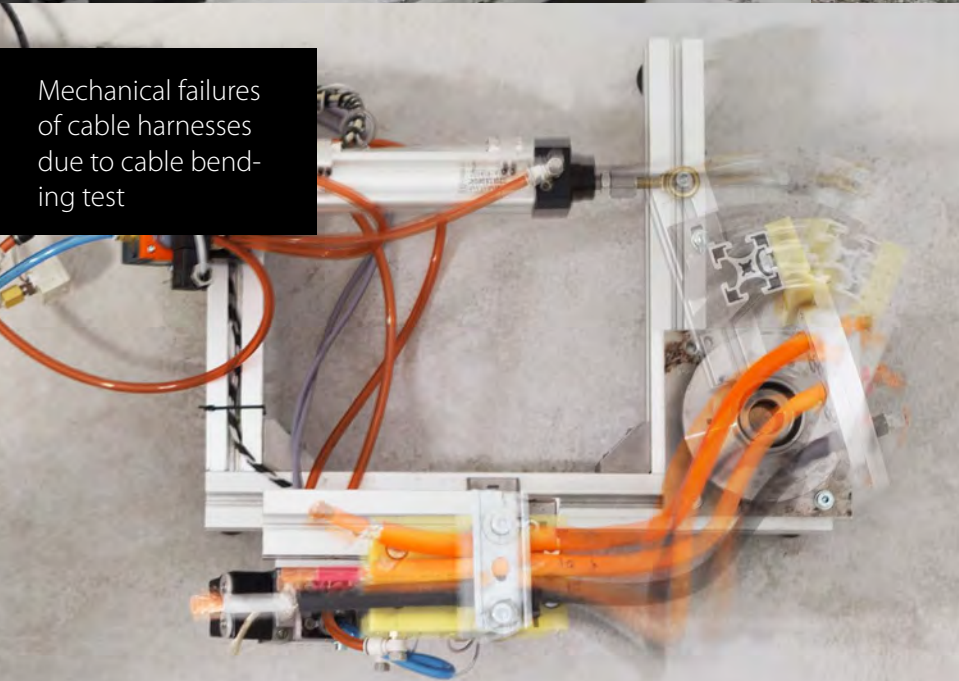
Ice-build-up test



Free fall test



Stone chipping test



Mechanical failures of cable harnesses due to cable bending test



Salt water immersion test

ENGINEERING MODULAR TEST EQUIPMENT

We have a skilled and experienced team capable of building testing equipment from the ground up. This includes designing and manufacturing mechanical components, developing electrical and cooling systems, and creating the software required to run the testing equipment. With extensive experience in data processing, we have the expertise to handle large datasets with ease and efficiency to extract insights and drive results.

With a comprehensive understanding of the entire process, our team can create custom solutions that meet the specific needs of our clients' testing requirements. A multidisciplinary background enables us to swiftly resolve issues, lower downtime and establish complex test set-ups. Whether it's a simple test bench or a complex testing system, we have the expertise to deliver high-quality and reliable equipment.



INFRASTRUCTURE



Endurance measuring station:

- Temperature and humidity life tests where device under test is dynamically loaded inside the thermal chamber
- Testing up to 6 DUTs at the same time (depending on the DUT size)
- Tests are performed in back-to-back configuration
- DUT: motor/inverter/both
- Supply voltage up to 800 V
- Control of environmental temperature and humidity
- Adjustable cooling system with different coolant mediums
- Online insulation condition monitoring of DUTs
- 24/7 operation without operator presence
- Rates from 39 € per hour

Performance validation measuring station:

- Supports R&D activities, validation tests and end-of-line testing for low-volume projects
- Supports both high-torque (up to 5000 Nm) or high-speed (up to 25000 RPM) motor testing
- Tests are performed in back-to-back configuration
- DUT: motor/inverter/both
- Supply voltage up to 800 V
- Adjustable cooling system with different coolant mediums
- Advanced power analyzers (sampling frequencies up to 10 MHz), with available supplier support for advanced measurement (e.g., transients)
- Modular structure of HW and SW which supports adjustments on the specific customer requirements
- Rates from 50 € per hour



Thermal shock chamber

- Temperature range hot chamber: +50 °C to +220 °C
- Temperature range cold chamber: -80 °C to +100 °C
- Time for changing basket between chambers < 10s
- Maximal basket load: 50 kg
- Rates from 8 € per hour



SWIB – Salt water immersion test:

- Dedicated measuring station for validation tests related to the DUT protection against dust, water, mud
- Supports temperature control of media
- Supports DUT operation in no-load condition
- Online insulation condition monitoring of DUTs
- Rates from 25 € per hour



Advanced cooling units:

- Coolant temperature range: -40 °C to +120 °C
- Cooling capability: 10 kW (@-20 °C)
- Heating capability: 6 kW
- Coolant temperature stability: ± 1 °C
- Cooling medium is glycol



Power supply units and battery simulator:

- Output voltage between 40 V and 1200 V
- Maximum output current: 600 A
- Maximum output power: 250 kW



Temperature chambers:

- Temperature range: -60 °C to +180 °C
- Temperature stability: ± 2 °C
- Humidity range: 10–98 %
- Humidity stability: ± 3 %
- Temperature slope: 10 K/min

PARTNERS

Dewesoft – Dewesoft – Powerful data acquisition systems with extremely high sampling rates are used for detailed power and NVH measurements. Advanced software enables both data acquisition and/or test set up control with quick adaptation to specific customer needs.

Kambič – Close collaboration on the engineering and implementation of dedicated thermal chambers and cooling systems which are part of the advanced environmental endurance measuring stations.

LMK – LMK – Laboratory of Metrology and Quality at the Faculty of Electrical Engineering of the University of Ljubljana contributes as a scientific partner. Academic approaches, combined with the real case testing scenarios, make a perfect combination for improving reliability of measurements and development of new and advanced testing methods.



REFERENCES

Lordstown Motors – Concept and design validation of the Endurance in-wheel propulsion system with the main focus on mechanical and endurance testing. Engineering development validation of specific parts.

Lightyear – Detailed performance testing in the scope of concept validation, where few R&D iteration loops were done. Complete design validation testing of the Lightyear 0 propulsion system.

XPT, emDrive Emsiso – Thermal and endurance testing of the inverter.

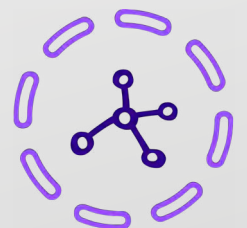
Various EU founded research projects (iRel40, XILforEV...)



Lightyear



LORDSTOWN



XILforEV



intelligent Reliability 4.0



WHY ELAPHE TESTING CENTER

- **Comprehensive approach** on testing, which includes support at definition of validation strategy, development of dedicated testing set-ups, time-optimized test execution, data processing and support at results interpretation.
- We deliver **customized solutions** that meet clients' unique requirements and help them achieve their goals.
- Modular, in-house developed measuring stations enable **flexibility and quick adaptation** to the customer requirements.
- Highly **dedicated multidisciplinary** team is committed to provide best test services on time.
- **Project management** of validation plan ensures time and cost optimization with optional test scope adaptation.
- We provide **24/7 on-site monitoring** and in case of faults inform the customer in real-time.
- Our **pricing is competitive** without compromising on quality.
- **Less than 10 % of down-time** at long lasting tests.

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