TURBO newsletter Aug-2025 (#5)

Towards turbine blade production with zero waste

Welcome to the fifth TURBO project newsletter!

The consortium met at NCC recently to see some resin infusion trials (see pg. 3) This edition contains technical updates on several TURBO research topics:

- CPI delivery of wireless sensors for the full-scale demo at Siemens Gamesa
- NCC digital infrastructure supporting the TURBO approach
- Synthesites resin arrival and cure monitoring technology
- TURBO workshop registration.

For more info visit the website: https://turboproject.eu

Please join the TURBO LinkedIn group! https://www.linkedin.com/company/turbo-project

TURBO takes on joint leadership of the 4ZDM Cluster

For some time, TURBO has been a member of the 4ZDM Cluster of projects working on zero-defect manufacturing (https://zdmanufuture.org). Since the lead project ZDZW finishes in Aug-2025, TURBO has agreed to take over the joint leadership with the FLASH-COMP project.

The next cluster activity will be a booth at the EFFRA Manufacturing Partnership Days event 20-22 Oct-2025 at the Event Lounge in Brussels. Please drop by and find out more on 4ZDM!

There are currently five members of the cluster: TURBO, FLASH-COMP, ZDZW, PlatformZero and Caelestis. There are a number of new relevant EU projects on defect reduction and manufacturing technology. *If you would like to join the group, please get in touch!*

Consortium

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Funded by the European Union

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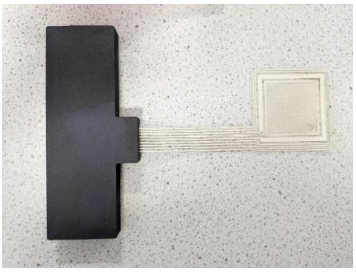
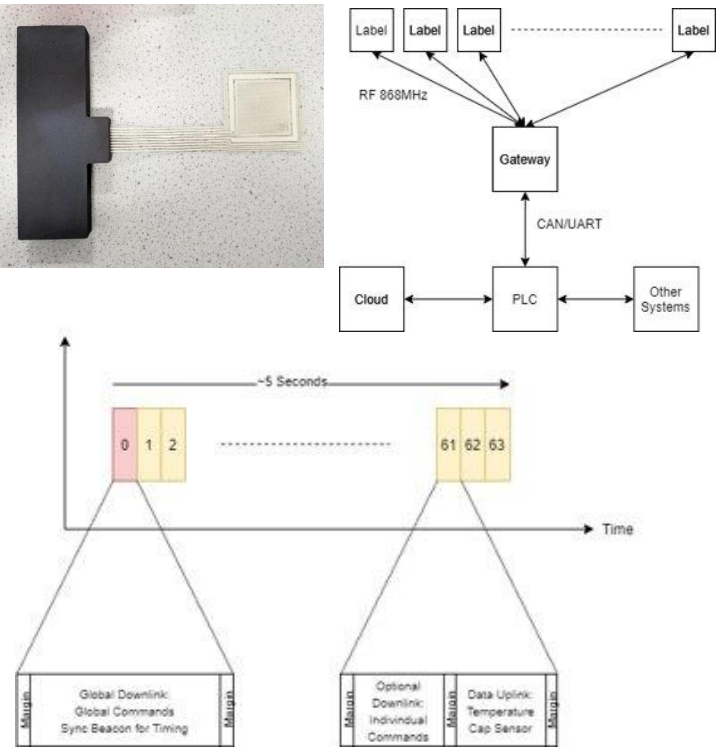
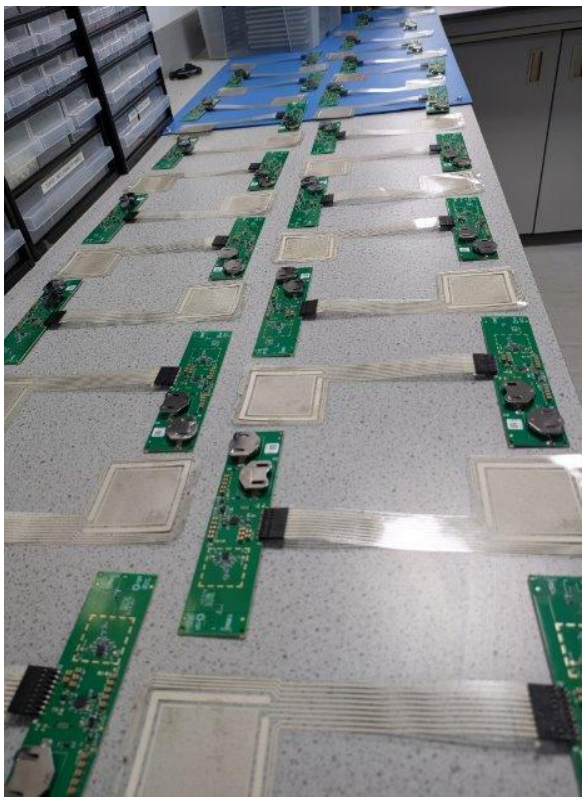
CPI wireless sensor network for TURBO demo: delivered!

CPI has successfully completed the development and delivery of a wireless sensor network under the TURBO project. This included the finalisation of hardware and firmware for both sensor labels and the gateway unit, full system testing and handover to NCC. The sensor label hardware was upgraded with a new PCB and an extended capacitor bank to support peak current demands, which significantly improves battery life. The label enclosures were also finalised using materials that demonstrated reliable performance under thermal cycling. Software development introduced a deep-sleep mode that can be activated either via signal loss or command, reducing standby current to under 300 µA and enhancing shelf life.







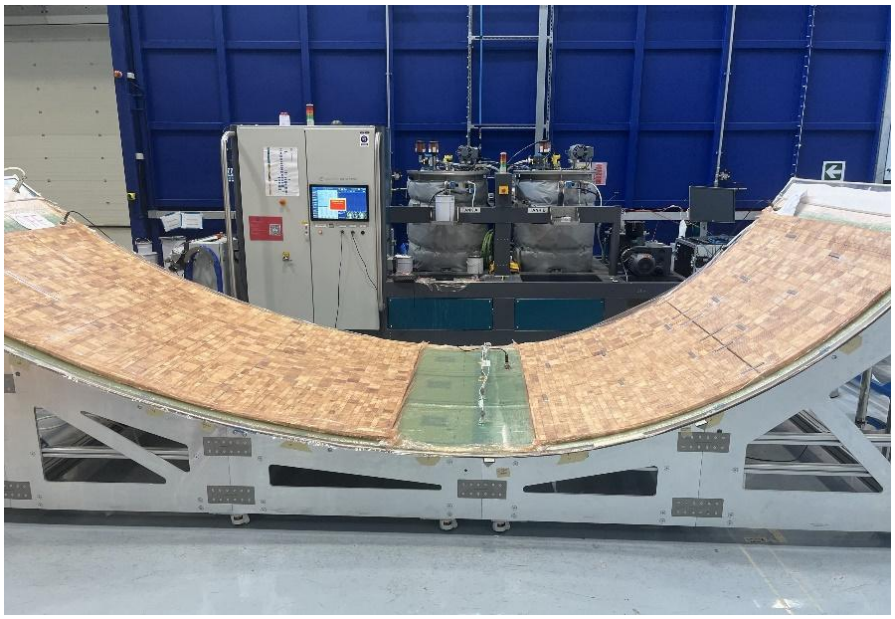
Right: Some of the ~40 sensor labels sent to NCC. Above: Schematic of the timing protocol + CAN architecture.

The gateway firmware was completed and deployed using development boards, with CAN selected as the communication interface to the PLC, supported by a custom desktop-based simulation tool. Comprehensive system testing was carried out with 40 sensor labels, confirming full network functionality, long-range communication (>30 m indoors), accurate performance under high temperatures, and promising early results in battery endurance. CPI delivered ~40 sensor labels and a complete gateway system to NCC, along with all supporting documentation including a user manual. Integration support was also provided to facilitate trials. This development marks a key milestone for TURBO, demonstrating robust sensor integration and readiness for application trials.

For more info please contact Adrian.Wong@uk-cpi.com

Building the digital infrastructure to enable adaptive infusion

The first adaptive control system trials for a sub-scale wind turbine blade infusion process have been conducted at NCC as part of TURBO, including a successful system demonstration during the 30M plenary meeting (see photo on pg 1) and the 30M project review in May-2025.



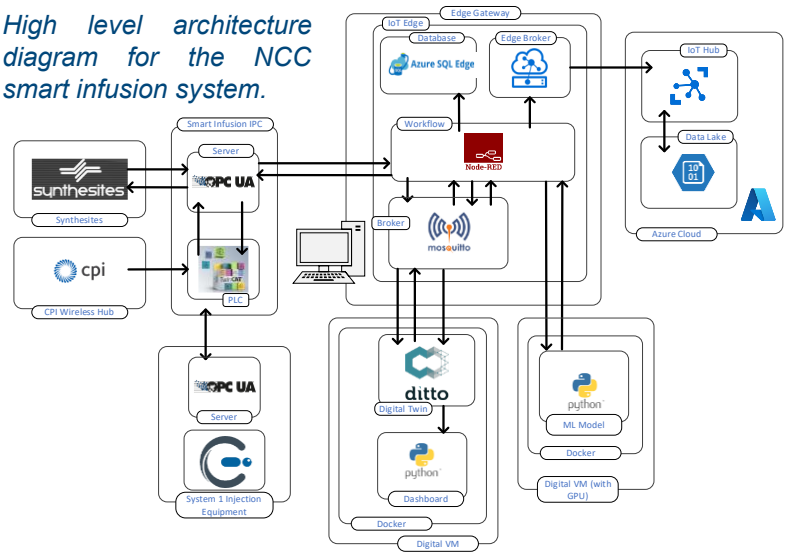
Smart infusion system demonstration held at NCC during 30M project review meeting. The asymmetric design mimics some critical features of wind turbine blade structures.

The smart infusion system that has been developed enables deviations between the positions of two meeting flow fronts to be detected using a combination of novel contactless and wireless sensors developed by CPI (p. 2) and commercial, tool-mounted sensors from Synthesites (p. 4). Action is then taken to control resin inlet valves to avoid the formation of unimpregnated regions (*i.e.* dry spots) that would otherwise form as a result of these deviations, using an machine learning-based control model developed by researchers at Polytechnic University of Valencia (UPV) and Technical University of Denmark (DTU).

These technologies are integrated with NCC's IoT platform to form an adaptive manufacturing system capable of taking corrective action within seconds of a resin flow deviation being detected. The high-level architecture diagram shown below outlines the digital infrastructure that has been developed and deployed by NCC to enable the transfer and management of data required to achieve this level of performance.

This NCC "Large Scale Tool" smart infusion system serves as a proof-of-concept demonstrator for TURBO, ahead of the final system demonstration to be conducted by Siemens Gamesa Renewable Energy (SGRE) later in the project. This factory-based demonstration, utilising a 16 m long section of a full blade mould, will reuse many elements of this architecture, with other elements reconfigured to enable cross-site data transfer.

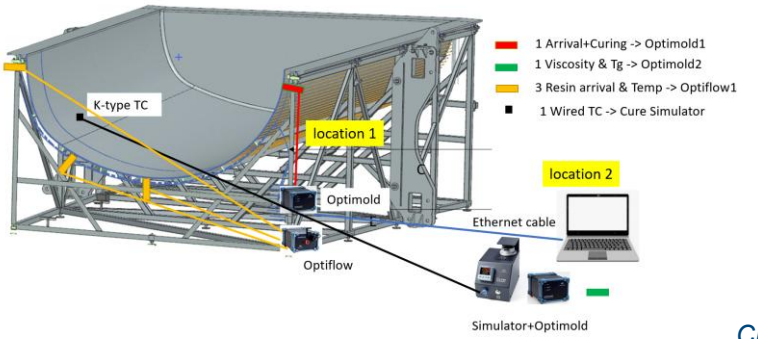
High level architecture diagram for the NCC smart infusion system.



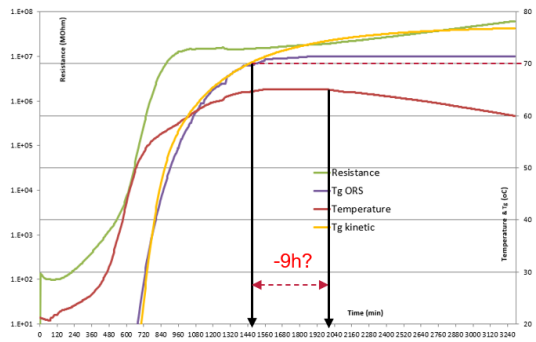
For more info please contact Dan.Griffin@nccuk.com

Synthesites sensors for TURBO demo: delivered!

Cycle time and manufacturing cost reduction are the main drivers in the production of wind turbine blades today. A novel approach is the use of intelligent process monitoring to optimise the infusion, curing and bonding by measuring the real process online. This can reduce energy and increase productivity by 30 % while ensuring product quality. In this framework, durable non-intrusive wireless sensors and external wired sensors have been developed within the TURBO project for the sensing of resin arrival, viscosity as well as curing.

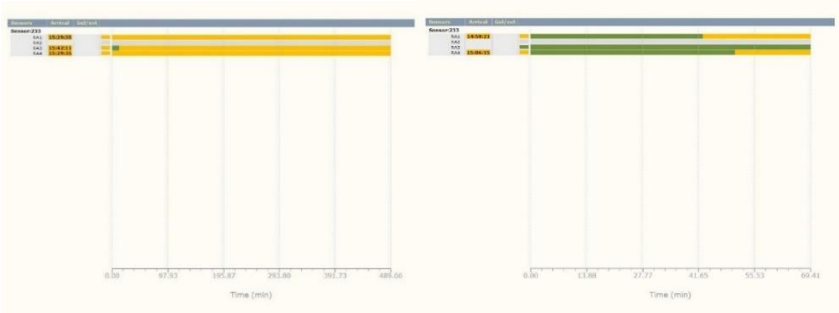


Lay-out of the wired sensors and monitoring units at the baseline trial of the WTB section.



Curing of a recorded thermal cycle from production: Resistance and temperature recordings with the two Tg estimations with kinetic model and online Tg.

In situ measurements of the resin electrical resistivity and temperature can provide online estimates of the viscosity during infusion and the dynamic Tg during curing. Furthermore, a new concept for improving the usability in everyday production and connection with the mould PLC has been launched successfully. TURBO includes an on-going demo with SGRE to apply this new technology to aspects of the manufacture of one of the most advanced blades in the market.



Resin arrival information during the baseline trial.

For more info please contact Nikos Pantelelis:
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TURBO final workshop: THU 04-Sep-2025

The final TURBO workshop will be held on THU 04-Sep-2025 at DTU Risø, Roskilde. The event will be held the day after the well-established conference:

45th Risø International Symposium on Materials Science: Advancement in composites through characterisation, modelling and digitalisation

Admission to the TURBO day is free, but places are limited so please register ASAP! Program and registration can be found on this link:

https://www.conferencemanager.dk/45thsymposium