“This specific project could potentially save industry millions of pounds.”

- CEO Richard Oldfield, National Composites Centre (NCC)
**Case Study**: National Composite Centre (NCC)
Application of Machine Learning to Autoclave Failure Prediction

**Problem:**
Autoclave processing is a key step in producing composite structures but comes with a large cost in terms of duration and energy consumption. When the process fails the structure being cured may have to be scrapped at a significant cost. The financial loss is further increased when the wasted energy and time is factored in.

**Business Case:**
Potential savings from using an early warning system for curing failure could be significant. For this particular project, with data spanning 5 years, 15 curing runs failed leading to part scrappage. Assuming that costs associated with each failed run could be up to £100k, the total potential savings would be in the region of £1.5m.

These estimates are for a single autoclave and for a relatively small production volume. Larger manufacturers with a larger number of autoclaves and higher production volumes would benefit from potential costs savings several orders of magnitude above this value.

**Solution:**

- **The Data**: We were provided with a relatively small dataset of autoclave runs that had been manually extracted from the machine software. An extra challenge was the imbalance of the dataset (number of failed runs was outnumbered by successful ones).

- **Domain Expertise**: The NCC has a wealth of knowledge and experience in autoclave curing. Consulting with these experts was crucial in generating our approach. One of the most important insights was the existence of a point of no return, beyond which the part being cured becomes unsalvageable; any prediction system would need to work on data available before this point to be useful.

- **Data Cleaning and Preparation**: Initial data processing included:
  - Redressing the imbalance: we used several resampling techniques for improving the balance between successful and failed runs.
  - Discounting certain sensor readings: invalid data due to dropped connections and other system errors were identified using the NCC’s domain expertise and removed.
**The Approach:** We split the analysis component into two phases. The overall system would then give two ratings for failure.

**Phase 1 Machine Learning: Before the process starts**
- Considering only data available before a cure starts (scheduling information and control profiles) we were able to create a classifier to correctly predict a failed or successful run about 90% of the time.
- Furthermore, from this model we could highlight certain features that contributed most to the prediction. Interestingly, amongst the top 5 features were two metrics relating to the scheduling of a run (day of the week and hour ended).

**Phase 2 Machine Learning: During the curing process**
- Using the time series data from the thermocouples and pressure sensors we trained a neural network capable of predicting a failure before the point of no return with up to 92% accuracy.
- Combining thermocouple data with the temperature control profile significantly improved the accuracy of the network.

**Further Work Ideas:**
- Consider other data sources: our analysis seems to support the suggestion that upstream factors are important to curing failure.
- Improve data capture: Data for this project was manually acquired. Developing a more connected and automated method would significantly increase the volume of data available and improve the robustness of the prediction models.

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![Composite Manufacturing Workflow](image.png)

**Results displayed in MAIO using the Dashboard Application**
Our vision as the world leading authority on composites is a commitment to innovation through bringing together the best minds and best technologies to solve the world’s most complex engineering challenges. Through our partnership with Smartia, who provide scalable AI solutions to industry, we are demonstrating the huge value that AI and Internet of Things (IOT) technologies could unlock for the UK industry.

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