5G-encode

In Factory Asset Tracking

4G Baseline

IN-FACTORY ASSET TRACKING 4G BASELINE

Industry Challenge

In any manufacturing facility there is a high likelihood that there will be time wasted trying to locate resources and equipment. Time wasted can lead to loss of productivity or reduction in profits, which especially in this current climate, is an avenue that businesses are trying to avoid. Asset tracking in any form can be an invaluable tool to help businesses operate safely & effectively and maintain better margins while ensuring the highest standards.

A proposition for a wireless asset tracking solution was made, that included the ability to track assets including materials and tools around a production facility, while monitoring time sensitive properties of the material from manufacture through to use in production. Essentially creating a digital passport of a manufactured component containing fully traceable material and tooling data.

A use case was identified that is based around an automated fibre placement (AFP) manufacturing workflow, autoclave cure and both non-destructive testing (NDT) and metrology techniques, in line with the Preform - Cure - Verify composite manufacturing cycle. AFP was chosen for the simple reason that this is relevant to high value manufacturing across a range of sectors including Aerospace and Defence, Automotive and Energy. The process itself involves using a robot to place pre-impregnated fibres (pre-preg: carbon fibre and a resin matrix) in specific locations to lay up a composite component.

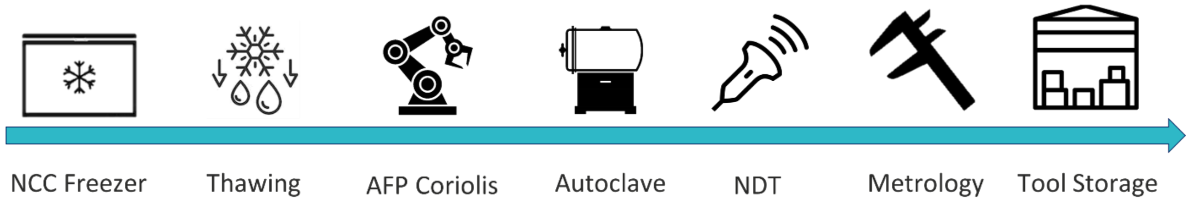

Figure 1 Factory movement flow (RFID stations)

Pre-preg material must be kept frozen prior to use to ensure that the resin system does not begin to cure prematurely, resulting in a need to track what is called the "out-life" of the material (time out of the freezer). If the material is left out of the freezer for too long, then the resin will begin to cure, and the material will have reduced mechanical properties which can lead to difficulty in manufacturing and quality issues.

Approach and Innovation

A network architecture was designed and implemented in a factory setting within the National Composites Centre (NCC), that utilises both 4G and RFID technology, to investigate and demonstrate the effectivity of these systems for asset tracking in composite manufacturing.

An initial solution was developed that used a private 4G network within the NCC factory to act as a baseline, and identify the limitations of a 4G cellular solution with the aim of mitigating and improving these by upgrading to a 5G solution in the second half of 2021. Having the RFID reader hardware wirelessly connected to the network eliminates the need for long cable pulls and bulky cable bundles which can be beneficial in factories that are already very busy with IT infrastructure.

Six 4G small cells operating on a 5MHz bandwidth were placed around the factory to provide coverage to this use case and other use cases within the 5G-ENCODE project. RFID gateways were installed in 7 locations around the NCC factory that would follow the flow of material, component pre-forms, manufactured parts and tooling around the workshop so that the zonal location of each asset could be identified by simply looking at a piece of software, in this case the Plataine TPO asset tracking solution. The zones used can be seen in Figure 1 with an example of an RFID gate shown in Figure 4. Five of the stations were connected to the 4G network while the remaining two, (Autoclave & Tool Storage), utilised a wired (POE) connection due to concerns over the 4G signal strength in these areas.

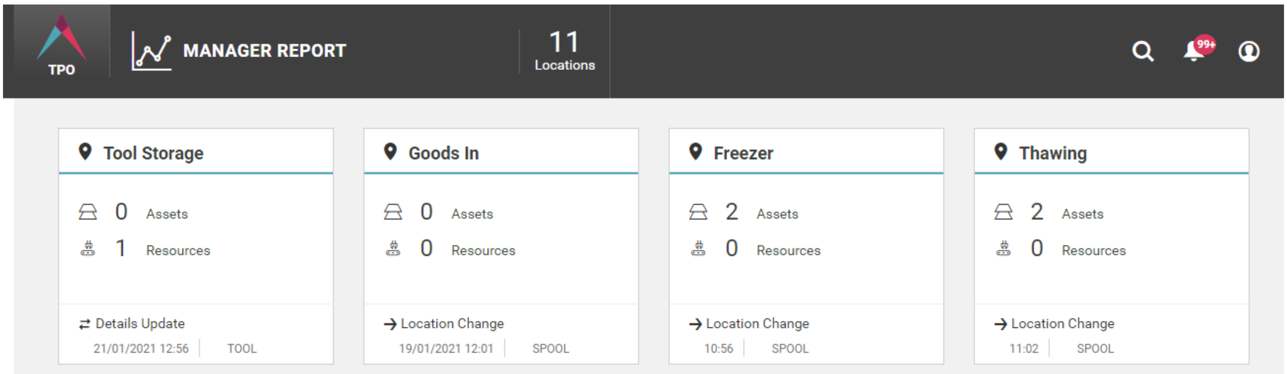

Figure 2 Plataine TPO UI

A portion of the TPO user interface that contains every station on the network is shown in Figure 2. Expanding each station will show information on the assets (material spools & preforms) and resources (tools) in that area. By clicking into each asset, information on utilisation and life of assets can also be viewed, with Figure 3 showing an example of a spool of material. Possessing a tool that can track not only the location, but also accurately track the exposure time of temperature sensitive material, will aid composite manufacturing facilities in driving quality up and material overspend down.

Location:	In Transit	Lot:	JK1901	Expiration Date:	01/12/2021
Sub Location:		Material:	5G Encode (MMR 12641.1)	ETL Bond:	423:59 Hours
Tag:	20001099D59D0A19	Weight:	2200 g	ETL Cure:	92:10 Hours
Created At:	19/01/2021	Project:	RunThrough JK	Max Exposure Bond:	600:00 Hours
Created By:	Joel Kelly	Inspection Status:	Unrestricted	Max Exposure Cure:	N/A
Manufacturer:	Solvay			Max Storage Temp.:	-18 °C
Date Of Manufacture:	01/12/2020			Defrosting Status:	Defrosted

Figure 3 Example Material Spool Information

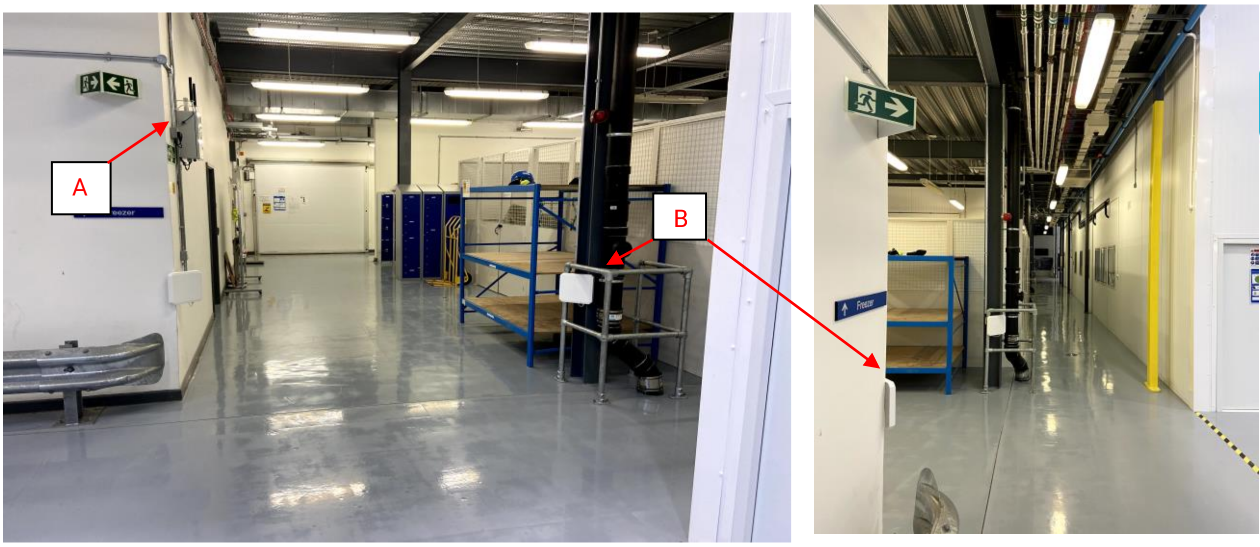

Figure 4 Example RFID station - Acclimatisation rack (Thawing)

From Figure 4, the box labelled with [A] contains a Zebra FX7500 RFID reader, a Siemens Scalance M876-4 4G router and two Siemens SINAUT ANT-794-4MR antennas to pick up the 4G signal. The two white panels labelled as [B] in Figure 4 are the Laird wide band circular polarity RFID antennas used for the majority of the RFID sensing in this use case.

The RFID antennas were connected directly to the RFID reader via co-axial cable, which is connected to the 4G router via a RJ45 (ethernet) cable. The 4G router sends and receives data over the private 4G network within the factory and communicates directly with a dedicated server for this use case. All assets that have a tag associated can be tracked between zones, with this being visualised on an IOT asset tracking solution developed by Plataine. This solution allows for the data sent over the 4G network to be viewed and managed on edge devices from anywhere within the workshop.

Outcome and Results

Tests were carried out within the NCC factory to verify that each RFID station was connected to the 5G-ENCODE network either via 4G or POE. At the time of writing, the Tool Storage station is not online as a further switch is required to connect it to the 5G-ENCODE network, and therefore will not be included in this schedule of testing. Each station was pinged 50 times and the packet loss and latency were measured with the results shown in
Table **1**.

Station	Packet Loss (%)	Min Ping (ms)	Max Ping (ms)	Average Ping (ms)	4G Signal (dBm)
Freezer	0	22	470	81	-62
Thawing	0	21	105	79	-70
AFP Coriolis	8	22	541	84	-59
Autoclave	0	0	0	0	N/A
NDT	0	25	113	66	-62
Metrology	0	22	217	73	-49

Table 1 RFID Station Ping & Latency

The average ping was found to be less than 85ms across all stations which appears adequate, however, there are some larger maximum values in the Freezer and AFP Coriolis which could lead to problems with latency and packet loss. The 4G signal strength was measured in all areas, with the Freezer and AFP stations having two of the strongest results (Table 1). Only the AFP station had any observed packet loss and it was determined that the likely cause of this was not to do with the strength of the 4G signal but rather interference in the area from other electrical power sources.

The observed packet loss appeared to cause some issues with the Plataine asset management system and the consistency of connection with the reader in question. The software is configured to notify the user if any packet loss is observed with a message on the UI, and the reader shuts down and does not come back online for approximately 60 seconds. This is carried out to ensure the system is as reliable as possible and the user is fully aware of any outages of the RFID tracking system, however, when using a 4G cellular connection rather than a wired POE connection the likelihood of encountering some level of packet loss is high.

The reader will still pick up the asset in the cell if initially missed as the RFID signal can read from up to 10m away, however, there are planned steps to be taken to eliminate the packet loss at this station.

A total of 4 assets were tracked throughout the facility, including one “tool”, (high temperature RFID tag simulating a tool). Assets were passed through the RFID gates in each station a minimum of three times and checked for accuracy in the Plataine TPO system. Every station tested bar AFP Coriolis (delayed detection), worked as expected - the asset was picked up by the correct antennas and the location updated in the UI with a correct timestamp associated (Figure 5).

TIME	TYPE	DETAILS	LOCATION	REPORTED BY
28/01/2021 09:33	→ Location Change	New Location In Transit	AC	system
28/01/2021 09:33	→ Location Change	New Location AC	In Transit	system
28/01/2021 09:32	→ Location Change	New Location In Transit	AC	system
28/01/2021 09:32	→ Location Change	New Location AC	In Transit	system
28/01/2021 09:26	→ Location Change	New Location In Transit	AC	system
28/01/2021 09:26	→ Location Change	New Location AC	AFP	system

Figure 5 Example location tacking test (Autoclave)

Taking the consistency of reader connection in AFP Coriolis into consideration, the asset tracking solution was still shown to be effective in tracking not only the location of the tagged assets, but also the assets out life as well, a crucial aspect of any solution involving frozen materials.

Conclusion and Industry Impact

An asset tracking and monitoring solution such as the one tested could potentially have significant financial and quality improvement benefits for any manufacturing facility, using, or intending to use large numbers of assets, or assets that require time sensitive properties to be monitored throughout their life.

A key benefit is a more accurate approximation of asset utilisation, both in material consumption and tooling usage. The Plataine TPO system allows for tracking of a materials weight; as material is consumed it's weight can be updated and this, along with density can be used to determine the quantity remaining. This can lead to a better understanding of a facilities stock management, while tooling usage and maintenance monitoring can lead to an improvement in quality by driving down the number of non-conformances resulting from improperly maintained tools.

In the short term there are some follow-on activities that are to be carried out to improve the reliability of this 4G baseline, including the addition of another 4G router in the AFP cell to reduce the likelihood of the reader disconnecting from the system, and research into the cause of packet loss and tolerance within the software being utilised.

The baseline has been shown to be effective in communicating RFID data wirelessly around a factory setting, however, it has also highlighted some limitations of a 4G system including sensitivity to interference and latency. While the 4G system could provide solutions for a small factory and a limited amount of assets, the ability to wirelessly track location and life of a large number of assets in a production composite manufacturing facility, while running other use cases in parallel, will require a network solution with higher bandwidth and lower latencies. As tracking systems become more business critical, increased reliability and data transfer speeds are imperative, meaning that a 5G solution could provide a more robust solution for industry. This hypothesis will be tested in phase 2.

About 5G-ENCODE

The 5G-ENCODE Project is a £9Million collaborative project aiming to develop clear business cases and value propositions for 5G applications in the manufacturing industry. The project is partially funded by the Department for Digital, Culture, Media and Sport (DCMS), of the UK government as part of their 5G Testbeds and Trials programme. The project is one of the UK Government's biggest investment in 5G manufacturing to date.

The key objective of the 5G-ENCODE project is to demonstrate the value of 5G on industrial use cases within the composites manufacturing industry. It will also validate the premise that using private 5G networks in conjunction with new business models can deliver better efficiency, productivity, and a range of new services and opportunities that would help the UK lead the development of advanced manufacturing applications.

The project will play a key role in ensuring that the UK industry make the most of the 5G technology and ultimately remains a global leader in the development of complex composites structures using robust digital engineering capabilities.

The project will showcase how 5G features such as neutral hosting and network slicing can be applied to transform a private 5G network into a dynamically reconfigurable network able to support a wide range of applications (URLL/eMBB/MMTC) including industrial applications of Augmented Reality/Virtual Reality (AR/VR), asset tracking of time sensitive materials and automated industrial control though IoT monitoring and big data analytics. Such a dynamic network would enable new business models and creation of bespoke virtual networks tailored to specific applications or use cases.

The state-of-the-art testbed will be deployed across three sites centred around the National Composites Centre (NCC) in the South West of England. In support of the West of England Combined Authority (WECA) industrial strategy, the NCC plans to keep the testbed as an open access facility for the experimentation and development of new products and services for the composites industry after the completion of the 5G-ENCODE project. The location and nature of NCC's business would ensure the creation of an industrial 5G ecosystem involving multiple industry sectors and SMEs.

The project consortium brings together a Tier 1 operator (Telefonica), leading industrial players (e.g. Siemens, Toshiba, Solvay), disruptive technology SMEs covering all aspects of network design, deployment and applications (Zeetta Networks, Mativision, Plataine), a world-leading 5G network research group (High Performance Networks Group in the University of Bristol) and the NCC representing the high value manufacturing industry.

For more information about 5G-ENCOCE, visit; https://www.5g-encode.com/ or email info@5g-encode.com