Intelligent Maintenance System for Port Infrastructure

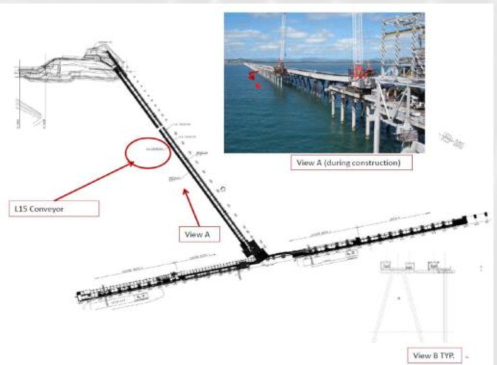
RMIT UNIVERSITY

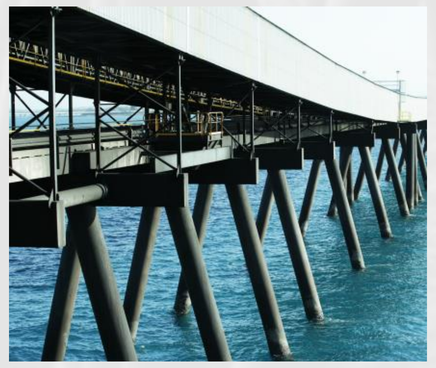
By: Antony King , Callum Johnson , Elisha Tilan & Vincent Lam

BETA INTERNATIONAL ASSOCIATES

INTRODUCTION

The Dalrymple Bay Coal Terminal (DBCT) "Conveyor L15" has been in operation since 1983. Overtime it has been subjected to a variety of harsh environmental and mechanical conditions and if not thoroughly monitored, the structure has the potential to fail in the near future. Our project focuses on the investigation of an intelligent maintenance system for the port infrastructure, Darlymple Bay Coal Terminal (DBCT) Conveyor L15. Our team has researched the development a digital twin to transform and optimise how this asset is maintained overtime. The research outlines the process of developing of a digital twin for predictive maintenance, and asset management optimisation.





RESEARCH QUESTIONS

- Can we identify an efficient method for assessing structural performance to improve decision-making processes in the management of the asset?
- Can a digital twin of a port infrastructure be made?
- What wireless sensors are required to complete the digital twin?
- What software(s) are required to perform the active structural analysis and how are they going to communicate with the sensors on the structure?

PROJECT METHODOLOGY

Step 1
Modelling of Structure and Analysis of Failure Modes

Afinite element model for the L15 Conveyor was built for analysis so that the failure modes could be determined

Step 2
Identify Wireless Sensors for Use

With an understanding of the structural geometries, geographical location, failure modes, and criticalities; a baseline for understanding the types of physical sensors required is formed

Step 3
Design Cyber Physical Model and Integrations

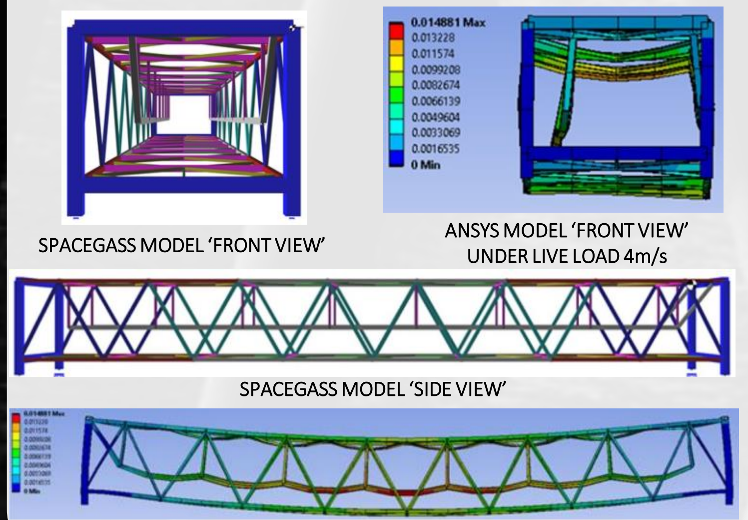
Integration between the physical systems (truss structure, hardware, people) and the cyber systems (internet, communications, software, analytics) has been designes

Step 4 (Future Stage)
Construction and Testing of the Digital Twin

Construct and check the digital twin model, ensuring that the entire cyber physical model is working correctly and that the visual outputs are reflective of the physical inputs to the sensors. All test cases will require documentation and acceptance will need to be measured against expected or precalculated outcomes

3D MODEL

Models of the conveyor in both SPACEGASS and ANSYS were analysed by the team, the purpose of using ANSYS was to enable the creation of a future digital twin using the ANSYS Twin Builder software. These analyses were what enabled the team to determine the wireless sensor locations



SPACEGASS MODEL 'FRONT VIEW'

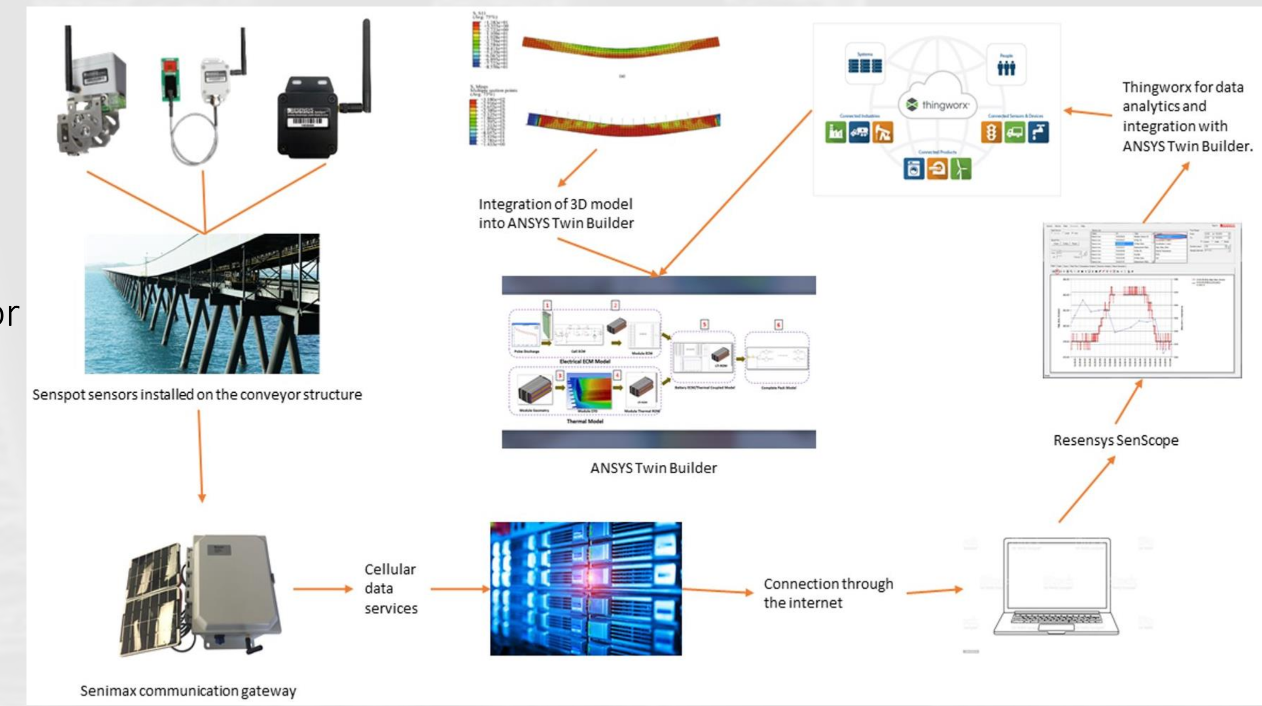
ANSYS MODEL 'FRONT VIEW' UNDER LIVE LOAD 4m/s

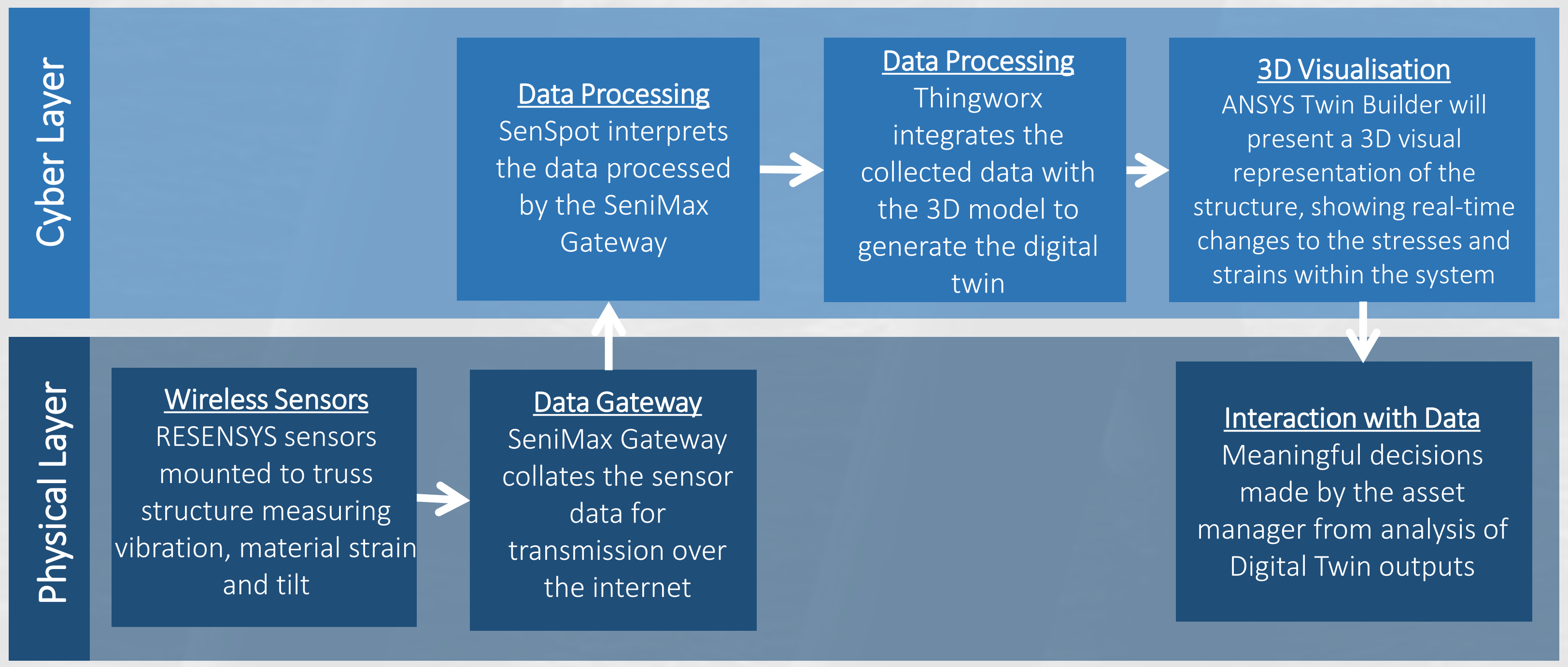
SPACEGASS MODEL 'SIDE VIEW'

ANSYS MODEL 'SIDE VIEW' UNDER LIVE LOAD 4m/s

SYSTEM INTEGRATION FOR DIGITAL TWIN DEVELOPMENT

It has been determined that developing a digital twin involves an ANSYS 3D model of the conveyor structure; RESENSYS Senscope software to read the data from the wireless sensors; and an Industrial Internet of Things (IIoT) platform software such as ThingWorx to perform analytics of the collected data and ensure effective communication and integration into the the 3D model. These software would all be integrated in ANSYS Twin Builder where the digital twin of the conveyor structure can be creates. The cyber-physical model below displays how the various systems mentioned will integrate:



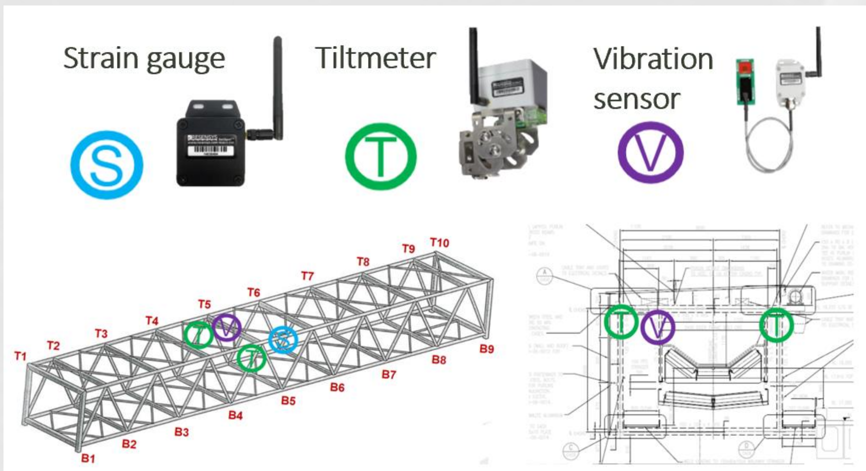


WIRELESS SENSORS

RESENSYS SenSpot wireless sensors have been chosen to provide long term health monitoring of Conveyor L-15 as they are easy-to-install and are designed to be maintenance free for a decade. The three types of sensors used are:

- **Strain gauge** - detects sudden strain changes that can affect the structural members
- **Tiltmeter** - monitors deflection, caused by the environment or loading
- **Vibration sensor** - detects significant shifts in critical structural elements

After comprehensive analysis of the 3D models, the number and location of sensors were decided as follows: 2 tiltmeters (one located on the centre of the conveyor one at the end), 1 strain sensor and 1 vibration sensor, both located in the middle of the outer structure.



BENEFITS OF DIGITAL TWINS

- **Enhanced Predictive Maintenance**

Digital twins enable the use of sensors to monitor failure trends throughout the asset's operational phase. Using this recorded data an estimate of the structural state of the asset can be determined, additionally this information can be used to forecast asset performance in the future

- **Maximised Asset Value**

The adoption of a digital twin for the long-term management of the asset has the potential to extend the lifespan of the structure by optimising the maintenance and operations with the aid of the information provided by the digital twin

- **Digital visualisation of asset conditions**

Digital twins can simulate operations and expected conditional changes to the structure by comparing previously captured data against recent data, outputting the results to a digital model

- **Reduced operational expenditure**

The traditional method of onsite structural inspection can be partially circumvented or supplemented by the use of a digital twin

CONCLUSION

This project explores the development and utilisation of a digital twin to assist with intelligent maintenance decisions of the DBCT conveyor structure in Queensland. After comprehensive research, the following points have been concluded:

- RESENSYS Senspot tilt meters, strain gauge, and vibration sensors are the ideal wireless sensors to be used for DBCT.
- Industrial Internet of Things (IIoT) platform software such as ThingWorx can be used to integrate the wireless sensors, data collector and 3D model.
- ANSYS Twin Builder is the optimal software to buld the digital twin of DBCT.
- Due to a variety of system limitations and installation delays caused by the pandemic, the 3D model and sensors could not be integrated into ANSYS Twin Builder in time.
- The main objective of this report which is to explore intelligent maintenance systems of port infrastructure has been achieved through the development of a framework for digital twins.