

Supporting Integrity Management with a CP Digital Twin

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ABSTRACT

Integrating inspection data with a CP simulation model enables the creation of a “digital twin” of the structure which can be used to predict the present and future protection provided to all parts of the structure.

The design of marine structures is typically based on design guidelines that specify the protection potentials on the structure to be achieved by the CP system and the rate at which elements of the protection system such as coatings are to be assumed to degrade over the life of the structure. As part of the design study, the performance of the CP system can be evaluated and optimised using a CP simulation model which predicts year by year the protection potentials, the depletion of the anodes, and in the case of ICCP the current to be required by the system.

While this type of simulation provides valuable information to the design engineer by confirming that the required protection will be achieved. In reality, the actual performance of the CP system will be often different as coatings for example often degrade at different rates to that described in the design rules, environmental conditions may vary, the “as-built” structure may be different and changes and retrofits are made over time. Integrating the CP data collected during the routine inspection surveys with a CP simulation model enables a “digital twin” of the structure to be created by adjusting the model to match the inspection data. In this way, the simulation digital twin represents the behaviour of the structure and the CP system at the time the inspection survey was performed. This then provides the ability to predict the present and future protection for all parts of the structure.

By repeating the process with each new inspection report the engineer can easily monitor the differences between the model predictions and survey data systematically to assess current “health” of the structure, identify anomalies, predict and plan for future risks, optimise the inspection strategy and provide early identification of problems which will require actions.

In this paper, a case study is presented where the approach is used as part of the integrity management of an FPSO. The paper will describe the system developed and applications of both the 3D corrosion data visualisation and the simulation-based digital twin.

Key words: Corrosion, Corrosion Data Management, Digital Twin, Cathodic Protection

INTRODUCTION

The aim of any digital transformation of integrity management and in particular corrosion control is the improvement of communication efficiency, planning efficiency and maintenance efficiency. Key issues are predictive maintenance and clarity of the information available so

engineers can make informed decisions. Therefore it is not just a question of collecting more information but also the way that information is used and shared with the decision makers.

Historically integrity management systems do not fully meet the needs of the engineer responsible for corrosion as they do not provide convenient access to the data engineers need to make fast and informed decisions. There is also often no easy way to visualise the trends in the data, or easily access the relevant video and photographic data also recorded during the survey.

Data from surveys are normally contained in reports and EXCEL spreadsheets often with different measurement locations in the report and inconsistent naming of the locations. These problems lead to poor information management and a significant hidden cost, accounting for up to a fifth of operational budgets, while a single unscheduled downtime can cost millions of dollars per day.

The recent development of advanced computational models^{1, 2} capable of predicting the level of protection provided by cathodic protection systems and how this changes over the life of the asset has significantly improved the information available to the corrosion/integrity engineer. Typically this modelling approach has been used as part of the design process to optimize the protection provided to the structure. However in recent years the benefits of integrating modelling into the management long term integrity has been understood and has enabled unplanned downtime and failures to be reduced.³

In this paper an improved digital corrosion data management system is introduced which is combined with a computational model which acts as a digital twin of the asset. The combined technology enables engineers to manage and visualise CP (Cathodic Protection) survey data and provide any member of the team with access to all the relevant information through a 3D visual interface. The digital twin provides a clearer understanding of the protection provided to the asset. By integrating the corrosion data with a simulation model (BEASY^{†1}) a “digital twin” of the structure can be created to make predictions of the present and future protection of all parts of the structure. For example the engineer can easily use the software to systematically monitor the differences between the model predictions and survey data to identify anomalies and to provide early identification of problems which will require action.

Corrosion Data Management

With the exception of some specialist applications corrosion data management systems are at best a small part of an overall integrity management system and do not meet the needs of the engineer responsible for corrosion.

- CP survey data is normally only available in pdf documents or at best EXCEL spreadsheets
- Results of CP modelling studies are provided to customers as pdf reports and presentations whereas an interactive visualisation tool showing both the survey and the digital twin simulation data would provide a clearer understanding

[†] Tradename

- Trends in the data are difficult to identify even when surveys are conducted at regular intervals as the data are often not measured consistently and are not stored in a suitable form
- It is frequently difficult to integrate model and data from individual surveys due to the small number of data points available

As the modelling and survey data are currently not easily integrated it is often difficult to fully understand the significance of the data. However through a digital transformation of corrosion data management using 3D Visualisation, it is possible to predict and identify problems and plan remedies thus maintaining a consistent level of maintenance effort over the life of the asset. The potential benefits are:

- Enhanced and optimised CP surveys by using modelling to interpret the information, identify anomalies earlier and predict future trends
- Corrosion degradation of structures is a relatively slow process and hence high risk problems do not show up in the short term. This corrosion worsens over time and, unfortunately, it's often only visible at an advanced stage of damage. Use of integrated modelling and survey data can predict future risks so that remedies can be properly planned and costly unplanned repairs avoided
- Model predictions correlated with survey data provide the information to proactively balance the maintenance effort over the life of the asset. The aim being to “Plan and pay now rather than pay a lot more later”

The business benefits to the asset owner are:

- Development of an effective proactive corrosion management strategy which can enhance production and lead to increased profits.
- Reduction of the risk of costs that can be incurred because of ineffective planning
- Improvement of design practices to prevent corrosion
- Development of an optimum inspection strategy based on budgetary restrictions and the “health” of the structure

Therefore the required capabilities of the Corrosion Data Management System are:

- Manage and visualise data obtained from CP surveys and ICCP (Impressed Current Cathodic Protection) systems
- Visualise trends and extrapolate data to predict the future condition of the structure
- Visualise model predictions and systematically compare survey and model predictions
- Integrate video and photographic data obtained from surveys
- Predict the data required by the engineer on the location of present and future anomalies and the risk to the protection of the structure

3D Visualisation Of Corrosion Data

In this application the data obtained from a CP survey conducted on an FPSO has been incorporated in the 3D Corrosion Data management software.

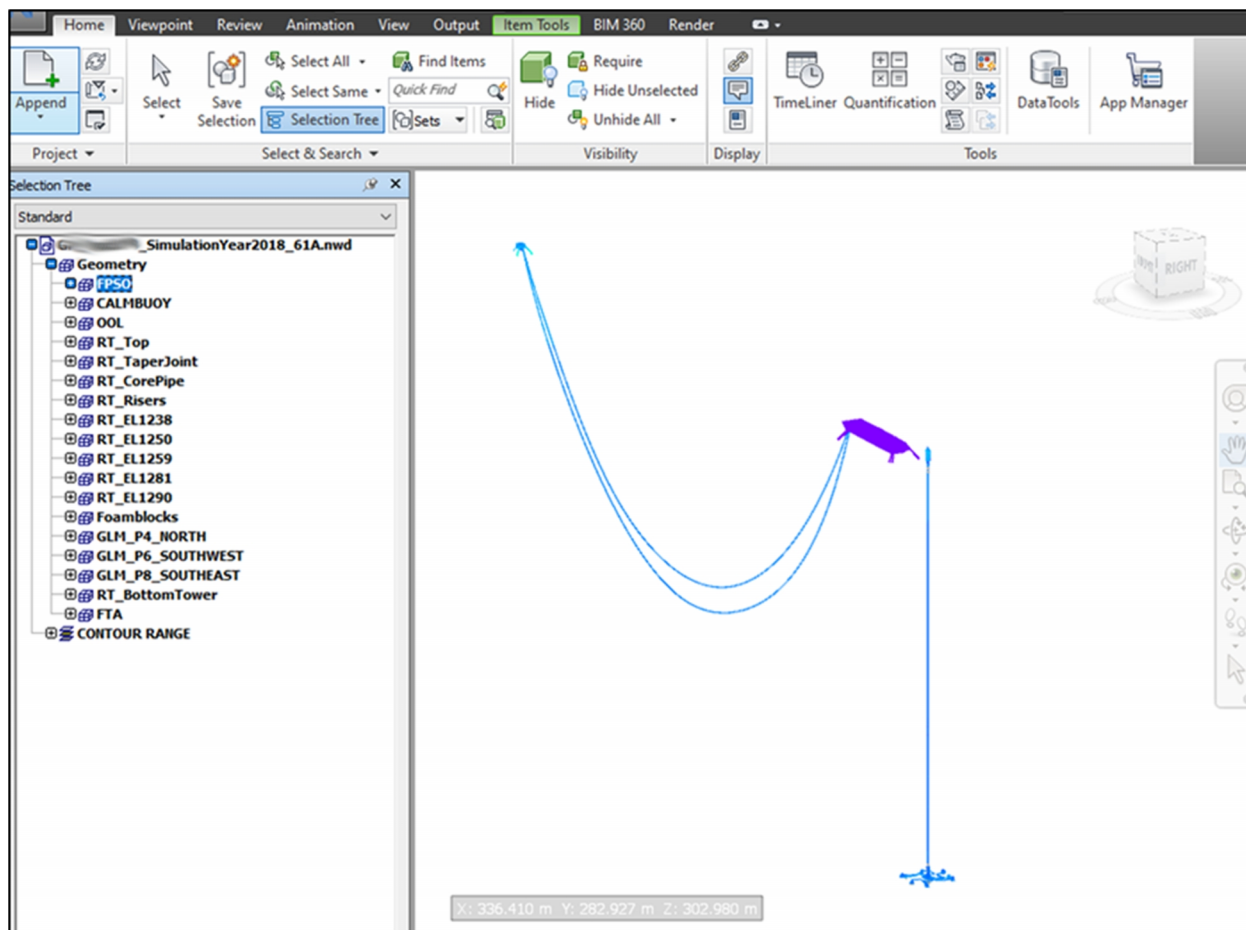


Figure 1 3D Visualisation of the Asset

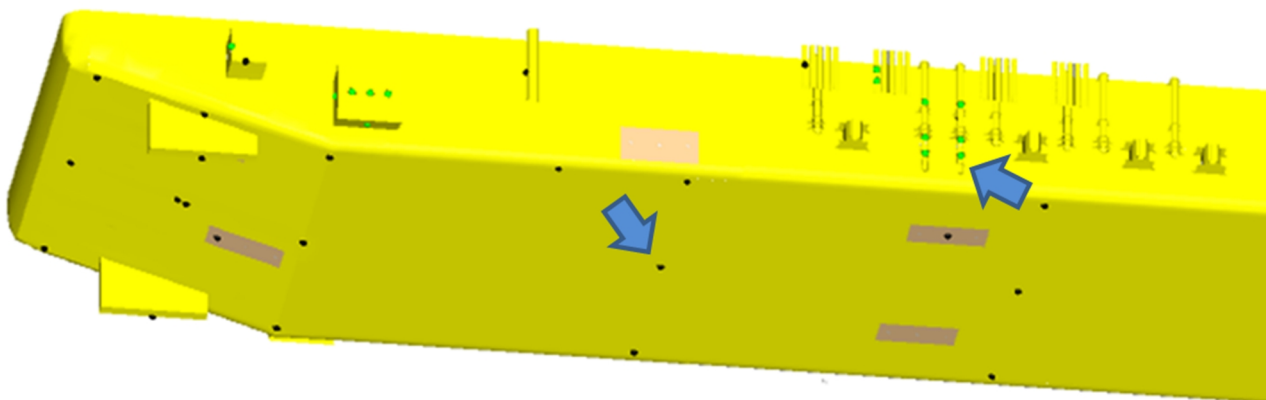


Figure 2 View of FPSO showing the location of the survey data points shown as spherical points coloured to indicate the value of the protection potential

In Figure 2 the survey points can be seen on the model. The value of the measured potential can be seen simply by moving the cursor over a survey point and the location and severity of anomalous data easily identified (Figure 3). Alternatively complete information about the survey location can be displayed in a pop up panel as seen in Figure 4.

Similar data can be displayed on sacrificial and ICCP anodes including for example the consumption rate and can be compared with simulation model predictions.