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Benefits of data management and data trending in the UK Continental Shelf oil and gas industry

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To improve the management of risks associated with ageing and life extension (ALE) of the oil and gas infrastructure on the UK Continental Shelf, HSE launched the 'Key Programme 4' (KP4) of targeted inspections in 2010. Two key findings were that industry could make better use of data trending and had not identified leading key performance indicators (KPIs) suitable to support ALE decision making. Data trending is the tracking of changing trends through analysis of data on equipment, systems and people performance. KPIs that indicate the current condition of equipment and systems are lagging indicators with respect to ALE, which is focussed on their future condition. The trending of lagging KPIs enables the future condition of assets to be estimated, thus producing leading KPIs that can directly support ALE decision making.

This report describes research to identify the barriers to the take-up of data trending to support ALE decision making, in order to identify issues that industry could address. Findings include issues surrounding data collection, management and use of data. Additionally, potential problems with analysis methods are discussed, suggesting that while basic trending can be done by engineers, there are pitfalls associated with trending that need to be understood.

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Benefits of data management and data trending in the UK Continental Shelf oil and gas industry

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EXECUTIVE SUMMARY

The Health and Safety Executive (HSE) instigated their Key Programme 4 (KP4) to look into the problem of Ageing and Life Extension (ALE) of the UKCS (UK Continental Shelf) oil and gas infrastructure in hostile environments such as the North Sea. Two key findings of the KP4 programme were that:

- better use could be made of data trending to support ALE decision making;
- the UKCS Oil & Gas sector had not identified leading KPIs (Key Performance Indicators) suitable to support ALE decision making.

As part of the KP4 Programme, HSE scientists undertook work to look at the apparent lack of data trending performed in the UKCS oil and gas industry, in particular, trending used to support ALE. Data trending issues were discussed with HSE offshore specialist inspectors who undertook the KP4 work, oil and gas engineers, and oil and gas specialist contractors who are involved in data trending.

HSE identified issues associated with the collection, storage and management of data that could impede the implementation of data trending in the UKCS oil and gas industry. The available data covered a range of factors such as, equipment performance, maintenance and production factors.

Industry uses KPIs as a metric for the measurement of key factors such as maintenance performance and equipment reliability. KPIs that indicate the current condition of equipment and systems can be said to be lagging indicators with respect to ALE. ALE is focused on the future condition of equipment and systems, and the trending of lagging KPIs enables the future condition of the asset to be estimated. Therefore, trending can be said to convert lagging KPIs into leading KPIs and it is these leading KPIs that can directly support ALE decision making.

This report presents and discusses key findings of the HSE work, such as issues surrounding data collection, management and use of data, and discusses how such factors can affect the uptake of data trending. This paper also suggests a number of KPIs that can be trended to support ALE, and presents three examples of trending of KPIs.

This paper also discusses problems associated with data trending. Basic trending of performance measures such as equipment breakdown frequency and maintenance rework can be trended by engineers and managers. However, there are pitfalls associated with trending that need to be understood to avoid obtaining misleading results.

The UKCS oil and gas industry records much useful information regarding the performance of their equipment, systems and maintenance processes, which could be used to support ALE decision making.

CONTENTS

1 INTRODUCTION

In July 2010, HSE's Offshore Division (OSD), now Energy Division (ED), launched The Ageing and Life Extension Inspection Key Programme 4 (KP4). The programme aimed to improve the management of the consequences and risks associated with the ageing nature of the UK's offshore industry, especially given the growing demands to extend the life of offshore installations beyond their original design life.

KP4 involved raising the profile of offshore ageing and life extension (ALE) issues through a series of targeted inspections, both onshore and offshore using specialist templates, which aim to achieve improved management of ALE and to identify and promote current good practice.

Data management and trending were identified during the KP4 programme as an area where the industry could turn its stored data into knowledge that can be used to manage ALE and Asset Integrity Management (AIM) by improving short and long term planning/scheduling.

This report presents work undertaken by HSE to look at data trending performed in the UKCS oil and gas industry. HSE has identified areas where improvements could be made to encourage the take up of data trending to better support ALE decision making. The aim of this work was to gain a snapshot of the extent of data trending performed in the UKCS oil and gas industry, and to suggest benefits that data management and trending can bring to the industry.

The following issues are discussed in this report:

- KP4 inspection programme findings
- Benefits of data collection and trending
- Barriers to data trending
    - Data collection and storage
    - Data management and use
- Data trending software tool support
- Data trending examples
- Conclusions
- Way forward

1.1 BACKGROUND

As part of the trending work performed by HSE, discussions were undertaken with industry professionals, in UKCS oil and gas operating companies, with specialist support companies and more generally at industry workshop events.

Questions were asked about the use of data trending within companies both to support AIM, and in particular as a tool to support ALE decision-making. It was suggested that data trending was performed on a case-by-case basis where a need was identified for AIM, and that the amount of trending performed varied between companies and between different departments within each company. It was indicated that at that time almost no data trending was performed to support ALE decision making. On the basis of this information, questions were asked about the barriers to data trending and the issues discussed in this section of the report are representative of the most common issues raised.

1.1.1 Lack of data

Over the last ten years, some of the original major companies operating in the UKCS have divested assets to smaller companies. Anecdotal evidence suggests that little or no information associated with these assets regarding equipment, system and maintenance records were transferred to the new operator. Anecdotal evidence further suggests that many such new installation owners have a limited inventory of their equipment and systems; this often results in them having to build up this information over time from scratch as they apply their own corporate standards. Not all of the installation's equipment is recorded by the new company, leading to items of equipment that have no information associated with it.

1.1.1 System Availability

The increased pressure of maintaining and improving profitability in light of dwindling reserves has led to increased focus on short term problems in an attempt to maintain system availability. In addition to this, many companies do not adequately understand the process and availability requirements of their assets at a detailed enough level to be able to measure and assess performance. In some cases industry wide performance measures for equipment or systems do not exist, for example, there are no published criteria associated with corrosion and minimum allowable wall thicknesses for vessels and pipelines. Generally companies do not know in detail, what performance levels equipment should attain.

There have been a number of improvements as companies attempt to manage availability with electronic collection of general monitoring data becoming more widely performed. However, it is still not evident that this data, typically collected by control room operators and operations personnel, is being managed effectively.

1.2 DATA COLLECTION AND TRENDING BENEFITS

Data collection and trending has many benefits that can contribute to ALE decision making, asset integrity management and production management. Figure 1 below depicts a data management and trending approach, which could help to target resources consistently and give rise to improved production and safety.

All installations need to know what equipment and systems they have, what their condition is now, and they need to know how this condition is changing with time; this is often not the case across each installation. Figure 1 depicts a data management and trending life cycle that could help companies achieve this goal.

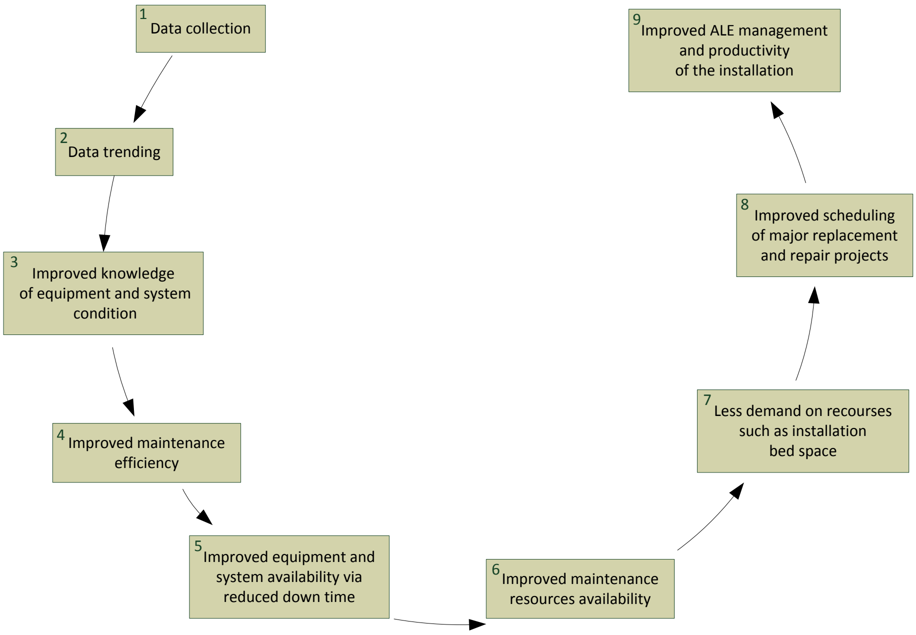

Figure 1. Benefits of data collection and trending

1. Collecting relevant data from multiple sources, all stored in a common repository that is readily accessible by those who need to use the data, is the first step to facilitating data analysis and trending.

2. Data trending is the analysis of equipment, systems and people performance, which can lead to a number of benefits.

3. Trending gives knowledge of past, present and future condition and/or performance of equipment, systems, maintenance capability and production. Trending can give advanced warning of when equipment and systems could fail. Trending can identify circumstances where further investigation is required to identify underlying ALE issues such as, creeping change, obsolescence, skills shortage in relation to each system or item of equipment.

4. This knowledge can lead to improved maintenance productivity through efficient, short, medium and long term planning of maintenance activities.

5. Efficient planned maintenance reduces unplanned equipment downtime due to unexpected failures.

6. Efficient use of resource, for example, scheduling of man hours and spare parts leads to improved equipment availability.

7. An example of efficient maintenance planning specific to ALE management at offshore installations is the increased availability of bed space at the installation, which can save the expensive use of floating hotels for major refit programmes.

8. Efficient maintenance can lead to improved scheduling for major replacement and/or upgrade projects.
9. Trending contributes to improved management of both ALE and AIM, and hence installation productivity and longevity

2 KP4 INSPECTION PROGRAMME

HSE's KP4 inspection programme considered a number of relevant aspects that affected ALE decision making in the UKCS oil and gas industry. Two key outcomes from the KP4 programme were that:

- There was insufficient use of data trending to support ALE decision making, and
- There was insufficient suitable Key Performance Indicators (KPIs) to support ALE decision making.

HSE was asked to look in more detail at these two outcomes and report on its findings. For this work information was obtained from two main sources, namely:

- HSE's KP4 inspection programme reports;
- Discussion with oil and gas professionals;
    - initial discussion with oil and gas operators,
    - oil and gas specialist contractors, and
    - discussions at HSE hosted post-KP4 workshops.

HSEs KP4 inspections were tasked with looking into a wide variety of aspects associated with ALE both onshore at company offices and at the offshore installations. When KP4 inspections were performed HSE specialist inspectors did not always have access to persons with the most relevant information to hand. This was due in part to operational reasons such as the duty rota systems employed, and engineers and technicians not being fully aware of ALE issues. This is possibly why the KP4 inspection reports contained insufficient information regarding data trending in general or about KPIs used for ALE decision making.

Where trending was stated as being performed, this was on an ad-hoc basis if a need arose. It was often not clear whether this trending was to support AIM or ALE decision making.

When noted in the KP4 inspection reports, the degree to which data trending was discussed varied for different topic areas within the same company. Topic areas most cited where some trending was performed were EC&I, and Fire and Explosion.

The KP4 inspection reports did not present information regarding software tool support for trending, although this was not specifically requested.

2.1 EXAMPLES OF DATA TRENDING FROM THE KP4 INSPECTION REPORTS

Engineers at one company said that they had problems with data in the Maximo system for existing and new equipment, resulting from the heavy capital expenditure for the next two years. This was because the data recording was not of sufficient quality to enable confident trending or prediction of SCE performance or compliance with the associated performance standards.

Another company had performance monitoring reports (PMR) for many SCE's (such as T30 times for gas detectors, deluge pressure at furthest nozzle, FWP flow rates etc.) recorded on

SAP. However, data retrieval for trending analysis was considered to be too difficult and hence was rarely performed. This company made little use of historic data to trend SCE performance.

Companies often record test results as “pass or fail”, as a result SCE historic data is of limited use in terms of what can be trended. It is important that Companies identify circumstances where they can look beyond the binary pass/fail criteria to get data that can be trended to predict future maintenance and replacement needs.

Figures 2 and 3 present a snap shot of the extent to which Fire and Explosion SCE performance monitoring and data trending was employed in the offshore oil and gas sector at the time of the KP4 inspection programme. It can be seen that Fire and Explosion SCE’s are not monitored, or data from them trended, by some companies.

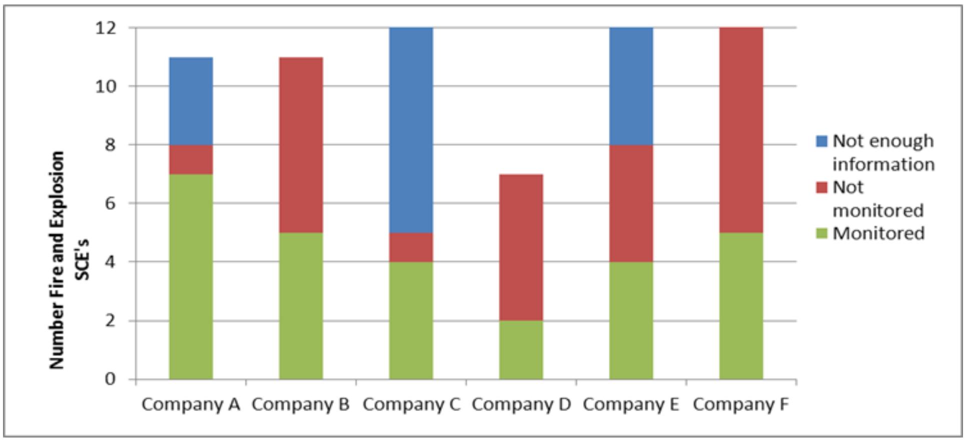

Figure 2. Examples of monitoring associated with SCEs from the Fire and Explosion inspections

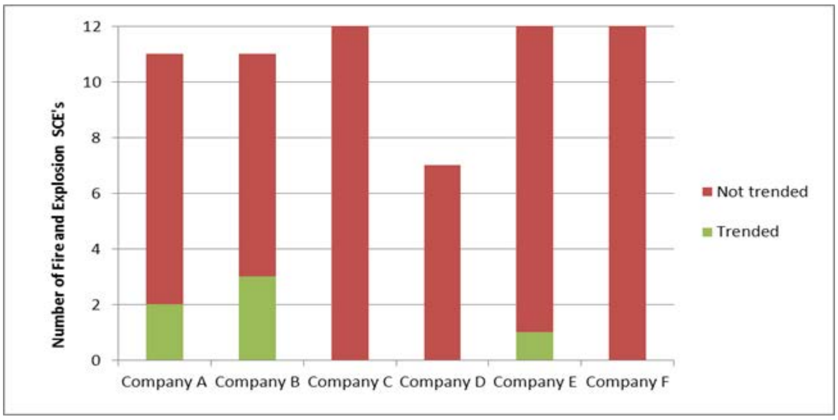

Figure 3. Examples of trending associated with SCEs from the Fire and Explosion inspections

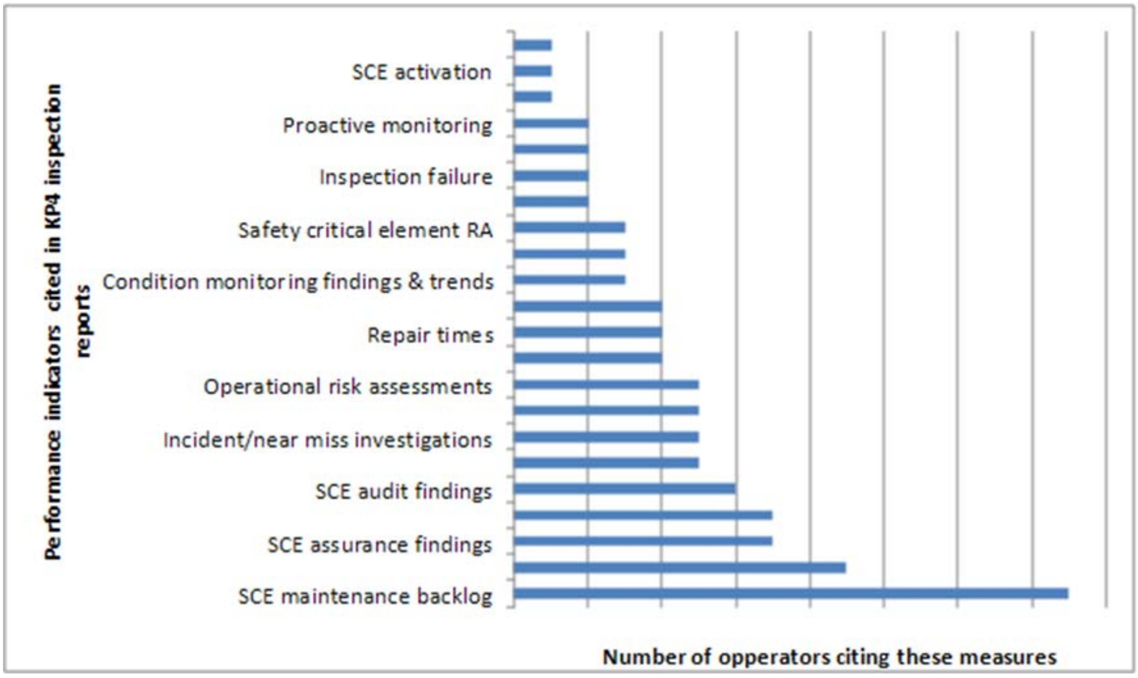

Figure 4. Performance indicators cited in KP4 inspection report

Figure 4 presents an indication of the use of performance indicators in the UKCS O&G industry, albeit based on incomplete information presented in HSE's KP4 inspection sheets. As expected the SCE related indicators that are required to be recorded were the most widely cited.

Of the 20 EC&I KP4 inspections, 11 stated that trending was performed to support ALE management ranging from active trending of ALE specific factors to ad-hoc trending for a specific purpose. However, it was not clear how or if they differentiated between AIM and ALE.

3 BARRIERS TO DATA TRENDING

Discussions with oil and gas industry professionals identified a number of barriers to the uptake of data trending that can be classified under the following areas:

- Data Collection and storage
- Data access
- Data management

3.1 DATA COLLECTION AND STORAGE

During the KP4 work, it was found that data associated with maintenance activities is typically recorded in text and numeric data fields within a Computerised Maintenance Management System (CMMS), which are based on common database engines such as Oracle.

CMMSs can be accessed by third party analysis tools, which can import and export data in an Open DataBase Connectivity (ODBC) compliant format, although these operations require specialist knowledge of such systems when first setting up the systems or performing modifications. The two prevalent CMMS tools used in the offshore oil and gas industry are SAP and Maximo, both tools have specific oil and gas versions of their CMMS tool.

The prime use of the CMMS is to generate work orders from stored data and to record the work activity outcomes. It is then up to the relevant engineers, TAs and managers to interrogate the CMMS to support their decision making processes. Those responsible for collecting data, including technicians, engineers, TAs, and specialist contractors, input data into the CMMS. Data can be entered and accessed either manually by persons with the relevant permission, or automatically by third party software tools that are designed to work with the CMMS. Like all database tools, the CMMS stores data in fields, whose size and format are predetermined by the company IT department.

Discussion with oil and gas professionals suggests that a significant number of persons who enter data may not fill all of the required CMMS fields in a consistent way. Where the CMMS data fields are considered too restrictive or ambiguous then data is often entered in the text fields associated with each task. The information entered this way varies according to the terminology used by different people from different companies or from different backgrounds and possibly, from different regions of the UK or different countries; this makes extracting data for analysis problematic.

Specialist contractors often use specialised equipment that has its own storage capability. For example, some handheld data logging devices are capable of performing basic analysis on their stored data for immediate display. This data is not generally downloaded into the CMMS because the CMMS is not designed to perform analysis on the stored data, such as data trending, which often needs to be performed by third party specialist software tools.

Data is stored typically stored using company designated codes. Data fields in a CMMS will typically store, as a minimum, data associated with the following:

- Site/location – which installation and where on that installation
- Work type - this refers to the type of maintenance/inspection/modification to be performed

- Work category – safety critical, production critical, routine
- Priority
- Assigned to/completed by
- Fault code/problem code
- Estimate/actual time to repair
- Date reported
- Work start/finish date/status
- Short text description of work to do/long text description of work and/or outcome
- Safety Critical Elements (SCEs)
- Live/follow-up required/shutdown/delay

The raw data from test and inspection tasks is sometimes embedded in a document linked to the relevant summary report in the CMMS. A summary report of the data usually concludes ‘pass’, ‘fail’, and where relevant ‘time to repair’, and is stored in the long text field within the CMMS. However, the summary does not say whether the system is in good or poor condition, thus not giving any indications regarding whether repair or replace would be a better option. For example, with ‘Ex’ rated equipment used in potentially explosive atmospheres, the maintenance reports the result as either ‘ok’ or ‘defect’. Where a defect is noted, a work order states what work is required to be performed for the equipment to be returned to an ‘ok’ state. This level of data storage limits the amount of useful information that can be gained by trending. Any detailed information, if it is stored, is in a separate report, which is not likely to have any known or predictable structure and hence data suitable for trending is difficult to extract.

Non-Destructive Testing (NDT) is generally performed by a specialist contractor. NDT reports for vessels or pipes will contain measurements associated with the vessel or pipe wall thickness, but not necessarily the location on the pipe or vessel where the reading was taken. Additionally, the raw data obtained from the NDT activity is not stored or linked to the companies CMMS. This is generally because the company do not request the raw data, they typically only require the analysis results and any actions to be recorded. Therefore, the specialist contractor will typically store the raw data themselves making it available to the companies if requested. This practice raises issues regarding what happens to the raw data over time, for example, how long will the contractor hold the data, especially if they no longer work for the company whose data they hold. This is one example of so-called ‘data islands’, i.e. data from specific tasks that is not directly accessible via the companies IT systems.

3.1.1 Fault codes

It was found that companies typically use a combination of industry specific fault codes (BSI 2006) and their own fault codes in their CMMS.

The reliability and maintenance data standard: BS EN ISO142242006 (BSI 2006) defines standard data formats and fault codes and is reported to be widely used in the UKCS oil and gas industry. However, industry specialists say that many companies modify the information formats and the extent of data recorded to suit their requirements or to match existing system use. The use of ISO14224 as a basis for data recording in the UKCS oil and gas industry is good practice and help would facilitate trending analysis of KPIs and other relevant data providing a consistent benchmark for the industry.

3.1.2 Tag location issue

Tag location is an example of poorly recorded data that acts as a barrier to data trending. It has been found that the tag hierarchy identifying equipment location often does not include a separate tag for replacement equipment. The CMMS identifies a hierarchy based on functional location, e.g. company, location and system, but not the specific equipment items that make up that system. Therefore, if the system comprises a motor, gearbox and pump, all three items are covered by the same tag. If the pump is replaced, the new one is labelled with the same tag ID as the previous defunct one, losing any traceability of the pump maintenance history.

A unique tag should be applied to each piece of equipment (a kit level tag) allowing tracking of where it has been, operating hours, failure history and type of failure etc. With the current system a new motor, based on the tag, could have associated with it a significant amount of maintenance and a large number of failures. This makes trending equipment to predict the next failure problematic.

3.2 DATA ACCESS

CMMS are based on common database engines such as Oracle, this facilitates data export/import in ODBC (Open Data Base Connectivity) compliant format. CMMS databases contain mostly text and numeric data fields, with some binary large objects (BLOBs) containing all the data. A means for an analysis tool to access the database is required to 'translate' between the third party application and the database. To make this work well there needs to be an understanding of all the tables and fields in the database, some standard and some customized, to allow reports to be generated or to allow data to be accessed by 3rd party tools for trending.

3.3 DATA MANAGEMENT

3.3.1 Relevance of software tools

When engineers request specialist software tools to perform tasks such as data analysis, engineers state that the company IT departments specify the relevant software tool requirements, without necessarily agreeing the best solution, modules and layout of these tools with the end users, e.g. engineers, TAs and engineering managers. Discussions with industry end users say that this results in a disconnect between their requirements and the IT departments decisions. Hence the company procures software tools that do not fulfil the end users requirements and as such this contributes to the common situation where end-users make use of uncontrolled tools such as spreadsheets.

3.3.1 Lack of information systems integration

To enhance reporting performance, including the use of data analysis, CMMS data is frequently assessed using third party data analysis tools such as Business Objects.

Typically, engineers will request a report that will include a requirement for the data analysis to support their decision making process. The request is subject to an approvals process and is then passed to the IT department, who will produce the requested report. The IT department often misinterpret the engineers' requirements and the resultant report requires reworking. Additionally, there are often delays in the approvals process, see Figure 5.

The lack of information system integration, easily accessible data and delays in the reporting process results in engineers maintaining their own data sources, be it manuals, operating characteristics or availability, and extract the data themselves from the CMMS. The same engineers then perform their own 'desktop' analysis and produce their own reports, as and when the need arises, typically using spreadsheets and storing the data and analysis locally. This is another example of data islands, where information is not available to users of the company IT systems. Additionally, if the engineer leaves the company the data and its analysis are lost. This loss of raw data equates to a loss of knowledge of the installation equipment and any analyses performed, the consequence could be a decrease in availability.

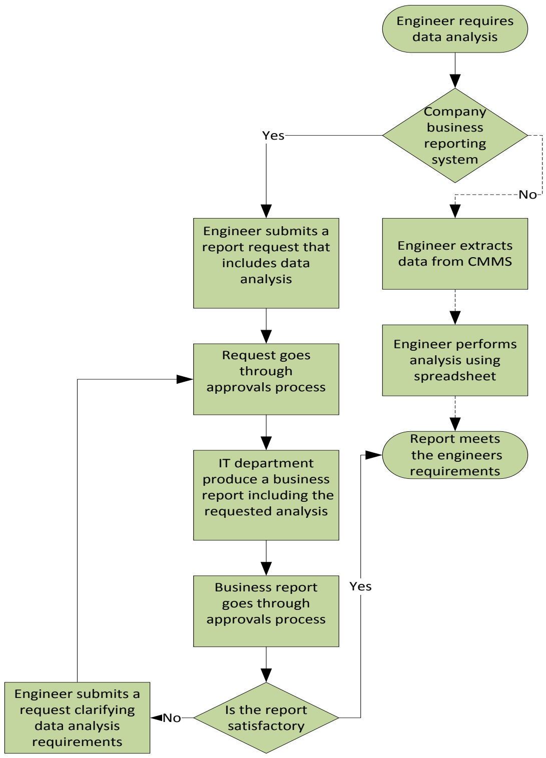

Figure 5. Typical reporting process with short cut alternative

3.3.1 IBM Maximo and SAP

The latest versions of Maximo and SAP for the oil and gas industry can be used to manage the asset lifecycle, including acquisition, work management, operations, inventory control, and preventive maintenance.

Maximo and SAP can perform the following activities for the oil and gas industry:

- Action tracking and regulatory compliance
- Asset specifications and failure codes
- Audit and survey preparation and analysis of findings based on results
- Benefits and losses that are associated with improvements and solutions
- Certification specification to verify that standards for assets or personnel are met
- Defects, incident management, and continuous improvement
- Drilling operations and reporting
- Investigations, reviews and analysis

- Management of change and action tracking
- Work prioritization and forward planning of work
- Duty Holders repair logs, loss reporting, solutions, and lessons learned
- Permit and certificate planning and risk assessment
- Permit to work creation and definition of associated activities
- Preparation of work activities in support of the various phases of work packages.
- ISO 14224 support
- Condition monitoring

Much of the increased functionality in new releases of CMMS are contained in add-on modules that the company can purchase.

3.3.1 CMMS use and limitations

Discussion with industry engineers and contractors suggest that the CMMS have the following limitations:

- Data fields are often considered too restrictive or ambiguous;
    - Data is often entered in text fields,
    - Data entered in text fields varies according to the terminology used by different people.
- Persons entering data into the CMMS do not always use standard fault codes and descriptors and the CMMS does not implement relevant restrictions.
- CMMS packages used within the oil and gas industry often have limited standard reporting capabilities.
    - Operators often use external tools such as ‘Business Objects’ to enhance the CMMS reporting performance.
- Basic CMMSs do not have trending capability.

3.3.2 Recent improvements in CMMS

New CMMSs have improved reporting capabilities with applications such as BIRT (Business Intelligence & Reporting Tools), which come with a set of standard reports that are claimed to meet the majority of user requirements, as defined by the IT department. There are also improved external interfaces to allow third party reporting tools to integrate with the data.

There are a wider range of third party data logging devices and data trending software tools that are designed to interface with CMMS tools via standard database links so data transfer operations can often be automated.

There are add-on modules that provide extra functionality such as trending of data stored in the CMMS. This only works for structured data such as fault codes.

Improved setting up and use of dashboards is also a useful tool to allow users to monitor KPIs of their choosing.

3.3.1 Data sharing

At the company level, communication between people who have and need information is poor, with disciplines having their own dedicated business systems with little sharing of information between them. The business systems generally are not currently configured to facilitate this.

3.3.1 Use of Spreadsheets

A significant problem in the UK offshore oil and gas industry is the extensive use of personal spreadsheets to manage data and perform analyses from multiple data sources. This practice leads to the creation of 'data islands', i.e. local storage of useful knowledge that is not visible to users of the company IT systems. There is an increased risk of corrupted data leading to a reasonable mistrust of the data gathered.

Other issues with the use of personal spreadsheets are:

- Data is not managed (usually entered by 'copying' from the CMMS user interface without traceability);
- There is no quality control, any trending performed may contain errors;
- Reports generated are not widely visible to other end users in the company,
- Creation of data islands
    - data stored independently from the company IT system
- When Engineers change roles this information is lost and it becomes reliant on the next individual in the role to find this information again.

This results in valuable information collected that could be used as part of the decision making process being lost. Discussion with industry professionals suggests that the ad-hoc use of spreadsheets for data analysis and trending is widespread.

3.3.1 Text analysis

A lack of appropriate mandatory fields within the typical CMMS has resulted in data being stored in plain text format. This text is rarely analysed because of the significant number of, and inconsistently recorded variables. Improving the selection of mandatory fields in CMMSs will aid data trending and analysis.

New advances in data analysis tools facilitate intelligent data mining from plain text fields thus allowing automated assessment. Examples of intelligent data mining and the results they can produce can be seen in (HSE 2008). However, implementing data mining for a company to support text analysis requires a non-trivial amount of effort and the use of knowledge engineering to turn stored information such as that stored in a CMMS into useful knowledge.

3.3.2 Trending, competence and reliability engineering

The Offshore oil and gas industry does not generally employ significant numbers of trained and experienced engineers who understand reliability issues beyond entering data in to software tools. Suitable qualified/experienced engineers could be used to manage both the data flow and to understand the results of the analyses and feed this into the ALE decision-making process.

The wide scale application of fundamental reliability engineering in the industry would help to better identify equipment requirements and the means of measuring and analysing effectively actual performance, thereby improving equipment availability.

The use of non-topic-specialist personnel from IT departments to perform data and trending analysis requested by engineers can result in misinterpretation of the requirements, and hence result in unsuitable trend analyses being produced. Whereas, competent engineers, who have a good working knowledge of reliability issues, would be more suited to the task of data analysis and in particular data trending of equipment and system lifecycle prediction tasks and provide a better support to ALE decision makers.

4 DATA TRENDING

4.1 TRENDING AND KPIS

AIM can be defined as managing present and short-term integrity requirements, whereas ALE can be defined as managing long-term or installation lifetime degradation issues due to ageing assets.

KPIs represent important information regarding the performance of equipment, systems or processes. KPIs associated with AIM are likely to be lagging in nature, i.e. they are reactive, and they tell us about the current state of equipment or process performance. With AIM, consideration is given to equipment and system integrity issues from one test/inspection/failure date to the next, and as such is concerned with the general day to day management of equipment and systems operation and hence production. Therefore, all that can be said is that the performance levels are acceptable or not at any given time. This has limited use in that it does not contribute useful information to the long term decision making process.

However, if we trend the KPI over time, a prediction of when the system or process is likely to fail its performance standard can be obtained. This gives much more information in terms of inferences that can be made and the options that can be considered.

Trending of maintenance related data highlights the link between AIM and ALE because trending takes past and present data and predicts future performance. It is not always that simple, in reality, you first need to identify what information you need. There are two approaches one can take to identify what useful information would support ALE decision making, either a top-down or bottom up approach, or both.

1. Consider specific ALE issues, such as creeping change, obsolescence and skills shortages and with regard to specific systems and/or processes consider what useful knowledge would be beneficial to have and then look at how trending could help obtain that knowledge, or,

2. Look at the data you have with regard to specific KPIs and consider what useful knowledge trending this data could produce.

Trending of maintenance data over time can be used to predict and hence identify many long-term issues such as:

- When to repair or replace,
    - scheduling,
- Whether the time to repair/replace is increasing,
    - difficulties in obtaining spare parts,
    - spare part quality,
- Maintenance quality improving or degrading over time
    - difficulties retaining knowledge and skills,
    - insufficient bed spaces on the installation.

Trending KPIs over time can identify whether further investigation is required, such as looking into ALE issues like obsolescence of equipment and spare parts and the availability of appropriately skilled repair technicians with relevant product experience.

4.1.1 What can be trended

Any KPI that can be measured can be trended, example KPIs suitable for trending are:

- Equipment reliability/availability;
- Maintenance performance;
- SCE demand rates;
- SCE failure mode occurrence frequency.

4.1.2 Example KPI identified in KP4 inspection reports that can be used to support ALE

KPIs identified during HSEs KP4 inspection program were mostly associated with AIM, and hence were focused more on the current condition of equipment, systems and maintenance processes. It is suggested that trending of relevant KPIs associated with production issues, hydrocarbon leaks and financial issues could also benefit oil and gas companies but has been omitted from the scope of this report.

Table 1 presents example KPIs taken from HSEs KP4 inspection program, with suggestions for possible outcomes of trending and possible links to ALE issues.

Table 1. Example KPIs from KP4 inspection program, potential trending outcomes and links to ALE

KPIs identified from KP4 inspection visits	KPI Trending outcome	ALE issues
Equipment/system reliability/availability metrics	Predict when repair/replacement is likely to be required	Obsolescence, maintenance quality, skills shortage, installation bed space
Inhibit/override/bypass records	Identify critical maintenance performance issues	Maintenance quality indirectly affects ALE related work
Incident/near miss investigations	Measures safety culture	A major safety incident could significantly affect the cessation of production date
Process Control System (PCS) alarm rates	Identify unexpected variance in process alarm rates	Change in operating conditions; degraded infrastructure and creeping change; obsolescence
Demand frequencies for Safety Instrumented Systems (SIS)	Identify unexpected variance in SIS demand rates	Change in operating conditions degraded asset; creeping change, obsolescence of SIS components, skills shortage
Operational Risk Assessments (ORAs)	Measure of maintenance performance over time.	Many possible causes, investigate root causes, could be degradation,

	Need to identify relevant aspects of ORAs, for example: number of overdue ORAs leading to escalation; number of ORAs satisfactorily closed out on time, number of ORAs linked to SCE etc	obsolescence, skills shortage
Safety Critical Element (SCE) assurance/audit findings	Identify recurrent issues over time	Investigate root causes of recurrent or unexpected SCE failures; creeping change; long term degradation issues
Condition monitoring findings	Identify variance in asset condition over time	Identify asset integrity issues due to degradation, creeping change etc.
Deferred maintenance	Measure maintenance performance over time	Skills shortage (competence), obsolescence, installation bed space (scheduling)

4.2 EXAMPLES OF DATA SUITABLE FOR TRENDING

Tables 2. (i) (ii) (iii) (iv) (v) present examples of data suitable for trending/analysis. The data type, its source and what information can be derived from the trending/analysis activities.

Table 2 (i). Example SCE data for trending / analysis

Item	Data type	How data obtained	Trending / analysis outcome	Comments
Vessel / pipe (wall thickness)	Numerical (mm)	NDT detailed corrosion report, result in CMMS	Predicted wall thickness at time x, possibly leading to modified inspection rates and eventual replacement date.	Consistent test point can affect the analysis performed; different test point may require specialist analysis; not all corrosion related failure modes are the same and corrosion rates may not be consistent.
Electrical switchgear operation	Textual / numerical (monitored temperature)	Thermal monitoring /analysis report in CMMS	Increase in switchgear component operating temperature noted as part of monitoring process leading to component / switchgear refurbish / replacement.	Excessive component temperature could result in immediate remedial action, but gradual or frequent increase could be linked to ageing issues.
Rotating equipment vibration	Numerical / textual based on monitoring	Outcome of monitoring survey report in CMMS	Trending of vibration leading to remedial action/prediction of replacement time.	Vibration is likely to be a symptom of normal ware or an indication of a fault within the equipment, but the underlying cause might be due to ageing.
Valve operational	Numerical/ textual	Test/failure reported in	Trending of degrading performance leading	Degrading valve performance could be a symptom of normal

performance		CMMS	to remedial action /prediction of failure /replacement time.	ware or an indication of a fault within the equipment, but the underlying cause might be exasperated by a company's failure to adequately manage ageing issues.

Table 2 (ii). Example reliability data for trending / analysis

Equipment reliability	Numerical (hours)	KPI in CMMS	Predicted, MBTF, MTTF, MTBR, leading to variation in inspection rates and estimated replacement time.	Failure rates can identify anomalies and equipment condition issues associated with ageing or maintenance issues.
Equipment repair time	Numerical (hours)	KPI in CMMS	Predicted MTTR, measures repair times; trend looks for value increasing or decreasing as a measure of maintenance productivity.	Could indicate issues with staffing levels, competence, supply chain, or ageing.
Worst actors	Equipment item most frequently repaired	KPI in CMMS	Measures worst performing equipment/systems.	Identified specific systems/equipment to be assessed in depth to identify underlying causes, possible ALE causes.

Table 2 (iii). Example equipment availability data for trending / analysis

Operational availability	Numerical (% time equipment is operational including maintenance)	PM and CM KPIs in CMMS	Change in, or poor, equipment availability over time may indicate ageing issues.	Proactive analysis required.
Technical availability	Numerical (% time equipment is operational)	CM KPIs in CMMS	Change in, or poor, equipment availability over time may indicate ageing issues.	Measures equipment availability at sites where practice is to fix on fail, reactive monitoring can still be trended to note potential ageing issues.

Table 2 (iv). Example maintenance performance data for trending / analysis

Predictive maintenance (PdM)	% predictive activities done	PdM KPIs in CMMS	Indicates ability to predict ALE issues and perform required actions.	Measures condition monitoring management performance.
Preventative maintenance	% maintenance	PM KPIs in CMMS	Measures of proactive work done,	This can be a measure of ALE management.

(PM) done	activities done		planned inspection, testing, servicing, etc.	
Corrective maintenance (CM) done	MTTR (# repairs done)	CM KPIs in CMMS	Measure of repair time, amount of reactive work done over time.	Could modify repair / replacement strategy.
PM overdue	% of PM WOs are overdue	PM KPIs in CMMS	Indication of PM backlog levels over time.	Can indicate staffing issues or supply chain issues associated with obsolescence.
PdM overdue	% of PdM activities overdue	PdM KPIs in CMMS	Indication of PdM backlog levels.	Less data for trending and decision support.
SCE backlog	% SCE maintenance backlog	SCE backlog KPIs in CMMS	Safety critical maintenance backlog as a % of total.	Can lead to modification of maintenance regime.
Inhibit / override / bypass records	% inhibit /override bypass	Override bypass KPIs in CMMS	An increased number of inhibits /override bypasses will require investigation.	
Deferred maintenance	% deferred maintenance	Deferred Maintenance KPIs in CMMS	An increased level of deferred maintenance activities can lead to increased failure rates.	Can indicate staffing issues or supply chain issues associated with obsolescence.
Rework	% rework	Rework KPI from CMMS	An increased level of rework can lead to a decrease in equipment availability.	This can indicate, replacement part quality, technician work quality and technician competence.
Operational risk assessments	Numerical/ textual	ORA KPI	An increased number of ORAs reflect an increase in the number of risks arising from abnormal operational situations. An increasing trend should be investigated.	An increasing trend in the number of ORAs could be an indicator of ageing issues that require identification via further investigation.

Table 2 (v). Example SCE demand rates

Process Control System (PCS)/distributed control system (DCS) alarm rates	Numerical	Alarm rate records	An increased level of PCS/DCS alarm rates requires investigation.	If the PCA/DCS alarm rate increases this could indicate creeping change in process operation parameters or ageing issues. This should require SIS demand rates to be checked.
Demand frequencies for safety instrumented systems	Numerical	SIS demand rate KPI	An increased level of SIS demand rates requires investigation.	If the SIS demand rate increases this could indicate creeping change in process operation parameters or ageing issues.

Table 2 (vi). Examples of equipment failure modes where trending/analysis could indicate ALE issues

Equipment item	Failure mode	What is trended (over time)	Comment
Valve	failure to close/open failure to open within specified time leakage rate higher than specified	Change in failure rate change in time to open change in leakage over time	Predicted time at which performance standards not met.
Pumps (rotating equipment)	failure to start on demand failure to perform at required capacity excessive vibration, noise, overheating	Change in failure rate change in capacity change in/excessive vibration, noise, overheating	Predicted time at which performance standards not met.
Deluge nozzle	% blocked nozzles on demand	Change in # of blocked nozzles	
Electric generator	failure to start/stop on demand output voltage low excessive vibration, noise, overheating	Change in failure rate change in output voltage change in/excessive vibration, noise, overheating	
Electric Motor	failure to start/stop on demand motor performance low excessive vibration, noise, overheating	Change in failure rate change in output performance change in/excessive vibration, noise, overheating	Failure rates are long term indicators that require investigation Increased vibration amplitude can indicate a fault developing
Power transformer	failure to function on demand wrong output voltage overheating structural deficiency	Change in failure rate change in output performance overheating levels	
Gas detectors	output , low, high, none spurious alarm levels	failure rate over time	
Uninterruptable Power Supply (UPS) for emergency lighting/SIS	failure to start on demand capacity too low for required PS (battery time on load) wring output voltage/frequency	cell impedance estimated charge battery output voltage/frequency	
Fire damper	fails to close on demand	failure rate over time	

4.3 DATA TRENDING EXAMPLES

The following examples show how data trending can be performed and indicates what useful knowledge can be acquired.

4.3.1 Trending Example 1 ESDV failure

Figure 6 depicts failure data for, in this case, an ESDV, where the pass/fail outcome with the associated dates and repair times is recorded in the CMMS. This could typically be the case where the company applies a fix on fail approach to equipment failure.

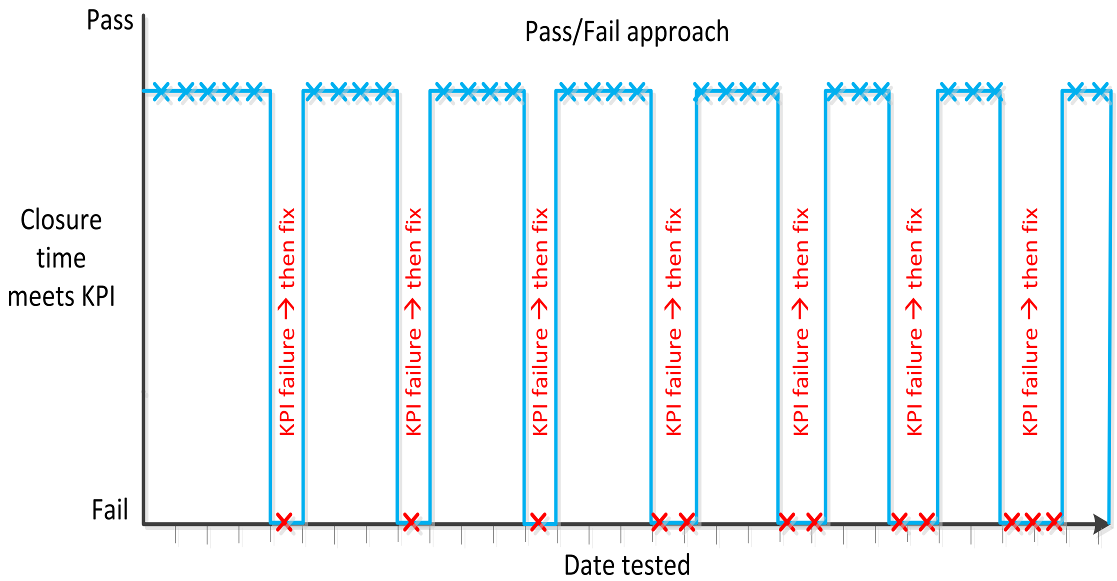

Figure 6. Graph showing ESDV pass/fail operation over time

There are ways in which pass-fail frequency can be modelled, which could give an indication of various KPI failure frequency variation over time. In Figure 6, the frequency at which the ESDV fails to meet its closure time KPI is modelled, as is the ESDV MTTR. Figure 6 indicates that frequency at which the closure time KPI fails is increasing. Additionally, a contributory factor to this is the increase in the ESDV repair time (MTTR).

However, what figure 6 does not tell us is what the closure time is at any given time and hence it cannot be determine how close to failing to meet the valve closure time ESDV is even when it has just passed its test. Additionally, the real data may not be so clear cut and it might not be a good indicator of future performance of the ESDV.

Figure 7 shows a trend analysis applied to a set of fictional test data representing the closure time in seconds of an ESDV. An increasing time value represents degraded performance. The maximum allowed ESDV closure time according to the KPI depicted in the example is 16 seconds in this example. Trend analysis of actual performance measurements can indicate the worst case, mean, and best case predicted time at which the ESDV is likely to fail its closure time KPI. This knowledge can be used for long term forward planning for repair/replacement.

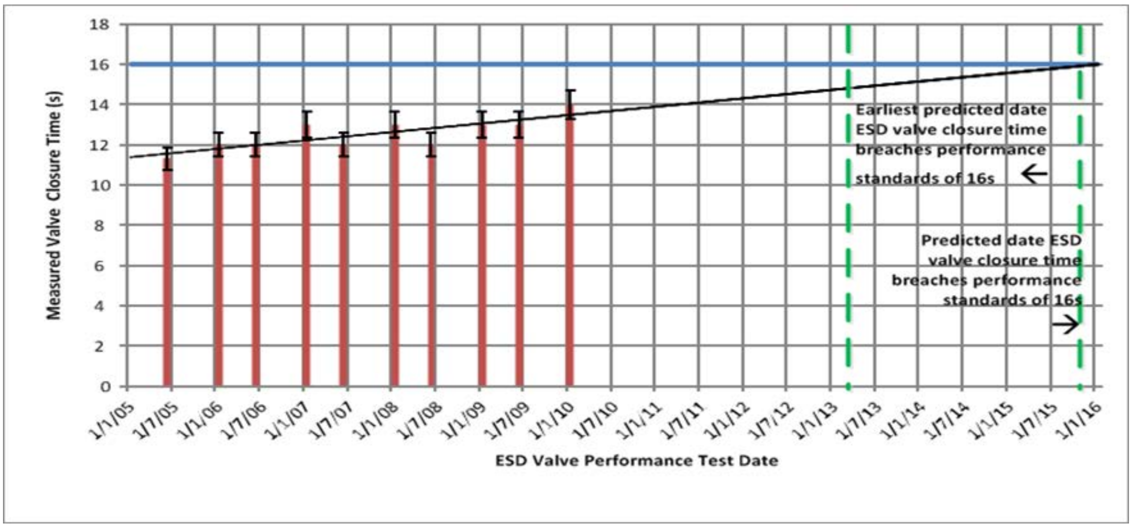

Figure 7. Graph showing ESDV closure times trended over time

4.3.1 Trending Example 2, percentage maintenance rework

Figure 8 shows trend lines fitted to fictional data over 12 months; the extrapolated line shows future predictions based on the current trends, whilst the blue trend line shows two point moving average. Comparison of the two lines shows marked differences in trend predictions.

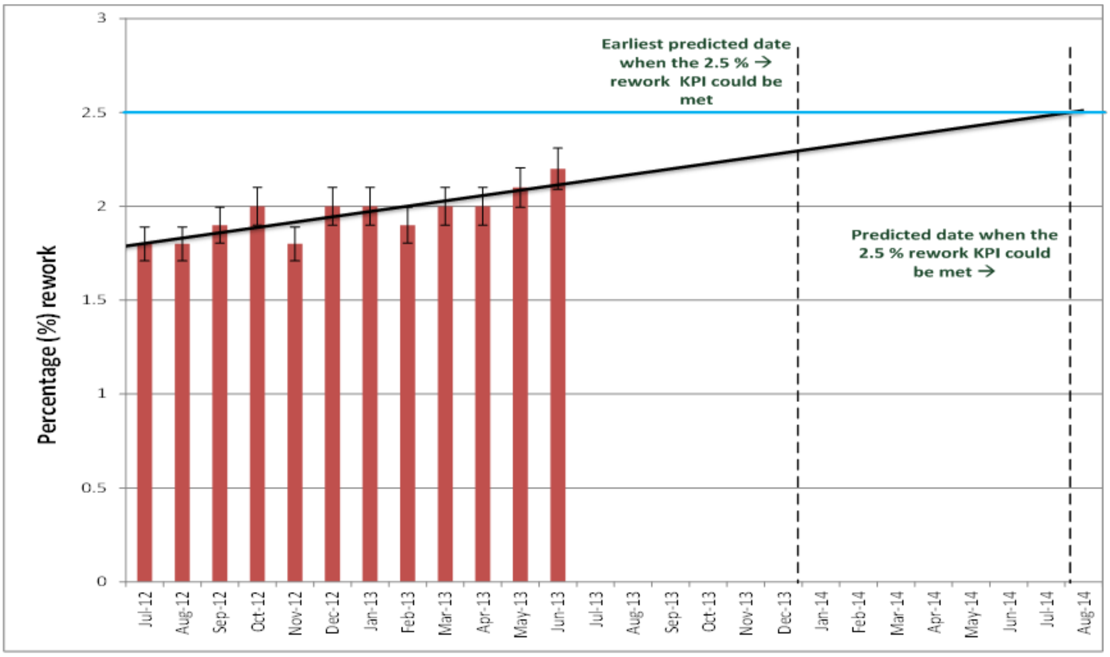

Figure 8. Percentage of maintenance rework trended over time for a fictional installation

If the KPI was set at 2.5%, the linear trend suggests that it would be met or exceeded by approximately May 2014. If we take into account a 5% error in the data to allow for uncertainty, the, 2% rework could be met between April/May 2013 and September 2013, representing a seven month variation. An outcome of this initial trending analysis could be to instigate an investigation into the root causes of this trend before it results in significant maintenance performance issues.
This lagging KPI of maintenance quality could be influenced by a number of factors such as replacement part quality, technician work quality and/or technician competency. By trending over time the lagging indicators becomes a leading indicator by predicting future performance and indication a requirement for investigation into the underlying causes to identify whether any corrective measures are required to be put in place.

4.3.2 Trending Example 3 vessel wall thickness and corrosion rate trending

Non-Destructive Testing (NDT) is used to measure vessel and pipe wall thickness. It is not practical to measure the wall thickness of an entire vessel or pipe, so a sampling approach based on the corrosion TA’s Risk Based Inspection (RBI) is often used.

This is a simulated example used to demonstrate the principle. In reality, measurements would be made at different points and treated statistically to gain the average wall thickness, the maximum depth of the corrosion pits etc. depending on the type of corrosion that would be expected in that vessel or pipe. These values could then be trended as per the method detailed below.

In this analysis of simulated historical NDT vessel wall thickness data, a prediction is made of when the Minimum Allowable Wall Thickness (MAWT) would be reached, using linear trend analysis. Wall thickness measurements were taken at fixed locations (test points) on the vessel for approximately six years, see Figure 9.

A linear trend analysis is applied to the data in Figure 9, and shows an apparent constant rate of wall thickness deterioration occurring from October 2004 until February 2008 for both test point 1 and test point 2, as depicted by trend lines T1 and T2 respectively.

A linear trend analysis is reapplied to the data measured starting February 2008 until January 2011 to account for a measured increase in the wall thickness deterioration rate. The date at which this change appears to occur, February 2008, is shown by a vertical dashed line labelled ‘rate change’ on Figure 9.

The new linear trend analysis shows an apparent increased but constant rate of wall thickness deterioration occurring from February 2008 until January 2011 for both test point 1 and test point 2, as depicted by trend lines T3 and T4 respectively.

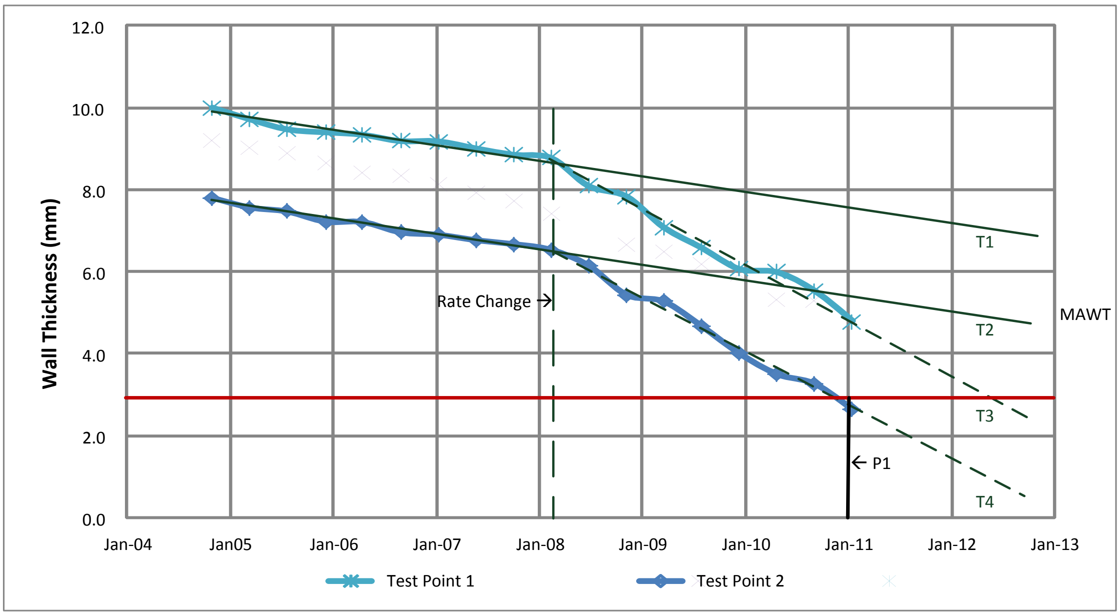

Figure 9. Simulated vessel wall thickness data trends including change in deterioration rate

Figure 9 shows that the vessel wall thickness measured at test point 2, reached the MAWT of 3mm, as depicted by the red line, by January 2011, as depicted by the vertical line P1.

Findings from this simulated case study are:

- According to the initial trend analysis, depicted by the trend line T2, the MAWT of 3mm was predicted, by extrapolation of the trend line T2 to be reached approximately seven years later than measured result, and the trend line T4, showed.
- The trend line predictions for test point 2, from T2 and T4, differ significantly, even though both trend lines appear to fit the data well for each period up to and after the rate change time.
- The simple trend analysis performed here has not accounted for vessel wall thickness at locations other than those measured.
- The new trend lines T3 and T4 were fitted to the measured data after the change in degradation rate was noticed, this could have occurred too late to prevent the MAWT limit being exceeded in real life, with potentially catastrophic consequences.

The change in the rate of wall thickness deterioration highlights problems in using a simple trend analysis for potentially complex problems such as corrosion.

Statistical methods can be used to model complex phenomenon such as vessel corrosion to improve estimation of minimum wall thickness over large area, using sampling methods, when combined with reliability methods and system knowledge [HSE 2002]. However, the use of statistics requires specialist knowledge to implement the analysis and interpret the results.

This example shows that trending can be used to predict asset degradation, if relevant pitfalls are taken into consideration, thus enabling long-term scheduling for repair or replacement of vessels and pipelines.

5 TRENDING TOOL SUPPORT

5.1.1 Trending methods

Numerical methods such as linear and nonlinear regression analysis using simple software tools can give initial estimates of equipment failure rates and when a performance standard may be breached.

Complex statistical analysis using mathematical tools can help to predict ALE issues for complex problems such as corrosion.

Qualitative reporting and data analysis using business reporting tools can identify type of problems occurring and present data analysis in support of the analysis.

5.1.2 Commonly used tools in the UKCS Oil and Gas Industry

Table 3 gives examples of data analysis and trending tools that are commonly used to support data trending and analysis in the UKCS oil and gas industry. Table 3 presents the tool, how it acquires data, what outputs are produced, finally the comments column provides generic information and where relevant a web address associated with the tool.

Table 3. Trending/analytical tools and capabilities used in the UKCS oil and gas industry

Tool/method	Data handling	Operations performed and outcomes	Comments
SAP PM	CMMS, manual or data logger input.	Data storage and work order output and dashboard display. Data analysis via optional modules.	SAP PM has a wide variety of functionality via standards and optional modules.
IBM Maximo	CMMS, manual or data logger input.	Data storage and work order output and dashboard display. Data analysis via optional modules.	Maximo has a wide variety of functionality via standard and optional modules.
OSISoft PI system	The PI system can collect data via data logging devices or via standard DB links to a CMMS. The PI system has its own infrastructure but can work with a CMMS	PI can perform any required data analysis and trending, see PI ACE.	Collect, store, analyses/trends, and reports process. Data input via a wide range of input devices,
OSISoft PI ACE	Manually or by data logging devices	Equation/algorithmic trending, prediction and analysis.	Real-time monitoring is analysed based on programmed equations and methods. Can interface to CMMS

IBM SPSS	Numerical and textual manually inputted or via CSV file indirectly from CMMS	Predictive analysis via statistical modelling methods	Requires professional application. Data can be output via CSV file
BI-Cycle RCM Analysis	Trending analysis of amongst other things, CMMS data, MTBF calculations, KPIs.	General trending of maintenance and reliability data.	Read interface into CMMS via DB links can be set up.
SAP Business Objects	Reporting on KPIs from CMMS, including basic trending.	Business Objects XI, has components that provide performance management, planning, reporting, query and analysis and enterprise information management.	Read interface into CMMS via DB links can be set up.
ACET	RBI/RBA inspection management database and analysis tool for corrosion management of, for example, pressure systems.	Stores equipment details, design information, inspection data. Can schedule work activities. Can perform analysis of anomalies and trending of results and data.	This is a self-contained system, with facilities required to collect, store assess and report corrosions issues and its management.
Pro-log	Used to take process readings around the plant to allow trending.	Can graphically trend data or can upload data to a process historian	Data transfer is by suitably configured OPC server to SQL database. Also data transfer via process historian such as PI historian.
Proact® and 5-Why RCA	Investigation Management System.	Root Cause Analysis (RCA) tools.	
COABIS	Vessel & piping corrosion data numerical and textual.	Inspection, corrosion and integrity management for piping, vessels and pressure systems including trending and prediction functionality with alarms and warnings.	Can interface into CMMS.
SmartSignal Predictive Diagnostics	Real-time performance monitoring and analytics of rotating and non-rotating equipment.	Vibration monitoring and analysis in real-time with relevant notifications/warnings issues in real-time.	

Availability workbench	Availability and reliability tools.	Simulate system availability using reliability tools and data from the CMMS.	Interface to SAP and Maximo.
Matlab	Mathematical modelling.	Bespoke, complex, analysis and trending.	Matlab can access data from the instruments and imaging devices via the CAN bus interface. Direct access data from ODBC, JDBC-compliant databases, and OPC servers.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

As part of the KP4 programme, HSE undertook work to look at the apparent lack of data trending performed in the UKCS oil and gas industry, in particular, trending used to support ALE decision making. Below, are the main conclusions.

Data trending is mostly driven by specific maintenance needs rather than being approached systematically with a well-developed set of goals.

Stored data quality is inconsistent, in particular the use of fault codes and task descriptions, which are often entered in long text fields in the CMMS due to a lack of relevant/flexible mandatory fields, making data extraction for trending problematic.

Other data recording issues leading to potential difficulties in data trending are:

- Tagging practices, which can result in misleading information;
- Recording of pass/fail inspection/test results only, which can limit possible trending outcomes;
- It is not always easy to extract data, especially from earlier versions of CMMS (SAP or Maximo), which require a database specialist.

A lack of business reporting functionality within a CMMS has led to extensive use of third party business reporting tools used to perform some data analysis tasks.

Data management issues listed below have resulted in engineers performing their own trending in an ad-hoc manner:

- Reporting approval process often viewed as long winded;
- IT personnel procure tools that may not suit end users requirements;
- IT personal with inadequate technical understanding of the end users requirements were cited as often producing business reports (including trending analysis) that did not meet the end users expectations, requiring rework.

The widespread use of personal spreadsheets is an impediment to intra-company knowledge sharing.

Information regarding an installations systems and equipment is often not passed on when the installation changes ownership leading to detailed knowledge of the assets being lost. Communication, especially between data rich established companies and data poor companies who have recently acquired installations, does not appear to occur.

Companies appear to be suffering from the creation of ‘data islands’, resulting in their being unaware of, and unable to access, all the information they possess.

Suitable ALE KPIs were not in general developed, however specific processes to address ALE issues were established or being developed in the oil and gas industry.

Trending requirements and methods did not appear to be widely understood. Complex/bespoke trending appears to be mostly performed on large scale projects such as significant pipeline validation.

Inappropriate trending can lead to misleading results (see example in Figure 9 “Corrosion”).

6.2 RECOMMENDATIONS

To make best use of data to support ALE decision making, improvement is required in the way that information is stored, managed and utilised so that useful output can better support ALE decision making. Below are suggestions for relevant improvements.

6.2.1 Understand trending requirements for ALE

The UKCS oil and gas industry requires a better understanding of the applicability of data trending:

- What information can data trending produce?
- What are the limits and applicability of data trending?
- What type of data trending is likely to require specialist support?

Careful consideration of each installations ALE requirements is the first step to better-informed ALE decision making:

- Identification of specific ALE outcomes and the information required to meet them;
- Relevant transformation of existing lagging KPIs into leading KPI’s will support ALE decision making;
- Identification of existing KPIs and consideration of what useful information trending can give.

6.2.2 Data collection storage and management

Develop a coherent data collection, storage and management system.

- Apply consistent data storage with trending in mind;
- Addresses issues like tagging that could impede data trending;
- Collect data based on required information analysis outcomes.

Improved specification of the CMMS data storage fields would better facilitate consistent data recording that would improve the usefulness of the stored data for end users.

Improved standardisation of data format and data storage communicated to all producers of data working for the company CMMS would help facilitate data trending by:

- use of standard fault codes;
- use of standard descriptors used for maintenance activity outcomes.

6.2.3 Company IT systems

Improved integration of company IT systems with the needs of the end user would be beneficial; specifically, a better interface between the company reliability engineering function and the company IT department, where the end users requirements were given the priority. This would be facilitated by:

- Suitably competent engineers being in charge of data flow and analysis, with IT support where required;
- End users having priority in the specification of software tools used to perform data analysis, including data trending.

6.2.4 Reliability and availability

The UKCS oil and gas industry could employ more suitably qualified engineers with a strong understanding of relevant reliability engineering issues beyond simply entering data into a relevant software tools. These engineers could work with the plant integrity function to better support long-term reliability issues as part of the ALE decision-making process.

6.2.5 Use of relevant software tools

The newer CMMS versions incorporate operations management tools that integrate maintenance planning, data analysis, supply chain management and overall project planning and operation if the company purchases all the relevant modules. CMMSs can capture and validate field data from disparate sources such as manual input, input from process historians, and field measurements via data logging devices, and are able to perform their own integrated analytics to present performance trends in context and can be configured to support ALE decision making. This may require obtaining the relevant modules, or giving consideration to how to better utilise existing third party software tools.

6.2.6 Information sharing

Management of ALE in the UKCS oil and gas industry would benefit from improved sharing of information at two levels:

- At the company level: it was generally thought that relevant departments within a company do not communicate with each other leading to a disjoint approach to AIM and ALE;
- Between companies: information contributed to the OREDA database project represents only a part of the information that could be shared in the UKCS oil and gas industry. Information sharing such as good practice would aid new companies to better deal with ALE decision making.

Complex/bespoke trending is likely to require specialist analysis and interpretation of results and hence has been applied to large scale projects such as significant pipeline validation . However, specialist analysis can be applied to small scale projects such as corrosion monitoring and analysis of process vessels on an installation.

A significant problem in the UK offshore oil and gas industry is the extensive use of personal spreadsheets to manage data and perform analyses from multiple data sources. This could be improved by given engineers better access to suitable company software tools and removing the delays associated with typical business report processes and procedures.

There is scope for improvement in a number of other areas, including:

- wider awareness of equipment availability and requirements;
- sharing of detailed equipment reliability and obsolescence data, and
- removal of ‘data islands’ by removing the barriers that lead to their creation.

To overcome the ‘tag’ location issue where the tag hierarchy identifying equipment location often does not include a separate tag for replacement equipment. A unique tag should be applied to each piece of equipment (a kit level tag), allowing tracking of where it has been, operating hours, failure history and type of failure etc.

An area where great improvements are being made is ‘text mining’, which is the application of data mining. Data mining is used in the analysis of large amounts of poorly structured text, such as that stored in text field in a CMMS, using a mixture of statistical, AI, machine learning and optimisation techniques from computer science, in collaboration with domain expertise to extract useful knowledge, for an example see (Pool 2008).

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Benefits of data management and data trending in the UK Continental Shelf oil and gas industry

To improve the management of risks associated with ageing and life extension (ALE) of the oil and gas infrastructure on the UK Continental Shelf, HSE launched the 'Key Programme 4' (KP4) of targeted inspections in 2010. Two key findings were that industry could make better use of data trending and had not identified leading key performance indicators (KPIs) suitable to support ALE decision making. Data trending is the tracking of changing trends through analysis of data on equipment, systems and people performance. KPIs that indicate the current condition of equipment and systems are lagging indicators with respect to ALE, which is focussed on their future condition. The trending of lagging KPIs enables the future condition of assets to be estimated, thus producing leading KPIs that can directly support ALE decision making.

This report describes research to identify the barriers to the take-up of data trending to support ALE decision making, in order to identify issues that industry could address. Findings include issues surrounding data collection, management and use of data. Additionally, potential problems with analysis methods are discussed, suggesting that while basic trending can be done by engineers, there are pitfalls associated with trending that need to be understood.

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