Automated Spares and Inventory Management System For Upstream Oil and Gas Producing Facilities Using RFID Based Item Tracking Integrated With Enterprise Resource Planning Through Centralized Onshore Sourcing Hub For Improving Uptime Reliability

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ABSTRACT : *This paper is about identifying typical challenges encountered by the upstream Oil and Gas exploration and production companies in managing the uptime of their assets in the production sites. There are several locational and logistical constraints specially at the well sites especially those which are located offshore deep inside sea.. The oil exploration and production infrastructure comprises of water, gas and utilities systems with multiple rotating equipment which are critical for the production operations. All these equipment's and facilities are highly maintenance intensive and proper spares management is crucial for effective usage of these capital assets and equipment's. Despite modern techniques, well site facilities encounter high level of unplanned shutdowns which affect the overall economics of oil exploration and production. The paper provides a framework of using Expert Based system to diagnose problems encountered at offshore well site and how can the spares management be integrated with maintenance routines triggers in the ERP systems using RFID tag based inventory management process*

KEYWORDS:Upstream, Well site, Uptime Management, Facilities Management, RFID, Expert System, Inventory Management, Maintenance Management

1. INTRODUCTION

The hydrocarbon industry, particularly oil exploration and production is highly facility -dependent industry. Facilities essential for production are installed/constructed while developing the field and their supply, storage, maintenance and services is categorized under the head "Well site Facility Management". This is required in order to ensure prudent handling of all the materials, both rented and the owned ones. Well servicing activities are generally conducted to maintain or enhance the well productivity, although some slick line and coiled tubing applications are performed to assess or monitor the performance of the well or reservoir. Once the facilities are constructed, they need to be continuously tracked for their performance and are maintained whenever required. As Oil and Gas production is highly capital intensive, many of the equipment's and assets are rented apart from being owned by the Oil exploration organizations. Many of these oil wells are located offshore deep inside sea while come facilities are also on the ground where oil or gas reserves are discovered. [1]

In case the field is an offshore field then, only certain materials are stored on-site. This is because the space at the offshore platform is limited and maintenance there becomes little tougher as compared to onshore. Hence the materials are stored at a location on shore nearby the offshore production platform. Spares/parts/Materials are ordered from the onshore location whenever required. This is called "remote logistics" and it covers all the activities like "remote logistics goods receipt processes", "remote logistics temporary holding processes" and "container management".

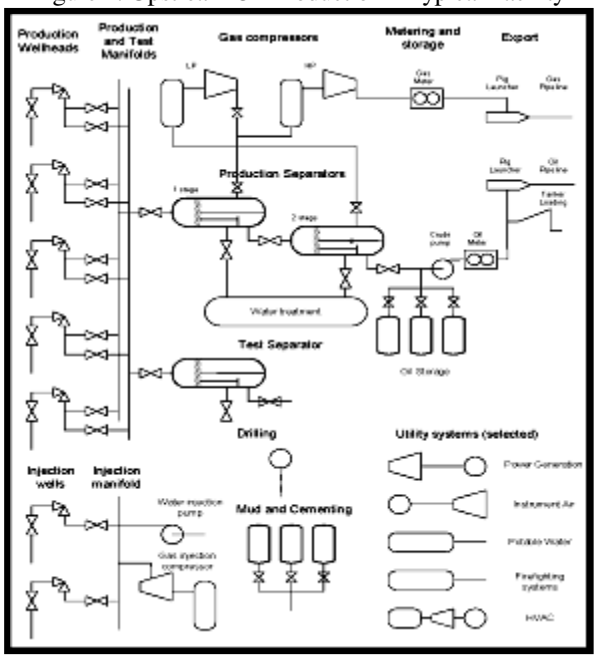
The well facility management consists of several different maintenance intensive equipment's such as drilling equipment, pumps, compressors, HVAC, generators, winches, mechanical drives etc.

The typical process carried out in any upstream production is as per the Figure 1 below[4]:

2. UPTIME RELIABILITY

Uptime reliability is proven key operation excellence metric. Improving uptime leads to increased profitability and can also be related to reducing operational risk of production well. Operating efficiency is the ratio of actual production over predicted production capacity (PPC) or Field capacity. PPC is an estimate of the potential production on any day based on the assumption that the field is operating at its own demonstrated best performance for each day of the entire year[5].

Figure 1: Upstream Oil Production – Typical Facility



Management on Oil-well platform

The production losses are accounted under following broad categories[6]:

- Planned downtime
- Unplanned downtime
- External Factors (Such as downtime due to OPEC quota restrictions, weather, mid-stream downtime)

Operational Excellence requires minimizing the frequency of unplanned downtime incidents and increasing time between planned downtime safely minimizing the time to regain full production from both planned and unplanned events.

In the recent global portfolio benchmarking study, the operating efficiency ranged from 83% to best in class high of 97% field capacity.

The E&P Sector is historically a 10-15% rate of return business, which means the last 10-15% of production, is profit. If an operator could eliminate or reduce half of the 8% Unplanned Production Loss, they could potentially double the rate of return from their assets. To assist operators capture additional production, revenue and profit from unplanned downtime, Since Production Loss Management often can be done at small expense or investment, no other activity has the same potential to positively impact the bottom line.

We have found unplanned production losses are generally related to the size and complexity of offshore deep-water production facilities.
Based on the study conducted it was found that the planned and unplanned downtime can be attributed to:

- Facility failures (on the platform)
- Well failures (subsurface)
- Midstream & market (e.g. pipeline), reservoir, weather and other external factor

This papers attempts to minimize the downtime due to the "Facility Failure" which is perhaps the single biggest cause of "Unplanned Downtime" As can be seen from table below, Facilities in a typical upstream oil well production unit comprises of following broad equipment's[7]:

Upstream Oil Well /Production Facilities Typical list of Equipment used	Importance to Uptime Reliability	Maintenance and requirement of spares	Inventory Management applicability
Aerotechnics	H	M	H
Drilling outfits and tools	H	H	H
Oilfield Equipment	M	L	H
Equipment for collection of Oil	M	L	L
Equipment and tools for cementation of wells	H	M	M
Pumping, Ventilation and Compressor Equipment	H	H	H
Electric Equipment for Extraction	H	M	M
Tools for equipment's for Oil and Gas Extraction	H	M	M
Other Equipment's and Tools	M	M	L
Raw Material & Stocks	H	L	L

(Table 1: Equipment list in upstream oil production)

As we may note from the above table, it is clear that the upstream production facilities comprise of several mechanical equipment's which are highly maintenance intensive and need to be services and maintained well in order to reduce the downtime.

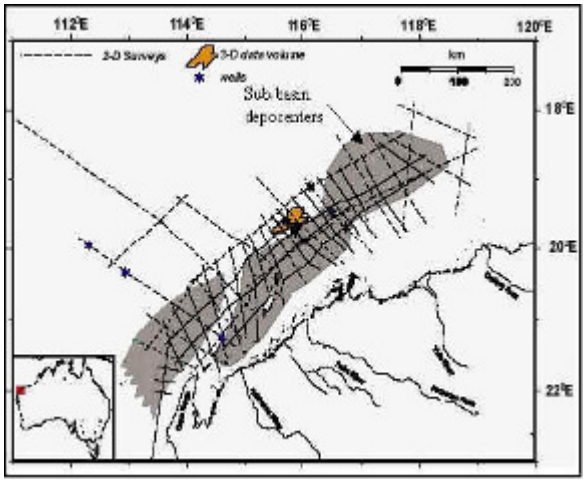
3. OPERATIONAL CONSTRAINTS IN ENSURING UPTIME

As has been mentioned earlier, the oil well production facilities are located in difficult offshore locations which are highly inaccessible to people as well as materials. The well locations are many times located hundreds of miles inside the sea and the only way to reach these locations is either by ships or by helicopters. Generally speaking there are multiple wells located in close proximity all having the facilities of exploration and production.

Figure 2below is a representative snapshot of the way the wells are generally located well inside the deep sea locations.

The well locations, as they are situated in such remote and complicated locations any kind of material supply or logistical activities requires very meticulous planning. Moreover the oil exploration and production operations are hazardous and need to be carried out under very high level of safety provisions[8]. All the equipment's and facilities installed need to be in top working conditions

and should support the oil exploration and production schedules.



(Figure 2: locations of oil wells at offshore)

The maintenance activities carried out are described in the figure 3 below[9]:

(Figure 3: Maintenance plans in upstream)

From the figure above, it can be noted that the maintenance activities are carried out under following categories:

a) Planned Maintenance:
   - Routine
   - Predictive
   - Proactive
   - Preventive
   - Shutdown

b) Unplanned Maintenance
   - Breakdown Maintenance

Amongst all types of maintenance activities, the one which impacts the organization the most is breakdown maintenance. Based on the statistics, it is seen that the unplanned downtime is almost 8% in some cases which is a significant impact to overall production costs as well as the profitability of oil exploration and production activities. The typical cost of oil exploration and production set up is exceptionally high and any such impact on profitability has considerable impact on overall economics of oil exploration and production.

Some of the critical areas where the uptime gets impacted as below:

- Availability of experts at these exploration and production locations to advice on equipment malfunctioning, abnormal operations, breakdowns
- Availability of spares well in time for carrying out maintenance activities. It has been observed that many times the maintenance activities are carried out without a proper availability of spares. Due to the locational hazards, many times it is not possible to get a full visibility and availability of spare parts. This results in non-availability of spares when required and results in equipment downtime. The statistics of one of the large Oil and Gas organization in upstream area is as per table 2 below:

Reliability Metric Summary

		Region 1	Region 2	Region 3	Region 4	Region 5
Production Efficiency (%)		94.9	96.6	96.3	91.2	95.1
⊟ Lost Production Opportunity (MBOE per day)	Total	77,216.58	13,872.92	18,676.16	31,617.95	13,049.54
	Surface Planned	18,870.95	3,206.54	3,868.65	9,334.25	2,461.51
	Surface Un-Planned	37,258.21	8,505.39	5,347.59	17,312.69	6,092.54
	Subsurface Planned	4,829.02	1,015.87	1,379.47	635.52	1,798.16
	Subsurface Un-Planned	16,258.40	1,145.12	8,080.45	4,335.49	2,697.33
Major Rotating Equipment Availability (%)		95.09	96.52	95.00	93.36	95.47
Major Rotating Equipment Reliability (%)		97.73	98.30	97.97	95.14	97.35
Major Rotating Equipment Runtime (%)		–	–	–	–	–
Surface Equipment LPO (MBOE per day)		473.06	7.34	10.59	455.13	0.00

(Table 2: Reliability Metrics and Equipment availability chart)

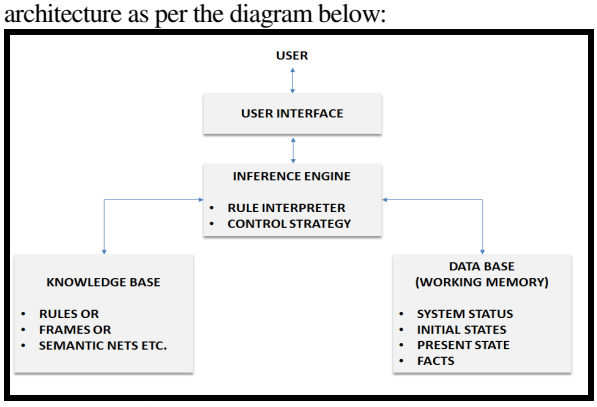
4. PROPOSED SOLUTIONS

In order to address both the issues stated in section 3 above, there are some powerful approaches proposed in this paper that can very well address the issue of downtime. The knowledge based industry has grown exponentially and has given multiple options for improving the overall operational aspects despite having severe locational and logistical constraints. These solutions can help in improving the reliability quotient significantly and result into improved profitability of the exploration and production organization.

Use of Expert Systems

Most of the equipment's installed and operated in the upstream facilities are rotating equipment's with a well-researched maintenance schedules and problem solving manuals. It is extremely difficult to get experts at the oil exploration and production sites especially since there are several types and makes of equipment's and systems installed. Many times the problems encountered have fairly simple solutions, but its just the absence of necessary expertise at the sites resulting in delayed resolution thus causing loss of production time. These kinds of cases are fairly commonly encountered in upstream operations and the downtime to equipment can prove to be very costly as it affects the production straight away.

The solution to making experts available is by making use of "Expert System" which has got system architecture as per the diagram below:



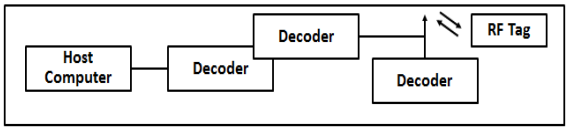
(Figure 4: Expert System schema)

The above system can actually be constructed based on repository of all commonly encountered problem with suggested resolutions. Based on the experience, almost 70% of the operational problems can get addressed if a properly designed Expert system is implemented for maintenance of all the equipment's and facilities installed on the platform.

RFID Tag based Inventory Control and Integrated ERP Operations

This is a system where all the essential spares critical for maintenance activities are tagged with RFID chips. The RFID chips will have following architecture.

RFID makes its products intelligent and interactive by using silicon chips as RF tags and senor technologies, along with wireless mobile communications. These chips can be embedded in a product or placed on consumers (via cards)[2]. This technology enables the products, inventory or any other physical assets into items that can sense, disclose their environment, their locations and other relevant information about the product.



(Figure 5: RFID Schema)

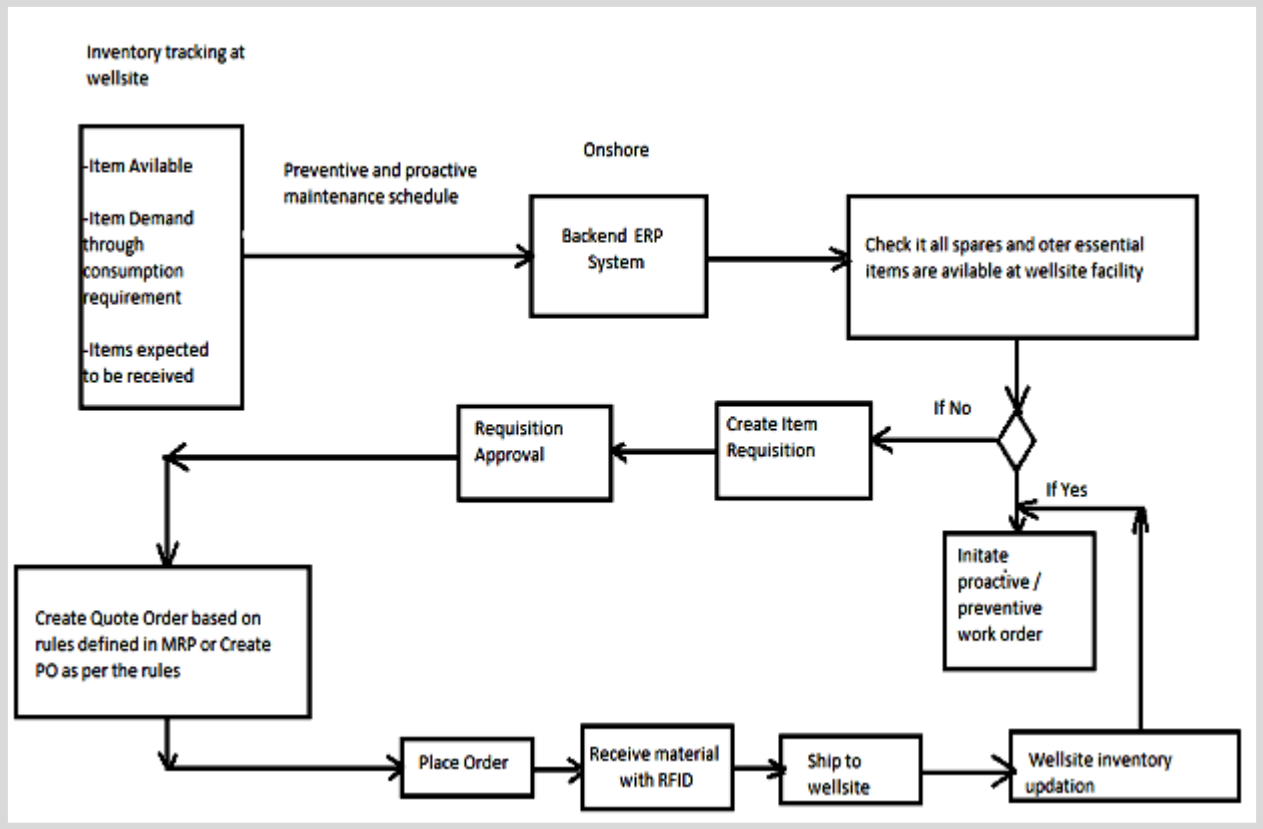
This RFID chip based systems helps in giving inventory locations at the production sites. The proposed solution is to integrate the RFID based information with backend ERP system for processing inventory transactions. The ERP systems developed would have "Business Rules" that can trigger maintenance orders only if a particular spare is available from maintenance perspective. The broad level features of such integrated systems are[3]:

- All maintenance activities would have listing of spares as essential for triggering ERP system
- RFID scanners can scan all the available spares at locations
- This information will be captured into ERP system through interface
- ERP system will generate procurement orders based on maintenance schedules being run based on lead time roll-up programs (typical lead time for procuring spares)
- Item demand query will summarize all spares requirement based on *"Future"* maintenance schedules
- The maintenance work orders will be initiated only when ALL spares are available
- The system can send messages through mobility offshore as well as onsite in case critical spares is missing or not available

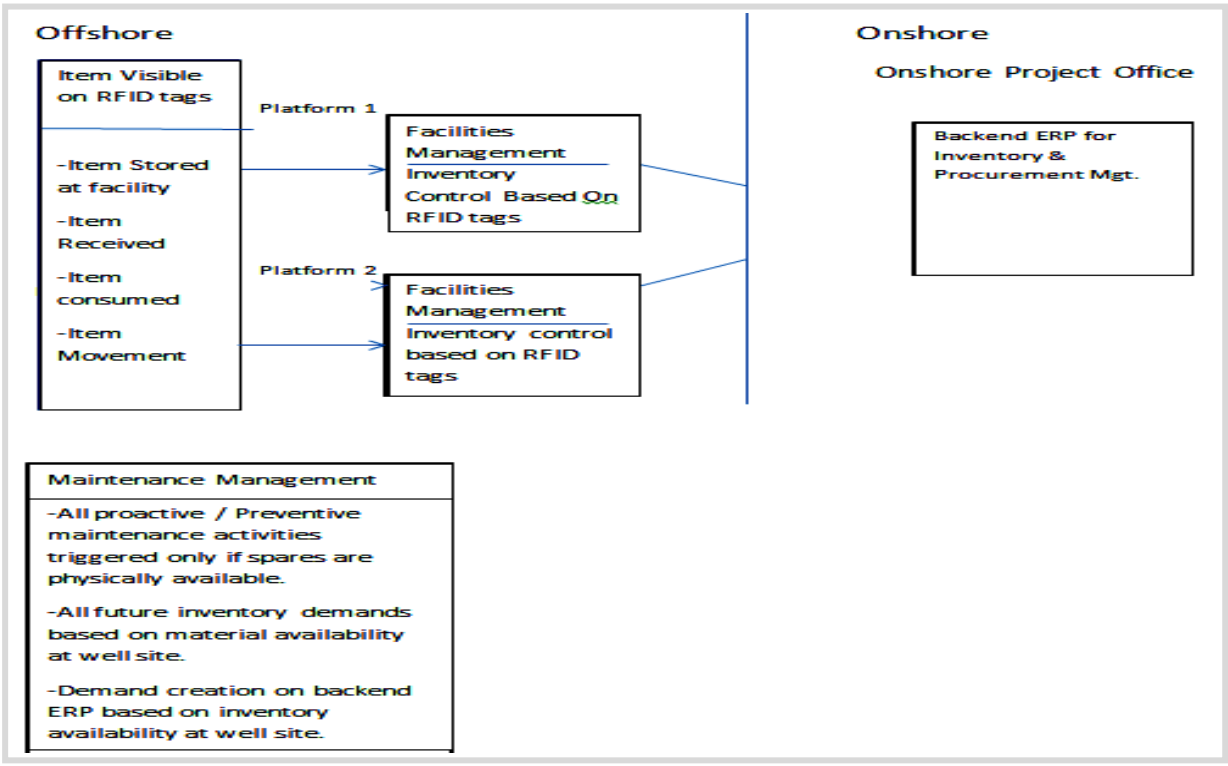
A typical simplistic business process of such integrated system is depicted in following Figure 6:

The above routine can be subsequently replicated across multiple well sites integrated centrally through a "Centralized ERP system". This can also facilitate a smooth transportation of the spares either through a helicopter service or through ships. This is explained in below Figure 7:

The back end ERP could be SAP, Oracle, Microsoft or and other ERP system.



(Figure 6: Maintenance routine integrated with inventory availability through ERP)



(Figure 7: Multiple well sites maintenance managed through onshore based ERP)

5. CONCLUSION

Upstream Oil exploration and production is very expensive proposition. Any downtime can be very expensive. While there are several factors for the downtime, such as bad weather, operational problems, planned shutdown, what concerns organizations is the unplanned downtime which has not been forecasted. The framework proposed is to identify all operational and equipment related problems using "Expert System" as well as using as RFID tag based inventory control integrated with ERP systems for ensuring predictability of all operational and critical spares before carrying out any maintenance activity. This system ensures absolutely fail proof maintenance routines thus bringing down the downtime of critical facilities and infrastructure to a manageable level. The typical downtime is between 5 to 12 % and by using this framework; the downtime can be reduced by clear 2 to 3% which is a major savings to the oil producing companies.

6. REFERENCES

1. Indian School of Petroleum, "Upstream Business Process", August 2007, Final Report
2. S. Jaya Krishna, RFID applications and cases
3. RFID solutions in Oil and Gas Industry, Motorola Mobile hand held solutions industry briefing
4. Oil and Gas Production Handbook, An introduction to Oil and Gas Production, HovardDevold
5. Offshore Technology Conference, 8th – 9th May, Houston, Presentation by Ziff Energy Group
6. Journal of Petroleum Technology, July 2013, Unplanned Downtime in the Gulf of Mexico, Richard M. Tucker, Tom Straub
7. Shutdowns and Turnarounds in the Oil and Gas Industry, Oil and Gas IQ
8. Environmental Management in Oil and Gas Exploration and Production
9. Mobility for smarter Infrastructure, Taking Maximo to the field, Puke, IBM Solutions connect release, Dec 2013