MANAGING mature assets

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The management of mature oil and gas assets is a complex and business-critical challenge that is faced by an increasing number of operators. End of field life (EOFL) is on the horizon for many fields, and ageing infrastructure or operating equipment requires decisions about replacements, refurbishments or decommissioning. These circumstances face changing risks and operating costs, such as maintenance and spares requirements. This paper considers two main areas. Firstly, the overall business/asset management perspective of this phase of asset life. This is when the asset is the whole business unit, comprising both reservoir and production infrastructure (Figure 1). Secondly, the more specific issues associated with individual equipment assets and options to change the mix of inspections, maintenance, replacements, upgrades and spares as such equipment gets older.

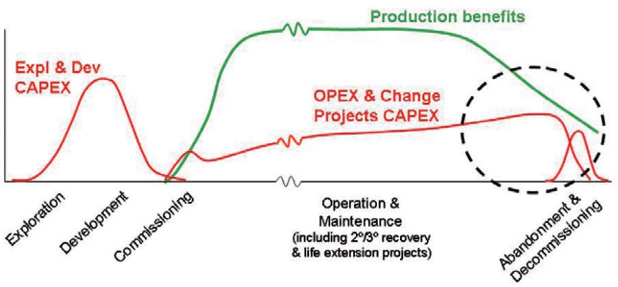


Figure 1. Generalised asset life cycle and the tricky end of life management area.

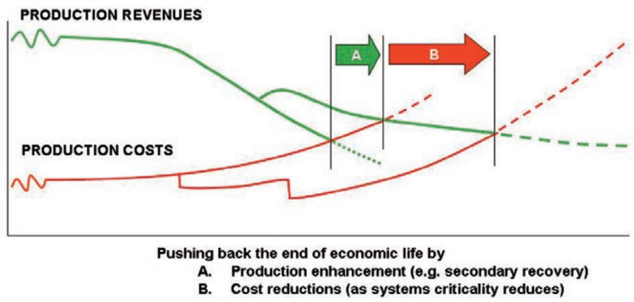


Figure 2. Exploring options to extend economic life.

An asset whole life plan

Of course the ideal situation is that end of life considerations and assumptions in the original field development plan have been captured and regularly updated with the changes in economic environment, development of new technologies, licencing relationships etc. Some organisations, e.g. Shell E&P and BP, use an asset whole life plan, or asset reference plan, to centralise all assumptions and act as a single source of truth for everybody. This is a plan that develops continuously from initial exploration through to field development, operations and maintenance, and final abandonment plans. Such a master plan should include the clear description of asset characteristics, the investment programmes, commercial and production plans, resource requirements, dependencies and risk management. If such a document exists, therefore, it is the obvious starting point for a controlled revision of the operating, maintenance and resource requirements during asset old age, including searching for options for life extension and cost efficiencies.

Of course, many assets and operators do not have such a convenient and joined up view of their ageing assets, and need to manage in a situation of poor historical records and data quality, fragmented functional responsibilities and conflicting performance pressures. In fact, it is this confusing scenario that represents the greatest value and urgency for introducing a systematic approach to maximise value in the remaining life available; when chaos rules, any structure and discipline has a disproportionate benefit.

Managed decline

The central problem in managing ageing assets is one of finding the least bad mix of reducing production scope, or asset performance, and increasing costs of operations and maintenance. This underlying challenge applies both to the macro scale of total reservoir/field economics and to the component equipment and production systems involved. Life extension, in both cases, can be achieved by finding ways of raising performance and/or reducing ongoing operating and maintenance costs. Figure 2 shows how the economic cut off point can be deferred by a combination of these efforts.

Evaluating opportunities and optimal timing

Most projects and investments are evaluated for cost/benefit using established criteria for net present value, cashflow modelling etc. Despite widespread understanding and usage in other industries, and the existence of an ISO standard[1] in the oil and gas sector, the application of life cycle costing methods is still only sporadic and is often incomplete or distorted, e.g. ignores risk, reliability and efficiency elements, or only considers a fixed horizon for benefits prediction. There are very considerable opportunities for E&P companies to improve their basic methods for project appraisal, both in the early life stage, e.g. in the design and engineering phase, such as equipment selection, and in the end of life decision making. For example, the BP Andrew project reduced total life cycle costs by approximately 30% by taking such a whole life cost/benefit view in the design and development phase. As EOFL approaches, such opportunities may not be as great, but there is still significant scope for extended profitable production and for better risk management or cost savings.

The following section considers how they can be applied, for example, to:

- Production improvement projects that extend profitable field life.
- Phased reduction of maintenance and spares as EOFL approaches.

Field life extension projects

Many opportunities to improve value for money are missed in the selection of which projects or activities are worth performing in the managed decline environment. For major investment programmes, such as a programme of infill drilling or introduction of secondary/tertiary production methods, there is usually enough at stake to justify development of full 'what if?' simulations and cashflow projections for each scenario. However, the small and many projects including individual well improvements, equipment modifications, new technology opportunities etc., are often missed, mis-targetted or mistimed. This is at least partly due to the lack of understanding and usage of proper life cycle cost based decision processes and tools.

The correct procedures should employ at least two levels of sophistication to determine which life extension projects, or cost reduction opportunities, are worthwhile and when they should be optimally timed. As was discovered in the European MACRO project[2], there is a big difference between project decisions that can be handled by simple before and after benefits appraisal and those that require consideration of optimal timing, life extension or cyclic activities, e.g. inspection, maintenance or equipment replacement/disposal. In the latter cases, the cost/benefit/risk criteria need to consider the pattern of deterioration and the degree of deferment of other expenditures or consequences to determine what is worth spending and when. So, while a project to increase production by a fixed amount can be evaluated as a net present value of the costs and subsequent benefits, if the decision is affecting the slope of future production rates, costs or risks, then more sophisticated appraisal is needed.

Fortunately, the decision support tools and procedures are well developed nowadays, so the main challenge is one of education and selective application. APT-LIFESPAN software, for example, ensures that the right questions are asked in describing patterns of changing risk, performance and costs. It then calculates the optimal intervention timing, and performs sensitivity testing to the assumptions to determine the robustness of the conclusion. It is used to evaluate:

- Equipment or system life extension projects.
- Refurbishment versus replacement options.
- Optimal timing for equipment replacement or upgrade.

System performance simulation tools, such as RAM[3] modelling, can also be used for similar decision support purposes, but the setup effort and data dependencies are much higher. These techniques are more suited to the design phase or major infrastructure configuration decisions, where thousands of small component assumptions need to be considered for their net effects. As the MACRO project revealed, the degree of analytical effort worthwhile to support decisions must depend on a combination of decision criticality and decision complexity. RAM modelling is worthwhile when decisions are both critical and very complex.

Reducing maintenance and spares

Inspections, condition monitoring, planned maintenance, and the contingency planning resources such as critical spares, can be progressively phased down as the EOFL approaches. But which tasks or expenditures should be discontinued, when?

Most maintenance and integrity management activities are, or should be, based upon a consideration of equipment functional criticality, failure modes and effects, and a logical selection of prediction, prevention, detection and correction tasks. Reliability centred maintenance (RCM) and risk based inspection (RBI) methodologies are examples of such decision tree logic to determine what tasks are appropriate in which case. As production declines, however, the criticality of component systems and equipment reduces in line with the lower consequences of failure. When items do fail, the degree of repair or replacement that is justified may also be affected; there is little point in a total renewal if a cheaper patch and continue option would see the system through to the EOFL. Determination of the appropriate reduction in infrastructure maintenance is a matter of calculating the changing cost/risk equation. Long cycle activities, such as compressor major overhauls, will be among the first to need reviewing, along with the inspections/monitoring of slow degradation mechanisms and activities that are aimed at equipment life extension, such as painting and oil changes.

The optimisation of such activities was also addressed by the MACRO Project consortium. The APT-MAINTENANCE tool, for example, calculates the optimal interval for tasks based on the mix of planned expenditures, failure risks, operational efficiency and life expectancy. It is

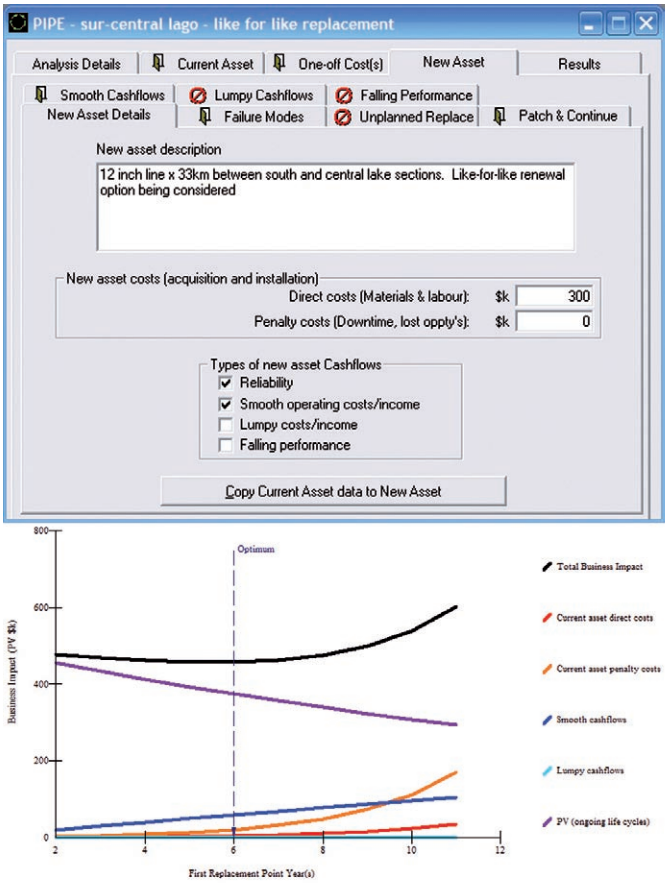


Figure 3. Optimal pipeline renewal timing.

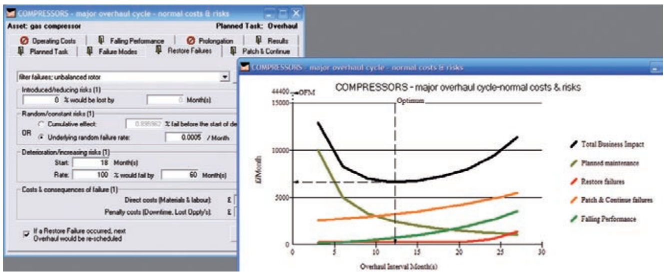


Figure 4. Calculating optimal maintenance intervals with incomplete data and structured tacit knowledge.

particularly effective in cases where there is little or no hard data available: the process captures and uses range estimates and tacit knowledge in a structured way, and then determines the best blend of costs, risks, performance impact and residual life (Figure 4). When production rates and failure consequences are reducing, therefore, it is simple to evaluate, almost instantly, what the appropriate extension in maintenance frequency should be (Figure 5).

Spares and inventory reductions

This is a quick win area if a logical, risk based process is followed, instead of the sweeping and shortsighted methods that are so common. The MACRO guidance and toolkit in this area represents one of the simplest and yet biggest opportunities in all the areas that were addressed. There are 13 key questions and a bit of economic/risk mathematics necessary to determine if a critical spare should be held in

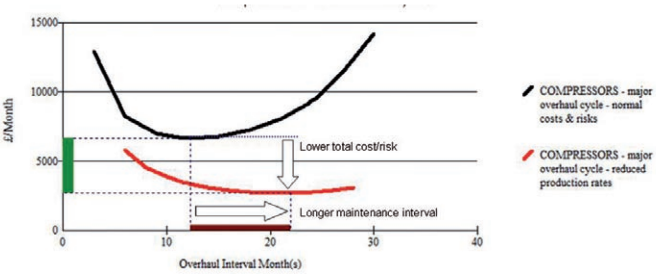
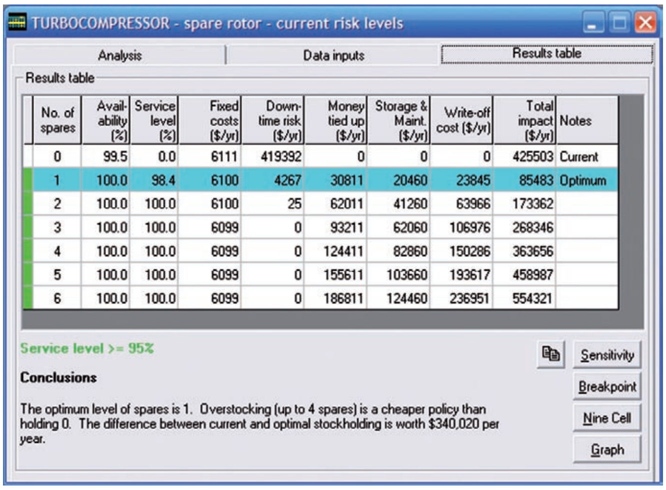


Figure 5. The impact of reduced production rates on maintenance intervals.



No. of spares	Avail-ability (%)	Service level (%)	Fixed costs ($/yr)	Down-time risk ($/yr)	Money tied up ($/yr)	Storage & Maint. ($/yr)	Write-off cost ($/yr)	Total impact ($/yr)	Notes
0	99.5	0.0	6111	419392	0	0	0	425503	Current
1	100.0	98.4	6100	4267	30811	20460	23845	85483	Optimum
2	100.0	100.0	6100	25	62011	41260	63966	173362	
3	100.0	100.0	6099	0	93211	62060	106976	268346	
4	100.0	100.0	6099	0	124411	82860	150286	363656	
5	100.0	100.0	6099	0	155611	103660	193617	458987	
6	100.0	100.0	6099	0	186811	124460	236951	554321	

Figure 6. APT-SPARES evaluation of optimal spares requirements.

stock. When production is declining and EOFL getting nearer, the justification will be changing, particularly in three such key factors:

- The consequences of equipment failure will be reducing and hence the value of holding a spare just in case.
- The chances of failure in the first place may be rising as equipment ages and/or maintenance is reduced.
- There is a growing risk of obsolescence or non-usage of spares that are held which is writing off their value.

The net effect of these changing circumstances needs to be considered whenever a critical spare is used or in periodic reviews of the inventory. A systematic, criticality targeted review of the rotating equipment spares for one North Sea E&P company, for example, revealed over US$ 150 million in reduced production risk and direct cost savings that could be made by adjusting which spares were kept, where, and in what quantities (Figure 6).

A new lease of life?

So far, the deterioration of asset performance towards the end of economic life, and the opportunities for reducing the decline or saving money during this phase have been considered. Of course the situation can change. If a major change in circumstances occurs, such as increases in oil price, or a new extraction technology becomes available, or operating licence extension, the exploitable EOFL might be suddenly changed. In this situation, we may be faced with already degraded infrastructure, which is approaching or exceeding its original design life and is no longer supported by OEM suppliers. In such cases, the correct project reinvestments and rapid shifts in maintenance and purchasing strategies are needed. Equipment renewals and refurbishments, materials upgrades, painting programmes and spares decisions become critical. For one North Sea operator, whose platform was suddenly given a further 10 year viable economic life, a review showed that approximately 25% of the annual maintenance budget would now need to be spent on painting and corrosion control. Getting these sorts of decisions wrong is very expensive and, more importantly, can render the new extended life very risky or even unprofitable.

In this environment, the pre-existence of RBI studies is invaluable. It allows the identification of potential integrity weakpoints, and remedial attention to be focused where it matters most. Certain key equipment items may need to be refurbished or replaced, and the same life cycle costing criteria are needed to evaluate which way to go, how much is worth spending, and when. Decision procedures will also need to consider obsolescence risks, existing operator and maintenance competencies and spares when comparing like for like replacements with new technology alternatives.

This is the scenario faced by other industry sectors as well, albeit for different reasons. Much of the European and US civil and utilities infrastructure was built during relatively short and intensive periods approximately 80 and 40 years ago. The electricity distribution networks, water supply and wastewater systems are all reaching their old age together and major reinvestment is required to meet future growing demands at a time when funding is increasingly constrained. Similarly, the UK mainline and metro railway networks are facing the massive challenges of managing deteriorating assets in a time of increased operational demand and restrictive resourcing. The London Underground system alone needs an estimated US$ 20 billion of reinvestment over a 30 year period. This does mean, however, that the problems of managing ageing assets are widely encountered, and examples of good practice can be found in the most unlikely places.

It has been decided, therefore, to update the research programme started by the original European MACRO project. The SALVO project (Strategic Assets: Lifecycle Value Optimisation) will, over the next three years, collate and refine the steps and best practices that are needed in the optimal management of ageing assets. It will refresh the learning points of the original studies and publish a combination of procedure guidance and case studies to enable better value maximisation in a fast changing world. The project is a cross industry collaboration, with a small number of selectively invited participants from international organisations and leading universities. Representatives from the electricity, transport and petrochemicals sectors are already involved, but at the time of writing, no E&P company has yet been identified as a core participant. OT

Notes

1. ISO 15663 Petroleum and natural gas industries: life cycle costing.
2. See www.macroproject.org.
3. RAM: Reliability, Availability & Maintainability (sometimes extended to RAMS to include safety).