General Technical Paper

The Challenges of Extending the Life of Topsides Equipment - it's not just Corrosion Related

Authors:	Andrew M Hollins	AMIMechE	ABB Engineering Services
	Brian G Hudson	FIMechE	ABB Engineering Services

Synopsis

Many of the Licence Holders and offshore operators are requiring their offshore installations to operate for 20-30 years beyond their original design life, whilst continuing to meet business and regulatory requirements for reliability and safety. The longer term viability of the field and the remaining life of the jacket are the fundamental considerations. The topsides equipment is also a major consideration.

A typical design life for topsides equipment is 20 to 25 years and much of the installed equipment is approaching or has already passed its design life. Operating the equipment beyond design life does not mean that it is no longer fit for service and will automatically require replacement. Experience suggests that, under the right circumstances, much of the topsides equipment can be operated for far longer. However, the operators of these assets face a common challenge namely, "how to maintain production capability against changing operational demands in a cost effective way whilst preserving integrity of the equipment?"

This paper reviews the principal factors affecting the on-going operation of the topsides equipment as it exceeds or approaches the end of its design life. Whilst corrosion is the most significant degradation mechanism the authors experience is that due consideration needs to be given to a much wider range of factors.

These factors include obsolescence, and the potential consequences of changes in process fluid conditions and composition. The age and competence of the workforce needs to be addressed as does the quality of historical records and the possible requirements for maintaining these into the future. Changes in legislation and standards also need to be considered.

Introduction

The offshore industry faced and overcame considerable challenges in opening up the North Sea. The "easy oil and gas" has by now been largely recovered. Oil and gas are now being recovered from more marginal fields and from more challenging fields in deeper water in areas such as West of Shetland and extending further north in the Norwegian sector into the Norwegian and Barents Seas. Even so many of the companies operating on the UK continental shelf are talking of production for a further 20 to 25 years. The Norwegian Petroleum Directorate is anticipating continuing production from the Norwegian continental shelf well into the 2040s (Source FACTS 2008).

Mature fields are generally characterised by falling production rates and increasing unit production costs set against a background of infrastructure that is already operating way beyond its intended design life and, typically, may be required to operate for anything up to another 30 years. This is summarised in figure 1.

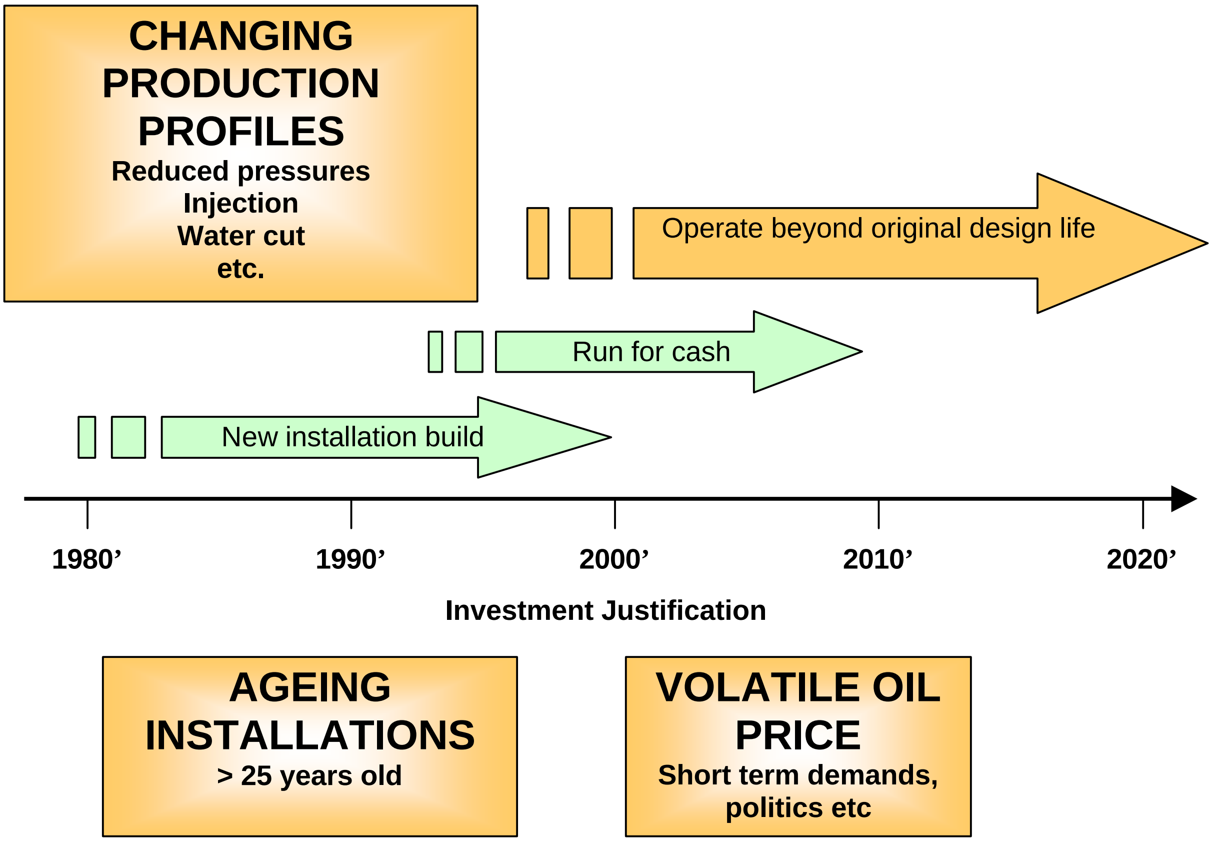

Figure 1: The Challenge facing Operators

Field lives have been extended by techniques to achieve increased recovery rates and, until quite recently, higher oil prices. New operators have acquired existing assets and are keen to maximise their returns by operating these assets in the most cost effective and compliant manner up to the point of decommissioning.

Recovery rates have increased with changes in technology. In the 1990s average recovery rates for oil were circa 40% and these have now increased to around 45 % or better. Nevertheless this still leaves substantial resources unexploited. New technology makes it possible to drill wells and develop wells in ways in which were simply not technically feasible in the past. For instance, smaller previously marginal fields can be exploited by tie-in to established platforms to make use of the existing infrastructure. Such fields are often too small to justify stand alone development.

Even so the lifetime of existing infrastructure is limited and it cannot be extended indefinitely. Therefore we find ourselves in a race to recover the economically producible reserves before the infrastructure has inevitably to be decommissioned. The overall challenge for the offshore industry is to increase the recovery from fields in production, to develop marginal fields near to existing infrastructure and to operate fields more cost effectively.

The long term viability of a field, in terms of recoverable reserves and a forward view of the likely oil price, is the key life extension consideration. Once the Licence Holders have determined that continuing to operate the installation is a worthwhile proposition up to a revised decommissioning date, establishing the overall capability of the existing asset to continue in operation for the extended period is the next step. When the world economy returns to growth there is reason to believe that oil prices will recover to a relatively high level in years to come.

The first stage is to determine whether the jacket is capable of literally supporting the topsides for the extended period. This aspect of offshore life extension has received extensive consideration. Indeed the Offshore Engineering Committee ran a successful seminar earlier this year on the Risk, Reliability and Life Extension of Ageing Offshore Structures. At this same seminar ABB presented a paper on North Sea Mature Field Asset Life Studies which focussed on the topsides equipment. Our continuing experience of performing these studies indicates that the following are key areas for equipment life extension that are often overlooked:

- Obsolescence
- Changes in process fluids
- Workforce age and competency
- The quality of historical records
- Dependence on contractors
- The regulatory framework and changes in legislation

This paper will explore these issues in more detail. Before doing so we will describe what a structure process for extending the life of topsides equipment should cover and provide some examples to illustrate what can often be missed.

Extending the life of topsides equipment

Having established that the jacket will continue to be capable of supporting the topsides, the topsides equipment must clearly be able to deliver the Licence Holder's new requirements for extended operating life, often with changing future demands and operating regimes, while maintaining HSE standards and compliance with legislative requirements.

This can best be achieved by undertaking a structured process to extend the life of the ageing asset by ensuring that it will remain fit for purpose. The deliverables of this process should include:

- An overview of the deterioration mechanisms and current status
- Asset life cycle actions and associated OPEX
- The identification of opportunities for improvement
- The development of CAPEX profiles for the investment required to maintain asset integrity, reliability and uptime. To secure stakeholder support and investment for future operation
- The capability of the equipment against the anticipated production profiles

The basic process for assessing the integrity of the equipment and its future life is shown in figure 2.

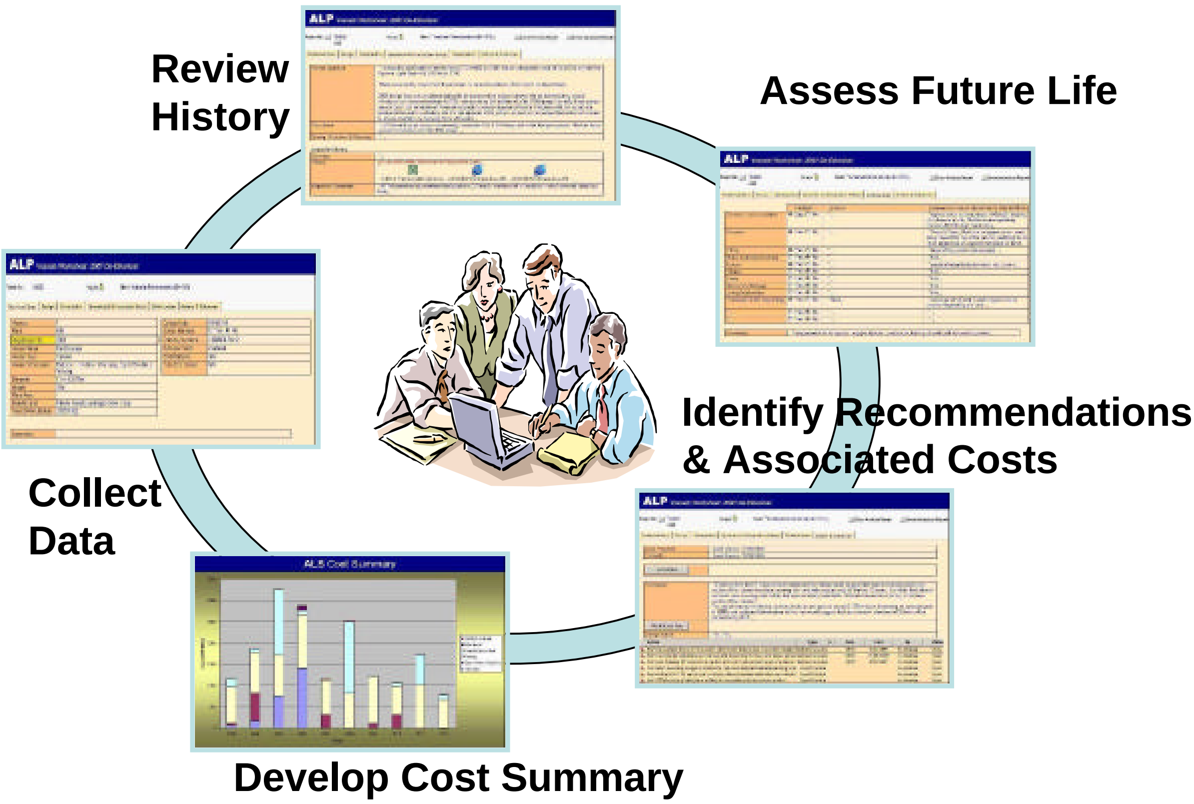

Figure 2: Asset Life Extension Assessment Process

A typical list of the deterioration modes relevant to topsides equipment includes:

- Corrosion - particularly that arising from changing operations and production profile
- Corrosion under insulation
- Microbiologically induced corrosion
- Erosion
- Fatigue - particularly where corrosion and material loss results in stress increases
- Creep / thermally induced deterioration
- Wear out
- Overstress as loadings change over time
- Dead legs for corrosion and overstress – including those resulting from blockage or choking

The equipment deterioration modes are dominated by corrosion considerations. This should not be surprising as analysis of equipment failures shows that corrosion is the dominant failure mode. This is illustrated by the data shown in figure 3.

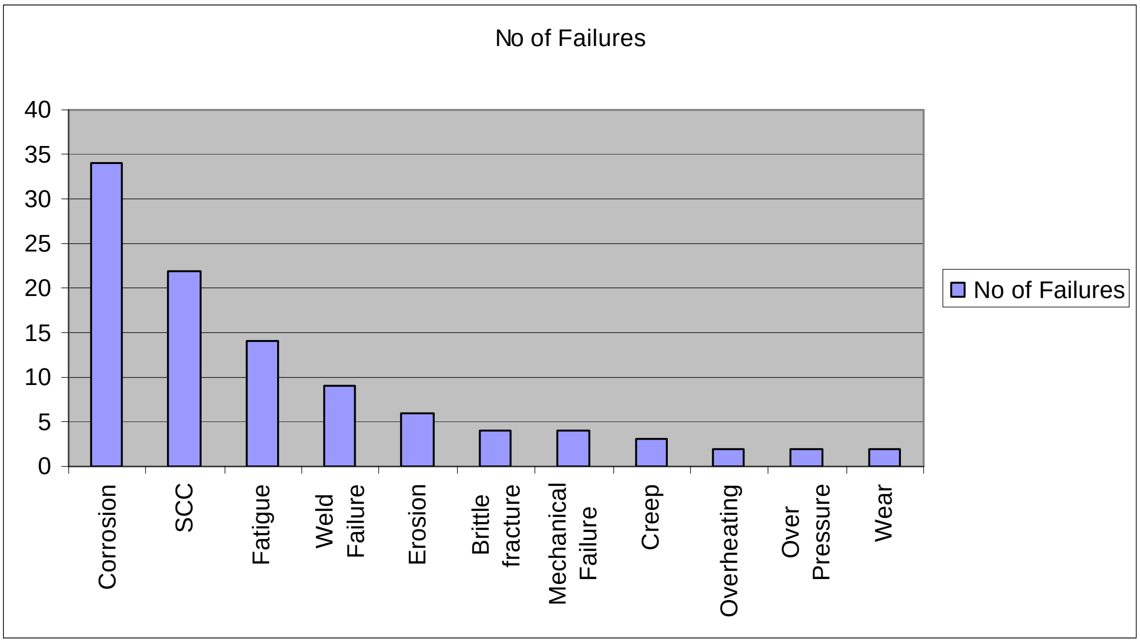

Figure 3: Data showing common causes of equipment failure

Nevertheless extending the life of the topsides equipment is not simply the integrity of the individual equipment items; such as the degradation of pipework or vessels. It also necessitates appropriate consideration of the ongoing capability and competencies of the operations, maintenance and engineering organizations to enable the life to be extended and cope with changes in operational circumstances. Furthermore, the equipment must also be capable of dealing with changing production demands such as changes in the anticipated process fluid composition and production rates as well as new deterioration mechanisms or potential failure modes that might arise from these changes. These aspects are given more detailed consideration in the following sections.

Some examples of what can be missed

The importance of considering these other aspects can best be illustrated by reference to some examples where important factors affecting the asset operation were overlooked and have subsequently caused significant issues.

- 30 year old equipment with low measured corrosion rates suffering accelerated corrosion damage driven by increasing levels of contaminants due to changes in fluid compositions.

- The life assessment focused upon the main hydrocarbon pipework. Failure to recognize the significance of the condition of the small bore pipework and branches resulted in failures with potential significant loss of containment.

- Compression trains did not have sufficient turn down capability to run reliably at reduced pressures and flow rates with a different molecular weight range.

- An increased requirement for electrical power due to installing addition equipment meant that the installed power generation capacity was no longer insufficient.

- Increasing unreliability of utilities – i.e. cooling water systems.

These are all pretty basic things but serve to illustrate why considerations of equipment life extension should not be too narrowly focused.

Obsolescence

Given the age of the equipment much of it was made by manufacturers who no longer exist or who are no longer prepared to support it into the future.

Obsolescence particularly affects the following types of topsides equipment:

- Rotating equipment
- Electrical equipment – i.e. switchgear
- Instrumentation
- Control Systems and software

One way of addressing this issue is to plan for the replacement of the obsolete equipment. However, the fact that the manufacturer no longer exists or is no longer prepared to support the equipment need not, of itself, necessitate its replacement. It should be recognised that continuing to operate obsolete equipment may require a different operating and maintenance philosophy. Obsolete equipment should be tested against the following questions:

- How reliable is it and is it getting less reliable as time passes?
- What are failures costing in terms of lost production and is this likely to get worse?
- Can the equipment be readily maintained?
- Are replacement parts and assemblies readily available or are they easily reverse engineered ?
- Are there companies supporting the aftermarket with spares and overhaul capability ?

The cost of operating the equipment over the remaining operational life can be assessed relative to the cost of replacement. Most rotating equipment can be supported in the above manner and can usually achieve an operational life exceeding 40 years. Electrical switchgear can also be supported after it has ceased production. The same cannot usually be said for software and computer based systems.

The best approach to obsolete equipment is to selectively replace the equipment which cannot be maintained into the future and to put in place effective strategies to manage the maintenance and repair of that which is to continue in operation.

Changes in process fluids

The fact that the equipment may have operated successfully and reliably for 25 + years without suffering significant deterioration does not necessarily mean that it will continue do so into the future if the fluid within the equipment changes significantly.
As wells are depleted the pressure and flow rates are reduced, the amount of produced water and solids can increase and the composition of gases can change significantly. The resulting change to the process duty may be outside the operating range for the installed equipment requiring significant modification or even replacement.

The following are typical problems created by changes in the process fluid:

- Equipment designed for single phase flow may, in future, have to process multiphase flow either continuously or during transients.
- Compressors may not be able to handle increased differential pressure, lower flow rate or changes in molecular weight.
- Increases in levels of entrained carbon dioxide or hydrogen sulphide can cause rapid increases in corrosion rates and can present an increased safety hazard.
- A 10°C increase in operating temperature can double the corrosion rate.
- Increased solid content can result in more rapid erosion of pumps, valves and at pipework bends.

The capability of the installed equipment to cope with changes to process duties needs to be adequately considered in assessing its suitability for continued operation.

Workforce age and competency

Safe and reliable operation is underpinned by a competent workforce. The age profile of existing operations and maintenance teams means that highly experienced personnel, many with 20+ years experience, will increasingly be lost to the industry as time progresses principally through retirement. The vulnerability to the loss of the collective knowledge held within the heads of such persons needs to be factored into any life extension study. Opportunities for succession planning and knowledge retention for key operating and maintenance roles need to be identified.

Part of the answer comes from applying new technologies to permit changes in working methods. Continuing developments in control and automation, and communications technology are enabling new working methods to be implemented. Application of these technologies facilitate improved decision making and enable equipment and processes to be remotely controlled. On-going operation can be controlled by fewer persons with different competencies. Some functions and personnel can be relocated onshore. This, in turn, can lead to more effective operation with consequent reduction in operating costs.

The installation of telemetry and/or high speed fibre optic links mean that some installations can be de-manned and operated from an integrated control room located either on a nearby offshore facility or from onshore. It seems inevitable that future operations will need to be supported by investment in an increasingly sophisticated digital infrastructure.

Quality of historical records

The quality of the available input data clearly has a major influence upon the confidence in the outputs delivered by any life extension study. The management of data is a challenge for all organisations. We are all aware of problems with electronic data in formats which can no longer be read. As well as issues with comprehensive operating and maintenance data only being available back to the last change of the maintenance management system. Earlier data was lost when the systems changed over.

Assembling the operating data and maintenance and inspection records for the asset from incompatible and incomplete records can be a time consuming task and there always gaps at the end of the process.

In extending the operational life of the asset, what is already 30 year old information and data will need to be kept for a further 30 – 40 years. The asset needs a strategy for keeping its records up to and beyond the decommissioning phase. By way of comparison the nuclear industry faced with keeping records over a much longer timeframe appears to be favouring paper based records for long term retrieval.

As pointed out in the previous section, retention of corporate knowledge is a significant issue as much resides in the heads of ageing staff. Retaining this important knowledge resource is a challenge. This cannot be addressed simply by moving to a software based document management system. A detailed understanding of what information needs to be retained for future reference is required together with a plan to assemble it and maintain it into the future.

Dependence on contractors

The development of the offshore oil and gas fields has relied upon the support of specialist contractors to build, maintain and support the continuing operation of the offshore assets and infrastructure. Since the 1990s the trend has been for the major oil companies to exit from the North Sea to be replaced by new smaller companies who have acquired the assets with the intention operating them at a lower cost base.

The new operators have much leaner organisations and are consequently even more dependent upon support from the contractor base. Dependence upon contractors seems set to increase. Going forward effective operation of assets will be increasingly dependent upon sharing of information with third parties. Agreement as to the ownership of knowledge, records and maintenance histories is consequently essential for the on-going operation of the equipment. It should be appreciated that this extends beyond the duration of the contract.

Regulatory framework and changes in legislation

Changes in safety and environment legislation since the asset was originally designed and commissioned can present some significant issues to life extension for the topsides equipment. Understanding the objectives of new legislation and why standards have been changed is an important consideration in assessing the current and future impact on ageing equipment and its suitability for continued operation.

At the most fundamental level there is a need to provide a technical justification for operating the equipment way beyond its life within the in Safety Case. Clearly a thorough asset life extension study is an effective way of providing suitable justification.

The key findings of the HSE's KP3 Programme included the maintenance of safety critical elements and high levels of maintenance backlog on some installations. In the KP3 Programme Report the HSE stated that in the light of the findings from KP3, asset integrity will continue to be one of Offshore Divisions main priorities for the foreseeable future. One of the underlying assumptions of an asset life extension process is that equipment will be correctly maintained into the future. Operators can consequently expect find it increasingly difficult to justify ongoing operation with significant levels of maintenance backlog.

Beyond this there can be more specific issues. Like for like replacement of old equipment can fall foul of the requirements of ATEX & PFEER and an ATEX compliant replacement may need to be specified.

The requirement to control emissions can be a particular problem for extending the operating life of equipment. For instance, existing gas turbine installations may not be able to meet future CO and NOX emission requirements. Measures to increase recovery rates from wells frequently require the installation of high pressure injection pumps and/ or booster compressors. These increase the electrical power consumption with a consequent increase in emissions. Also HVAC refrigeration systems using R22 need to have this replaced.

In some instances there is the potential for conflict between the various requirements of different sets of regulations. Diesel engines for installation within hazardous areas are a case in point. ATEX requires the control of potential ignition sources and imposes limits upon surface temperatures. Conversely the need to reduce emissions by increasing the efficiency of the engine will tend to increase operating temperatures. While the manufacturers of new diesel engine packages have addressed this issue existing installations may not be able to comply and may require replacement.

Consequently the requirements of regulatory framework needs to be given due consideration within a life extension study.

Conclusion

Licence Holders and Operators are increasingly looking at ways to increase field life as a means of creating longer revenue streams.

Operating topsides equipment way beyond its design life will be a feature of on-going operations in the North Sea and elsewhere for the foreseeable future. For topsides equipment corrosion is the most significant degradation mechanism but any consideration of extending the operational life must, of necessity, consider a much wider range of factors that are essential for the safe and reliable operation of the equipment. Figure 4 illustrates some of these factors. Ensuring that these are in place and remain effective throughout the extended life of the asset is but one of the numerous challenges for the offshore industry.

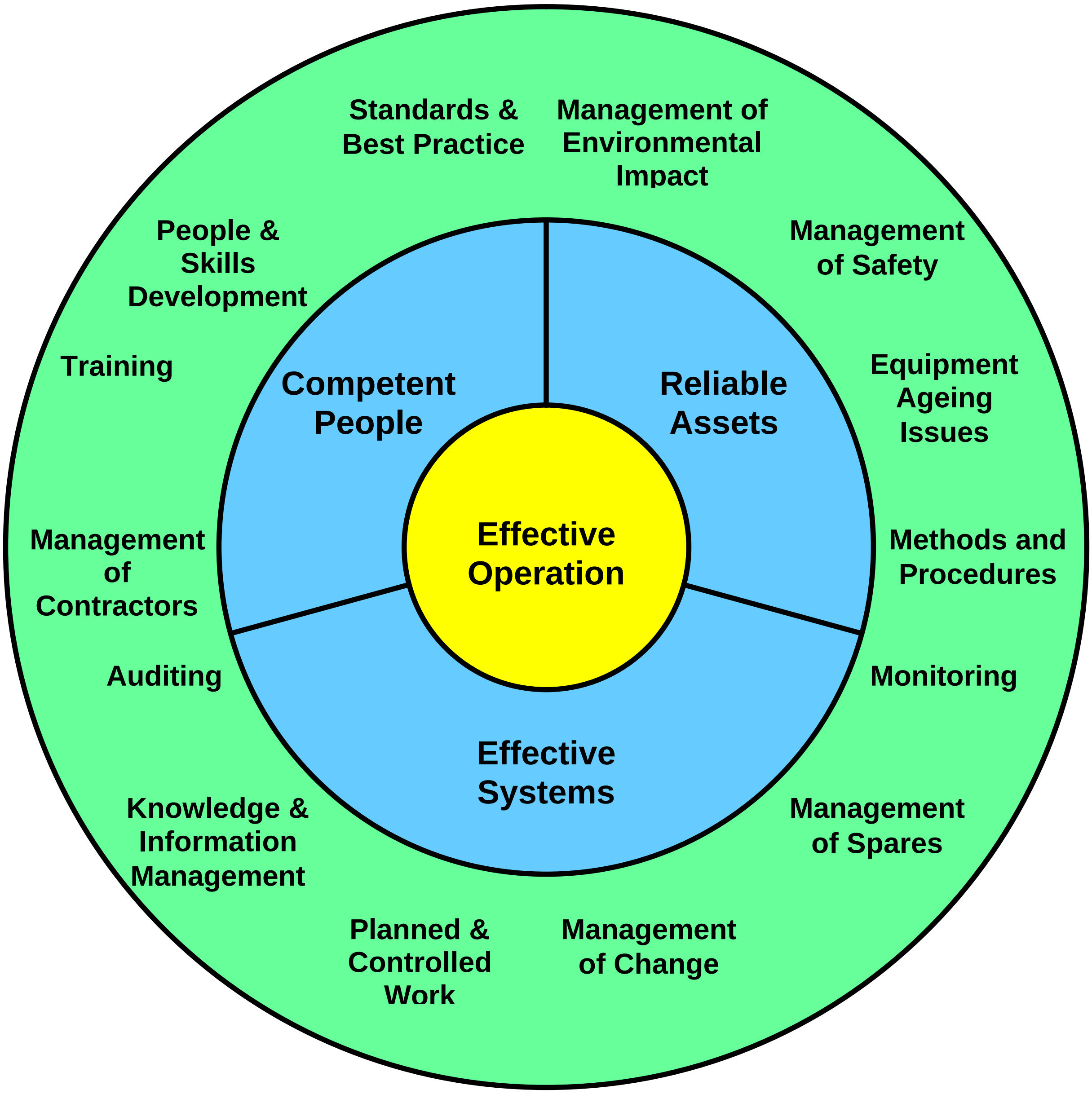

Figure 4: Some of the factors necessary for effective on-going operation

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B G Hudson, Seminar paper presented at IMechE Risk, Reliability and Life Extension of Ageing Offshore Structures Seminar in Aberdeen, 25 February 2009.

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