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Viewpoint

Applying maintenance strategies from the space and satellite sector to the upstream oil and gas industry: A research agenda

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HIGHLIGHTS

- Oil and gas industry and space and satellite sector are very similar in several important ways.
- Paper suggests that oil and gas industry should adopt best maintenance practices from satellite sector.
- Research agenda outlined to accelerate the rate of learning and sharing between the two industries.

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ABSTRACT

Practitioners from both the upstream oil and gas industry and the space and satellite sector have repeatedly noted several striking similarities between the two industries over the years, which have in turn resulted in many direct comparisons in the media and industry press. The two sectors have previously worked together and shared ideas in ways that have yielded some important breakthroughs, but relatively little sharing or cross-pollination has occurred in the area of asset maintenance. This is somewhat surprising in light of the fact that here, too, the sectors have much in common. This paper accordingly puts forward the viewpoint that the upstream oil and gas industry could potentially make significant improvements in asset maintenance—specifically, with regard to offshore platforms and remote pipelines—by selectively applying some aspects of the maintenance strategies and philosophies that have been learned in the space and satellite sector. The paper then offers a research agenda toward accelerating the rate of learning and sharing between the two industries in this domain, and concludes with policy recommendations that could facilitate this kind of cross-industry learning.

1. Introduction

Practitioners from both the upstream oil and gas industry and the space and satellite sector have repeatedly noted several striking similarities between the two industries over the years, which have in turn resulted in many direct comparisons in the media and industry press. A senior program manager at the U.S. National Aeronautics and Space Administration's (NASA's) Jet Propulsion Laboratory notes that, in many respects, the oil and gas business "is not that different from space exploration. How does landing on Mars have anything to do with managing assets [in an oil company]? Both enterprises have objectives that are very hard from a technical and management/leadership perspective, and both have the same almost paranoid aversion to risk and failure" (Cook, 2006). And getting subsea oil production equipment into place on the ocean floor has been likened to "landing a ship on Mars but with more extreme temperatures and pressures" (Gold and Campoy, 2007, p. B6). The similarities between the two industries have even resulted in a modest amount of cross-pollinating between their respective supply chains. Because the operating conditions of both industries are so extreme, some oil and gas equipment vendors have occasionally sourced motors and other parts from aerospace contractors (Gold and Campoy, 2007).

The two sectors have also crossed paths before within the academic literature in ways that have yielded some important breakthroughs. Satellites are now being used to assess oil fires (Limaye et al., 1991), detect subsidence in oil fields (Fielding et al., 1998), measure oil spills (Brekke and Solberg, 2005; Macdonald et al., 1993), collect and transmit operational data from oil and gas fields (McCoy, 2009; Sann, 2011), and monitor the movement of icebergs that might potentially collide with offshore installations (Randell et al., 2011).

Relatively little sharing or cross-learning has occurred between the two industries with regard to asset maintenance, however. This is somewhat surprising in light of the fact that here, too, the sectors have much in common. First, the technical challenges facing both industries are often complex and technologically demanding (e.g., Kluger, 2012;

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Tillerson, 2006). Second, assets in both sectors are typically difficult to access and offer limited servicing opportunities. Third, they both operate in harsh environments (e.g., Jukes et al., 2011), and manage assets that are habitually subjected to component wear-out and degradation. And fourth, the lifecycles of assets in both industries frequently extend into decades (Perrons and Hems, 2013).

This paper accordingly puts forward the viewpoint that the upstream oil and gas industry could potentially make significant improvements in asset maintenance—specifically, with regard to offshore platforms and remote pipelines—by selectively applying some aspects of the maintenance strategies and philosophies that have been learned in the space and satellite sector. The paper then suggests a research agenda toward accelerating the rate of learning and sharing between the two industries in this domain. Finally, because the oil and gas industry is carefully regulated in many countries, the ideas discussed in this paper are necessarily connected to a broad range of policy implications. The paper therefore concludes by recommending that these nations' regulatory agencies should allow oil and gas companies to try innovative approaches to asset maintenance that may seem unfamiliar in a traditional oil and gas context so long as they are safe and do not represent any additional risk to the environment.

2. Best practices from the space and satellite industry

The ability to service satellites has evolved from a series of growing on-orbit capabilities over nearly five decades of human experience in space. The legacy of on-orbit servicing (OOS) ranges from early U.S. and Soviet manned space programs such as Skylab and the Salyut space station (Bluth and Helppie, 1986; Hacker and Grimwood, 1977; NASA Office of Space Flight, 1988) to more recent tests of autonomous servicing technology by the Japanese space agency (Yoshida, 2003) and the U.S. Air Force (Partch et al., 2003). Fig. 1 depicts a timeline of historical milestones in the evolution of OOS technology.

These five decades of experience in OSS have resulted in the learning of many valuable lessons in the space and satellite industry. As shown in Table 1, Richards (2006) synthesizes these lessons into four broad principles for maintaining orbiting satellites: maximize the knowledge you have about the target satellite, manage the scale of servicing activities, minimize the precision of servicing activities, and minimize the temporal constraints of the maintenance task.

2.1. Maximize knowledge of target satellite

Maximizing knowledge regarding the state of the target satellite is critical to reduce the amount of uncertainty associated with servicing operations (Richards, 2006). If an orbiting servicing vehicle has perfect information about the satellite, then operations may be precisely scripted. The less the knowledge that is available on the target satellite, the more the operations need to be adaptable, thereby adding to the complexity of the procedure. Toward improving the amount of data available in a servicing mission, serviceable spacecraft should incorporate extensive fault detection, isolation, and diagnostic capabilities. When an anomaly occurs, operators at control centers on the ground need to be able

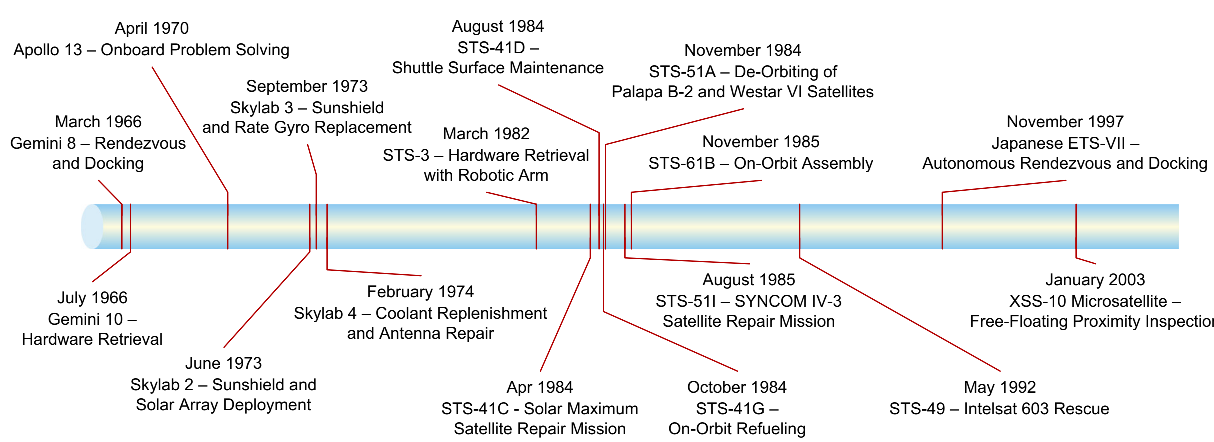

Fig. 1. Timeline of historical milestones in OOS (Richards, 2006).

Table 1
Satellite servicing best practices (Richards, 2006).

Maximize knowledge of target satellite	Manage scale of servicing activities
• Incorporate extensive fault detection, isolation, and diagnostic capabilities • Enforce configuration control during manufacturing, assembly, and pre-launch operations • Limit structural deformation from launch, radiation, and thermal cycling	• Consider the proximity of other potential OOS targets in orbit selection • Co-locate electrical interfaces, fluid transfer modules, and Orbital Replacement Unit storage bays with docking ports • Use common components • Design electrical, thermal, and attitude control subsystems with margin for loads of additional payload modules
Minimize precision of servicing activities	**Minimize temporal constraints**
• Design "safe modes" of satellite operation to mitigate thruster plume impingement • Control servicing interfaces tightly • Substitute highly-integrated designs with modular, loosely-coupled configurations	• Compile empirical data on component degradation to enable scheduled servicing • Allow for temporary outsourcing of functions to shield end-users from operational downtime