Impact of 3D Printing for Oil and Gas Industry
IT Leaders

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While 3D printing offers CIOs of O&G firms, as well as oil field service companies, opportunities for cost savings and productivity gains, it also raises challenges relating to intellectual property protection.

Impacts

- While use cases for 3D printing by O&G CIOs are proliferating, the technique’s use in the industry has not been fully developed.
- Concerns over intellectual property confidentiality and the security of 3D printing threaten to inhibit progress unless O&G IT leaders can ensure proper governance.
- The impact of 3D printing on IT architecture will be substantial, requiring O&G CIOs to provide the flexibility needed to foster innovation and collaboration while enabling access control and security.

Recommendations

O&G CIOs:

- Determine if your company is an innovation leader or fast follower when exploring 3D printing. Leaders must support programs to test 3D printing technologies and uses; fast followers must remain abreast of hardware, software and material developments.
- Enlist your legal department to help determine the impact 3D printing will have on intellectual property protection, then build a supporting governance model.
- Coordinate with IT leaders to develop the appropriate IT architecture deployment roadmaps for enabling 3D printing in the short term, midterm and longer term.
- Engage 3D printing service providers to test different designs and materials while simultaneously determining the appropriate use cases and best delivery models.
Strategic Planning Assumption

By 2019, 10% of all oil and gas, as well as oilfield service, companies will be using 3D printers for the production of parts and equipment used within operations.

Analysis

Introduction

The use of 3D printing is expanding exponentially, fueled by steady technology improvements, a widening material range and improved quality. Worldwide, there are hundreds of startups looking to gain a foothold in what promises to be an explosive growth opportunity in nascent market segments ranging from 3D printing of consumable products to 3D bioprinting systems, as well as to consumer 3D printing.

For upstream oil and gas (O&G) companies, as well as oilfield service companies, 3D printing offers potential opportunities to cut costs and/or improve productivity. In any case, oil company CIOs should not overlook new ways to harness the wide range of practical enterprise uses of 3D printing that have been developed during the past 30 years. These range from 3D printing of dental devices to 3D printing service bureaus and 3D printing for prototyping.

"Hype Cycle for 3D Printing, 2015" illustrates the fact that 3D printing is a 30-year old technology with demonstrated use cases that is acting like a newborn. Clustered on the left side are the nascent technologies and applications of 3D printing climbing to the Peak of Inflated Expectations or just past it. On the right side is a group of well-established use cases for 3D printing that have been developed during the past 30 years.

Gartner defines 3D printing, often referred to as additive manufacturing, as "an additive technique that uses a device to create physical objects from digital models." All 3D printers build parts by adding one layer of material on top of another. The printer produces items using computer-aided design (CAD) or modeling software, or results from a three-dimensional scan of an existing item.

Presently, there are about 40 major manufacturers of enterprise-class 3D printers worldwide. Priced from a few thousand dollars (U.S.) to more than $2 million, enterprise-class 3D printers produce prototypes, tools, jigs and fixtures, and finished goods out of a growing range of ceramics, plastics and metals. Regardless of the manufacturer, it is important to note that individual 3D printers use only one of the seven technologies that enable additive manufacturing. Depending on the item, any one of the technologies could be used to print a prototype or part using metal, plastic, paper or ceramic materials (see Table 1).
Table 1. 3D Printing Technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Description</th>
<th>3D Printer Price Range</th>
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<tbody>
<tr>
<td>Material Extrusion</td>
<td>Material is selectively dispensed through a nozzle or orifice</td>
<td>$500 to $400,000</td>
</tr>
<tr>
<td>Stereolithography</td>
<td>Liquid photopolymer is selectively cured by light-activated polymerization</td>
<td>$3,200 to $800,000</td>
</tr>
<tr>
<td>Binder Jetting</td>
<td>Liquid bonding agent is selectively deposited to join powdered materials</td>
<td>$5,000 to $1.8 million</td>
</tr>
<tr>
<td>Material Jetting</td>
<td>Droplets of build materials are selectively deposited</td>
<td>$20,000 to $5 million</td>
</tr>
<tr>
<td>Direct Energy Deposition</td>
<td>Focused thermal energy fuses materials by melting them as they are being deposited</td>
<td>$200,000 to $5 million</td>
</tr>
<tr>
<td>Power Bed Fusion</td>
<td>Thermal energy selectively fuses regions of a power bed</td>
<td>$20,000 to $2 million</td>
</tr>
</tbody>
</table>

Source: Gartner (December 2015)

With enterprise-class printers costing tens and hundreds of thousands of dollars, for 30 years prospective 3D printer buyers have taken a “try before I buy” approach to investing in a 3D printer. Not only does this enable buyers to physically assess the output of a 3D printer, but it also enables their creative personnel and engineers to learn how to design for 3D printing. Prospective buyers have also leaned on use cases that align with their potential use of 3D printing before they even get to the point of having a design 3D printed.

Specific Use-Case Examples

Part Production

- **Business Objective** — GE Oil & Gas wanted to manufacture control valve parts with special configurations for use with various applications across the energy industry.

- **Solution Offered** — Using Matsuura Machinery’s Lumex Avance-25 metal 3D printer, which combines direct energy deposition using metal powder and a fiber optic laser with milling processes by a machining center into one unit, several benefits accrued:

  - It made it possible to manufacture control valve parts with complex shapes, such as hollow structures, curved shapes and meshes (these are difficult to make using conventional additive manufacturing methods), thereby allowing for a substantial improvement in design freedom.

  - It made integrated molding possible, which reduces the steps required for processing mold dies, realizing faster manufacturing times and lower cost when compared with conventional methods.\(^1\)
Display Model Development

**Business Objective** — Norway’s Det Norske commissioned a 1:100 scale model of its Ivar Aasen oil rig platform that had a height of 138 meters and a depth of 112 meters. The model was to be the centerpiece of its display at the Offshore Northern Seas 2014 annual show held in Stavanger.

**Solution Offered** — Plastic 3D printing was selected for two main reasons — cost and time scale. Traditional model making would have taken a year to produce such an accurate and intricate model due to the time needed to create customized components, and would have cost many times more than 3D printing. In addition, the use of selective laser sintering of nylon powder produced a model that was so accurate and intricate, it was even possible to see the toilets through open doors within the superstructure. Even small items, such as the anodes and railings, were all faithfully reproduced directly from the CAD design.

Assembly Design Enhancement

**Business Objective** — Engineers for Elster Aerotech, Romania’s main producer of equipment for gas measurement and regulation, needed to verify that a specific assembly could function as designed, and that it could be accurately produced in the Romanian facility. However, the geometry of the part was so complicated that computer numerically controlled (CNC) machines couldn’t produce the prototype at the level of detail required to get a true picture of its performance.

**Solution Offered** — By turning to 3D-printed UV curable plastic technology, using 3D Systems' ProJet 3510 CPX 3D printer (formerly ProJet 3500 CPX), the engineers were able to create microdetail down to 16-micron layer thickness. The process also resulted in reduced design cycle time.

Product Modeling

**Business Objective** — The sales force for Wood Group Pressure Control (WGPC), a manufacturer of surface wellhead equipment and gate valves for the O&G industry, needed a more effective way to communicate how WGPC products worked in the real-world environment. Due to the large size of the components involved, traditional 2D drawings were inadequate.

**Solution Offered** — To help solve the problem, WGPC turned to Stratasys' Dimension's BST 3D printer, which is essentially a networked, desktop modeling system that builds functional 3D models with ABS plastic. In less than three months, WGPC was able to develop functional models in-house for more than 100 components, saving thousands of dollars and cutting development time substantially over less advanced technology.

The nature of 3D printing technology is disruptive, so it will need to be managed accordingly. For example, extensive use will likely increase concerns over the use of nontechnically approved design standards, which will, in turn, open new areas of concern around patents and patent infringement. O&G CIOs will be required to develop expertise in controlling the use of the technology in
information management as well as storage. Finally, 3D printing will require investments in new software and IT enterprise configuration management.

**Figure 1. Impacts and Top Recommendations for O&G 3D Printing**

<table>
<thead>
<tr>
<th>Impacts</th>
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<td>The impact of 3D printing on IT architecture will be substantial, requiring CIOs to provide the flexibility needed to foster innovation and collaboration while enabling access control and security.</td>
<td>Coordinate with IT leaders to develop the appropriate IT architecture deployment roadmaps for enabling 3D printing. Engage 3D printing service providers to test different designs and materials while determining the appropriate use cases and delivery models.</td>
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Source: Gartner (December 2015)

**Impacts and Recommendations**

While use cases for 3D printing by O&G CIOs are proliferating, the technique’s use in the industry has not been fully developed

While 3D printing technology is not yet ready to replace large-scale industrial fabrication of equipment for O&G firms, it does offer value-add potential in the near and long terms. For the near term, 3D printing offers value by significantly reducing the time required for prototyping, producing, reworking and redesigning components. Longer term, 3D printing is positioned to play a key role within the upstream O&G supply chain by transforming how components of a wide range of equipment are produced. The use of 3D printing will create significant value, particularly in locations where the supply of ordinary parts is limited, or where shipping and customs clearance for parts are likely to cause time delays.

O&G industry use cases for 3D printing are developing rapidly in several areas. These include conceptualization, prototyping, manufacturing, augmented manufacturing, on-demand manufacturing and alternative design. The three areas of most immediate interest to the oil and gas industry are:
- **Prototyping** — Creating product prototypes for early-stage product development to understand suitability for fit, function and use.

- **Alternative design** — Conceiving and printing parts that cannot be produced using other traditional manufacturing processes.

- **On-demand manufacturing** — Enabling as-needed and distributed production of new and replacement parts, as well as the repair of worn components.

There is great promise for the use of 3D printing in manufacturing short-run parts or for the actual production of parts used in drilling. Upstream O&G companies are becoming increasingly aware of 3D printing’s value, and are beginning to expand its use in their R&D activities, as are oil and gas operators, oil field service companies and OEMs — all of which have begun to increase their investments in 3D printing in some of these ways:

- Printing 3D rock models to reproduce microscopic, intricate pore networks of rocks to help geologists better understand how fluids flow through a reservoir.

- Combining 3D printing with laser scanning to create files that can be used to produce drilling parts, such as a drill bit nozzles that are customized to run cleaner and cooler through better lubrication of the interface between the drill cutting and rock formation.

- Testing the ability to 3D printing onboard an oil rig/tanker to repair equipment malfunctions.

- Integrating 3D printing outsourcing services into operations, as a way to test and print on-demand components, without the need to invest in the technology and talent.

- The 3D printing of peripheral spare parts in remote locations on land and at sea, where stock is limited and the delivery time is long.

As upstream O&G companies find 3D-print-based solutions to any of these or other industry-specific problems, CIOs and other IT leaders must play central roles in determining if and how any innovating ideas can be transformed into business opportunities. While your engineering and operations counterparts will make the 3D print technology decisions, you and your staff will be responsible for supporting those decisions with a robust and secure IT infrastructure.

**Recommendations:**

CIOs in the O&G and oilfield service industries must determine when and how to harness 3D printing across the organization by:

- Determining if their companies are an innovation leaders or fast followers when exploring 3D printing. Leaders must support programs to test 3D printing technologies and uses; fast followers must remain abreast of hardware, software and material developments.

- Evaluating how competitors and suppliers within the O&G industry are leveraging 3D printing, while also looking at near-neighbor industries as potential sources of use cases.

- Beginning with simple scenarios that add immediate benefit, such as prototyping innovative part designs and producing operational replacement parts. Use small successes to build support for future and larger 3D printing investments.
Employing a bimodal IT strategy that simultaneously emphasizes sustained, incremental improvements in a 3D engineering modeling architecture, while encouraging and enabling fast, innovative and risky experiments.

Concerns over intellectual property confidentiality and the security of 3D printing threaten to inhibit progress unless O&G IT leaders can ensure proper governance.

Despite the growing adoption of 3D printing, concerns over intellectual property confidentiality and security, especially within the engineering domains, remain a drag on its progress. O&G companies, like other users of 3D designs, need to manage the intellectual property issues associated with 3D printing with great care. They are entering uncharted territory when it comes to intellectual property and design risks. Licensing and manufacturing stipulations for legally and safely reproducing parts using 3D printing are in their embryonic stages. Senior managers — and their law firms — are only now beginning to address these issues. Intellectual property issues will undoubtedly loom large in the future.

For example, the opportunity to use 3D printing to manufacture replacement parts on-site, which is particularly attractive in remote O&G drilling locations, may lead companies afoul of patent and other legal issues surrounding the duplication of parts without permission or without proffering payment.

Additionally, O&G firms need to ensure that every 3D-printed part meets the manufacturer’s quality and performance specifications. This will be of particular concern for critical components being produced or repaired at remote drilling locations. In such cases, concerns over part specifications extend well beyond simple patent considerations to safety and liability concerns — at which point the repercussions from failed 3D-printed parts could be measured in lives, rather than money. On the other side of this scenario, should your organization begin producing specialty parts for O&G applications, it will be necessary to protect your product designs created with 3D printing processes.

With increasing adoption of 3D printing, O&G, as well as oilfield service, companies must enable intellectual property protection, especially within the engineering domains. CIOs and other IT leaders will need to address issues such as:

- Preventing intellectual property theft and counterfeiting. This may call for proactive legal and compliance teams to assess potential impacts to business operations.
- Ensuring the durability and high performance of 3D-printed parts. This will involve a broad and aggressive testing strategy (including long-term recordkeeping) to identify material and process weaknesses.
- Enable collaboration and involvement of enterprise architects with engineering and operations personnel to implement security best practices.

Recommendations:
Work with your legal team to determine the impact 3D printing will have on intellectual property, both yours and that of suppliers whose parts may be repaired — and build a supporting governance model.

In conjunction with your organization’s legal and compliance departments, develop principles to guide the use of 3D printing technologies to avoid loss or theft of intellectual property.

Explore options for the security and management of critical 3D printing designs.

The impact of 3D printing on IT architecture will be substantial, requiring O&G CIOs to provide the flexibility needed to foster innovation and collaboration while enabling access control and security.

The use of 3D printing will not only improve existing business processes and products, it will also lead to innovation and, possibly, the creation of new products, new business models and new ways of competing. Beyond concerns over protecting their own and others' patents, companies must also consider how to securely manage 3D designs and print files, especially in the engineering domain. In anticipation of dealing with the increased complexity in configuration and management of software libraries, and to explore opportunities for exploiting 3D printing, CIOs and their enterprise architects must enable dispersed and secure access to 3D print files that will be used by employees, vendors and customers. Implementation of strategic and tactical security architecture best practices will enable O&G CIOs to detect and mitigate threats across the network internally and externally.

Designers and engineers need to collaborate on new and revised products, rigs and more. Vendors need to collaborate with O&G IT personnel to ensure that designs: (1) are manufacturable; and (2) can be manufactured at a reasonable price.

The geographically dispersed nature of the upstream O&G industry can also create challenges in terms of where and how to store data — which can include 3D printing data — as well as with industry and governmental standards for the transporting or sharing of data. Using 3D print service bureaus with regional or multinational facilities can help alleviate some of these issues and facilitate timely delivery of a broad range of 3D printing technologies while not requiring investments in multiple and geographically dispersed in-house devices.

**Recommendations:**

The impact of 3D printing on IT architecture will be substantial, so O&G CIOs and IT leaders must ensure flexibility while enabling access control and security by:

- Developing the appropriate IT architecture and roadmaps for enabling 3D printing in the short term, midterm and for the longer term.
- Developing a robust, secure infrastructure that enables collaboration within their organizations and with their suppliers and customers, easy file storage and retrieval, and secure file transfers across their networks and to suppliers and buyers.
Enlisting service providers to determine the appropriate use cases and best delivery model (that is, printing bureau, experimentation with printed parts, in-house printing) in the short term, midterm and for the longer term.

**Gartner Recommended Reading**

Some documents may not be available as part of your current Gartner subscription.

"Market Guide for 3D Print Service Bureaus, 2015"

"Market Guide for 3D Printing"

"Top 10 Technology Trends Impacting the Upstream Oil and Gas Industry in 2015"

"Cool Vendors in 3D Printing, 2015"

"An Enterprise Architect’s Best Practices for 3D Printing"

**Evidence**

1. GE Measurement & Control press release, "GE Oil & Gas Uses 3D Printing to Produce Control Valve Parts at Kariwa Plant."

2. 3T RPD, "3D Printing for Oil Rig Model."

3. 3D Systems Case Studies.

4. Stratasys application story, "Wood Group Pressure Control Streamlines Sales Process."