4th Industrial Revolution
November 2018
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Localization is a focus for the KSA – Saudi Aramco’s IKTVA program aims to achieve 70% local content by 2021

- Drives domestic value creation by working with suppliers for mutual benefits
- Envisions to improve investment, and maximize long term economic growth and diversification
- Focuses on delivering quality jobs, advancing innovation and enhancing global competitiveness

IKTVA is designed to reward Saudi Aramco’s suppliers for the use and development of local labor and sub-suppliers
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<td>Mohammed Jughaiman</td>
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<td>Bodong Li</td>
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<td>Abdulkarim Sofi</td>
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- Drives domestic value creation by working with suppliers for mutual benefits
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IKTVA is designed to reward Saudi Aramco’s suppliers for the use and development of local labor and sub-suppliers
Localization is supported by a comprehensive ecosystem of government stakeholders

- **Saudi Export Development Authority** – enablement of export opportunities for SMEs
- **Human Resources Development Fund** – implementation of HR practices
- **MERAS** – Unified electronic platform to facilitate business start-ups
- **Small and Medium Enterprises Authority** – improvement of regulations and promote SMEs
- **Certificate of Conformity** – provision of confirmation certificates for KSA imports
- **Saudi Industrial Development Fund** – provision of finance and advisory services
- **National Industrial Clusters Development Program** – investors to industrial clusters connection
- **Royal Commission of Jubail and Yanbu** – development of Jubail and Yanbu industrial cities
- **Saudi Industrial Property Authority** – development of industrial cities
- **Saudi Arabian General Investment Authority** – oversight of investment affairs in the KSA
- **Ministry of Finance** – monitoring of loan policies for the KSA Government
- **Public Investment Fund** – SME investment on behalf of KSA

Saudi Aramco: Company General Use
Industry 4.0 Enabling Technologies & Major Trends

- Additive Manufacturing
- 3D
- Augmented Reality
- Robotics & UAV
- High Performance Computing
- Big Data & Advanced Analytics
- Cloud Computing
- Cyber Security
- Mobility
- 4.0
Digital Hub Goals and Structure

**DIGITAL HUB OBJECTIVES**

- Establish a Digital Hub (Virtual & Physical)
- Increase localization
- Develop Local Supply Chain
- Focus on SME development
- Custom Tailor Technologies
- Enhance local support and availability
- Reduce Operating Costs
- Validate opportunities and value propositions

**DIGITAL HUB STAKEHOLDERS**

<table>
<thead>
<tr>
<th>Internal</th>
<th>External</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iktva</td>
<td>Suppliers</td>
</tr>
<tr>
<td>Information Technology</td>
<td>Government entities (MIEM, MCIT,..etc)</td>
</tr>
<tr>
<td>Engineering Services</td>
<td></td>
</tr>
<tr>
<td>EXPEC Computer Center</td>
<td>Chambers of Commerce</td>
</tr>
<tr>
<td>EXPEC Arc</td>
<td></td>
</tr>
</tbody>
</table>
Digital Hub Roadmap

Planning & Teaming Phase
- Collaborate on IR4 with proponents & suppliers
- Identify steps required to launch, Define dimensions of the Digital Hub
- Set plans for IR4 nucleus

Value Proposition Creation
- Identify current and forecasted gaps through Market Analysis (known areas of spend)
- Conduct cross-organizational studies (potential new areas of spend)
- Increase awareness within proponent organizations

Digital Hub Launch
- Prepare vendors to offer IR4 to SMEs
- Offer incentives through DH (website marketing, preferential packages in DTV, etc)
- Sign MoUs
- Build Innovation Center

Expansion Phase
- Follow up on execution
- Support SMEs
- Develop Localization Potential

Transition to SPARK
The ultimate goal of the Digital Hub will be to create an all-in-one IR4.0 Industry centralized.
Saudi Aramco’s Digital Transformation
### Saudi Aramco’s Digital Transformation Program

#### 12 Business Domains

<table>
<thead>
<tr>
<th>Business Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- Hydrocarbon Operations</td>
</tr>
<tr>
<td>2- Planning, Sales &amp; Trading</td>
</tr>
<tr>
<td>3- Health, Safety, Security &amp; Environment</td>
</tr>
<tr>
<td>4- Material Supply Chain &amp; Logistics</td>
</tr>
<tr>
<td>5- Power &amp; Utilities</td>
</tr>
<tr>
<td>6- Knowledge Management</td>
</tr>
<tr>
<td>7- Human Capital Management &amp; Development</td>
</tr>
<tr>
<td>8- Aerial, Maritime &amp; Ground Operations Support</td>
</tr>
<tr>
<td>9- Capital Projects</td>
</tr>
<tr>
<td>10- Community Spaces</td>
</tr>
<tr>
<td>11- Technology Management</td>
</tr>
<tr>
<td>12- Finance</td>
</tr>
</tbody>
</table>

#### 10 Technology Domains

- Robotics & UAVs
- Intelligent Sensing
- Cloud
- Mobility
- Augmented / Virtual Reality
- Artificial Intelligence
- Analytics
- Blockchain
- 3D Printing
- Modeling
- Manufacturing
- Connectivity
- Computing

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*Saudi Aramco: Company General Use*
Saudi Aramco’s Digital Transformation Program

Saudi Aramco Digital Vision

In 2022, Saudi Aramco is the world’s leading digitalized energy corporation, maximizing shareholder value and spearheading digital innovation in energy globally.

Digital Mission

- Improve the Margin
- Innovate with Technology
- Revenue Diversification
- Develop the Digital Workforce
- Maximize Localization

A Forward Looking Innovation Hub
Cybersecurity
Attack techniques are becoming increasingly sophisticated, requiring continuous developments in countermeasures.

- Technology of attacks evolves quickly: While known threats continue, new ones are added all the time.
- Easy to use attack tools and compromised systems as base for launching the attacks are sold on the black market.
- Attacks are fully professionalized and often backed by big money of national intelligence agencies or organized crime.

**Development of technology**

<table>
<thead>
<tr>
<th>Attack technology</th>
<th>Countermeasure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Targeted attacks/ APT</td>
<td>DLP, SIEM</td>
</tr>
<tr>
<td>DDoS</td>
<td></td>
</tr>
<tr>
<td>Spyware, Trojans, bots, rootkits</td>
<td></td>
</tr>
<tr>
<td>Worms</td>
<td></td>
</tr>
<tr>
<td>Viruses</td>
<td></td>
</tr>
<tr>
<td>Viruses scanners</td>
<td></td>
</tr>
<tr>
<td>Firewalls</td>
<td>DPI firewalls</td>
</tr>
<tr>
<td>IDS/IPS</td>
<td></td>
</tr>
<tr>
<td>DPI firewalls</td>
<td></td>
</tr>
<tr>
<td>DLP, SIEM</td>
<td></td>
</tr>
<tr>
<td>SIEM</td>
<td></td>
</tr>
</tbody>
</table>

Note: APT = advanced persistent threat, DLP = data loss prevention, SIEM = security information and event management, DDoS = distributed denial of service (attack), IDS = intrusion detection system, IPS = intrusion prevention system, DPI = deep packet inspection.
Security architectures typically consist of intrusion detection, intrusion prevention and event management systems.

**Intrusion detection system (IDS)**
- Monitors network traffic or events on a single host
- Analyzes monitored data for suspicious behavior and possible incidents

**Intrusion prevention system (IPS)**
- Initiates measures to stop a possible attack detected by an IDS, e.g. dropping malicious packets, resetting connections and/or blocking traffic
- Needs to be placed in-line with monitored traffic

**Security information and event management (SIEM)**
- Combines security information from networks, systems and applications in a single place
- Complements IDS/IPS by correlating events and validating alarms

In modern security architectures, IDS are used in conjunction with prevention and information & event management systems.

Sources: [National Institute of Standards and Technology](https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-37r4.pdf)
The ME Cybersecurity market is $13.2 B in 2015 and will reach $55.7 B by 2022 at an estimated CAGR of ~23%.
In KSA, cybersecurity is expected to grow at a CAGR of ~22% with anti-virus/anti-malware leading the growth.
There are opportunities to localize cybersecurity in KSA across two main functions.

Opportunities in cybersecurity

1. Infrastructure & Platforms
   - Opportunities exist for SMEs to localize security infrastructure design and hardware manufacturing.

2. Cybersecurity Software
   - SMEs can offer solutions that prevent and detect attacks, with an emphasis on endpoint protection software.

Source: A.T.Kearney
Key messages and next steps

Key messages

- Cybersecurity infrastructure and software have great potential in fortifying Saudi Arabia’s industries.
- The KSA and ME market for cybersecurity are growing rapidly at ~22% and ~23% CAGR, respectively, to reach ~$11 BN and ~$56 BN by 2022.

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Cloud Computing
Cloud is a “service model”

It is a way of **providing IT-enabled business services** with **multiple sourcing options** (SaaS, PaaS, IaaS etc.) and **multiple hosting options** (Private, Public, Hybrid etc.)

- **Software as a Service (SaaS)**
  - In SaaS, **software is licensed on a subscriptions basis and is centrally hosted.**

- **Platform as a Service (PaaS)**
  - In PaaS, a third party **provides the necessary platform and tools for running, developing and/or managing software.**

- **Infrastructure as a Service (IaaS)**
  - In IaaS, the **fundamental computing resources such as processing, storage, networks are provisioned and managed for the consumer.**
The energy industry is not new to cloud computing—several players globally have already embraced the cloud.

### Cloud computing initiatives in the energy industry

<table>
<thead>
<tr>
<th>Situation</th>
<th>Cloud solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>In 2013, Hess decided to streamline its business to focus on energy exploration and production (E&amp;P). As part of the process, the company decided to divest its downstream businesses, including retail, energy marketing, and terminals.</td>
<td>In anticipation of separating business systems and data for potential buyers, Hess IT initiated work on Amazon Web Services (AWS) in July 2013 and entered a contractual agreement to have the environment operational and in production by January 2014. The project was about speed to market and they completed the migration to the AWS Cloud in six months, twice as fast as it would have taken with physical servers.</td>
</tr>
<tr>
<td>GE Oil &amp; Gas migrated 500 applications to the cloud by the end of 2016 as part of a major digital transformation.</td>
<td>The company’s leveraged Amazon AWS cloud solutions eliminating legacy processes, resulting not only in lower IT costs but also in greater speed to market and more agility to compete even better in an industry experiencing immense market challenges. Project resulted in 52% reduction in TCO.</td>
</tr>
</tbody>
</table>

Source: Press research, Saudi Aramco
Saudi Aramco is also pursuing a number of cloud computing related initiatives.

Source: Saudi Aramco analysis
Market for cloud computing in KSA is expected to grow at 16% CAGR to reach a value of $2.5 bn by 2025

Source: BMI Research
Within cloud computing, SaaS services are growing at 36% CAGR, to reach ~$730 mm by 2025.

Source: AT Kerney, IDC
Localization potential exists at all stages of the cloud computing value chain

<table>
<thead>
<tr>
<th>Step</th>
<th>Gaps/opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware and equipment</td>
<td>No local manufacturer of servers and storage systems in KSA, strong potential for local manufacturing</td>
</tr>
<tr>
<td>Connectivity and system integration</td>
<td>Several players already offering system integration services and players offering connectivity active in KSA. Potential to enhance services to include cloud to cloud/cloud to ground integration service</td>
</tr>
<tr>
<td>Software and platforms</td>
<td>Strong opportunity to localize cloud platforms in KSA, especially in light of regulations restricting data storage outside KSA. Great Potential to offer/localize SaaS solutions</td>
</tr>
</tbody>
</table>

Source: A.T. Kearney, Intel, Cisco
### Key messages

- Cloud computing is taking off and has **applications both in oil and gas and several other industries** in KSA (e.g. shared services)
- The KSA market for cloud computing is growing rapidly at **~16% CAGR to reach ~$2.5 bn by 2025**
- Within cloud computing, SaaS services are growing at **~36% CAGR to reach ~$730 mm by 2025**

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Robotics & UAV
The energy industry is adopting robotics.
Focus Areas

Air Robotics (UAV)

Ground Robotics

Subsea Robotics
Saudi Aramco robotics program

- Deployed Mini-Copter UAVs
- Expanding UAV fleet
- Deployed Mini-ROV
- Developed Robotic technologies

Technology

- Developed UAV & Robotics SDP Specialty
- Established PEDD training & Certification Program
- Collaboration with ABB, Avitas, Airbus on UAV & Robotics

Workforce

- Established UAV & Robotics Standard Committee
- Developed robotics and UAV standards & procedures

Procedure & Governance

UAV & Robotics
Industrial Robotics Market
Industrial Robotics Market
Localization potential exists at most stages of the Robotics value chain

<table>
<thead>
<tr>
<th>Step</th>
<th>Hardware and equipment</th>
<th>system integration</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaps</td>
<td>No local manufacturer of robotic components in KSA—strong potential for local manufacturing</td>
<td>No local integrator of robotic solutions KSA.</td>
<td>limited presence of robotics &amp; UAV service providers for industrial applications such as inspection</td>
</tr>
</tbody>
</table>

Source: Desktop research, Saudi Aramco analysis
### Key messages

- Robotics is taking off and has **applications both in oil and gas and several other industries** in KSA (e.g. shared services)
- The KSA market for robotics is in line with global growth of at **15% over the next 3-5 years**
- Saudi Aramco is also adopting robotics solutions to enhance its operations and improve performance.

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Big Data & Advanced Analytics
Analytics vs. Advanced Analytics

Performance Analytics
- Descriptive
  - Reports
  - KPIs
- Diagnostic
  - Alarms
  - Feedback
- Predictive
  - Condition-based monitoring
  - Fault Prediction
- Prescriptive
  - Scheduling
  - APC
- Visualization, Expert Systems, & Basic Statistics
- Correlations & Simulation Models
- Optimization & Machine Learning

Advanced Analytics
- Big Data

What Happened?
Why it Happened?
What Will Happen?
What To Do?
The energy industry is realizing the value of analytics solutions

<table>
<thead>
<tr>
<th>Situation</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>To drive optimization, ExxonMobil unified data storage to one huge data lake.</td>
<td>ExxonMobil created its first <strong>Big Data shared service</strong> across an enormous enterprise – from <strong>data ingestion</strong> at the edge using Hortonworks DataFlow to <strong>long-term storage</strong> in Hortonworks Data Platform</td>
</tr>
<tr>
<td>BP recognized that it is underutilizing its data repository and needed to invest in data mining to fully leverage all available data</td>
<td>In 2012, the organization established a <strong>decision analytics network</strong> – now 200-strong among its professionals – to examine ways to advance use of data and maximize business productivity</td>
</tr>
</tbody>
</table>
| Dow Chemicals creates enormous amounts of data in numerous silos and wished to effectively utilize it to drive business efficiency | **Dow Analytical Technology Center** was recognized for tackling two distinct challenges  
  - integrating multiple data sources into a uniform operational domain and then  
  - applying leading edge data analytics to conquer the multiple large data sets tied to its industrial chemical production processes, |

Source: Press Releases
Furthermore, several large enterprises in KSA are already embracing data analytics solutions

<table>
<thead>
<tr>
<th><strong>Examples of Analytics deployment</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Saudi Aramco</strong></td>
</tr>
<tr>
<td><strong>SABIC</strong></td>
</tr>
<tr>
<td><strong>Bahri</strong></td>
</tr>
<tr>
<td><strong>SAUDIA</strong></td>
</tr>
</tbody>
</table>

Source: Desktop research, Microsoft, Saudi Aramco
Big data/analytics have several applications within Oil and Gas—there exists potential for local companies to offer these services.
Market for Advanced Analytics in KSA is expected to grow at ~14% CAGR to reach a value of $716MM by 2025

Source: IDC
Localization potential exists at most stages of the analytics value chain

<table>
<thead>
<tr>
<th>Step</th>
<th>Hardware and equipment</th>
<th>Connectivity and system integration</th>
<th>Software and platforms</th>
<th>Data Science Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaps</td>
<td>No local manufacturer of commodity storage, GPUs, and other server components in KSA - strong potential for local manufacturing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Several players already offering system integration services and players offering connectivity active in KSA</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Potential to enhance services to cater to analytics applications</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Potential to upgrade connectivity and infrastructure</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Potential to localize platforms for advanced analytics in light of regulations limiting storage of data outside KSA. <strong>Vertical industry analytical solutions</strong> are required to exploit the large amounts of data amassed.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Development of <strong>predictive and prescriptive models</strong> for plant operations and business applications. Required <strong>specialties</strong> include data services, data analysis, modeling, optimization, data mining, and machine learning.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Key messages and next steps

Key messages

- Advanced analytics is taking off and has applications both in oil and gas and several other industries in KSA (e.g. manufacturing)
- The KSA market for advanced analytics is growing rapidly at ~14% CAGR to reach ~$700 mn by 2025

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Mobile solutions have several applications within Oil and Gas—there exists potential for local companies to offer these services.

Examples of mobile applications in oil and gas:

### Field Mobility
- HSE
- Operations
- Inspection
- Maintenance
- Engineering

### Enterprise Mobility
- Finance
- Procurement & Supply Chain
- Transportation
- Community Services
- Human Resources
- Project Management
- Industrial Security
- Medical

Source: Saudi Aramco
The energy industry is adopting mobile solutions for its field and enterprise applications

Companies that have adopted field mobility in the oil, gas, and chemicals industry

- Saudi Aramco
- ExxonMobil
- bp
- Shell
- Chevron
- Total
- Statoil
- BASF
Market for Mobile Apps in KSA is expected to grow at ~11% CAGR to reach a value of $780MM by 2025.
Localization potential exists at most stages of the mobility value chain

<table>
<thead>
<tr>
<th>Step</th>
<th>Gaps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware and equipment</td>
<td>No local manufacturer of mobile devices. There is some potential for local manufacturing. There is potential in localizing the network and wireless infrastructure.</td>
</tr>
<tr>
<td>Configuration and system integration</td>
<td>Configuring mobile applications and integrating with existing systems and data sources can be done locally. Potential to enhance services to cater to analytics applications</td>
</tr>
<tr>
<td>Software and platforms</td>
<td>Potential to localize software development for mobile applications. Potential for customizing mobile platforms in KSA.</td>
</tr>
<tr>
<td>Application Development &amp; Support</td>
<td>High potential for localizing the development of mobile applications. Support for mobile hardware and software can be done in KSA.</td>
</tr>
</tbody>
</table>
### Key messages

- The oil and gas industry along with other sectors in KSA are adopting mobile solutions.
- The KSA market for mobile apps is growing rapidly at ~11% CAGR to reach ~$780 mn by 2025.
- Saudi Aramco is also adopting field mobility and enterprise mobility solutions to enhance its operations and improve performance.

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Source: Saudi Aramco analysis
Additive Manufacturing
Several Organizations that have already implemented 3DP and have realized improvements across the value chain

### Case Studies

<table>
<thead>
<tr>
<th>Productivity Improvement</th>
<th>Supply Chain Simplification</th>
<th>Speed to Market</th>
<th>Mass Customization</th>
<th>Complex Design</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3DP used to fabricate ligs and fixtures for the production line. One such tool is used to attach name badge to car.</strong></td>
<td><strong>The United States Navy uses 3D printing for replacement parts for submarines, missiles, aircrafts etc.</strong></td>
<td><strong>Under Armour released a limited edition running shoe with a 3D printed lattice sole and upper. The first batch sold out immediately.</strong></td>
<td><strong>Phonak uses 3DP to manufacture unique hearing aids customized for each customer’s ear.</strong></td>
<td><strong>GE’s LEAP jet engine features 3-D printed fuel nozzles with complex designs that cannot be made using traditional techniques.</strong></td>
</tr>
<tr>
<td><strong>Cost and time savings compared to traditional CNC machining: 58% cheaper and 92% faster.</strong></td>
<td><strong>USS Essex, a full-up assault ship, has a printer permanently installed.</strong></td>
<td><strong>The new UA innovation center is outfitted with the latest 3D scanning and printing machines.</strong></td>
<td><strong>Since 2000, Phonak has sold more than 10 million 3D printed hearing aids.</strong></td>
<td><strong>GE engineers produced a model of a GEnx jet engine using direct metal laser melting 3DP.</strong></td>
</tr>
</tbody>
</table>
The 3D printing ecosystem consists of several aspects including scanning, software, and service bureaus.

**3D scanning** facilitates customization and reverse engineering by generating CAD files from physical objects.

**Printers/Materials**

**Software**

**Content Libraries**

**Users**

**Service Bureaus**

**Scanning**

**3DP Ecosystem**

**Printers/Materials**

- Includes part design, print optimization, and digital simulation software

- Provides open-source and paid access to design files developed by hobbyist and design engineers

**Service Bureaus**

- Service bureaus enable organizations to 3D print with minimal risk and no capital investments on hardware

- Provides open-source and paid access to design files developed by hobbyist and design engineers

**Scanning**

- 3D scanning facilitates customization and reverse engineering by generating CAD files from physical objects

**Software**

- Includes part design, print optimization, and digital simulation software

**Content Libraries**

- Provides open-source and paid access to design files developed by hobbyist and design engineers

**Users**

- Service bureaus enable organizations to 3D print with minimal risk and no capital investments on hardware

**Source:** A.T. Kearney, Press Research and Interviews
Today, 5 end-markets account for ~80% of the market, leading the transition from prototyping to direct manufacturing.

<table>
<thead>
<tr>
<th>End-markets</th>
<th>5 year CAGR (Global)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial/Business Machines</td>
<td>15-20%</td>
</tr>
<tr>
<td>Consumer Products/Electronics</td>
<td>25-30%</td>
</tr>
<tr>
<td>Automotive</td>
<td>15-20%</td>
</tr>
<tr>
<td>Medical</td>
<td>20-25%</td>
</tr>
<tr>
<td>Aerospace</td>
<td>20-25%</td>
</tr>
<tr>
<td>Defense</td>
<td>15-20%</td>
</tr>
<tr>
<td>Other</td>
<td>20-25%</td>
</tr>
</tbody>
</table>

End-markets revenue allocation (% 2014, 2015)

1. Industrial/Business Machines includes the printer hardware and peripherals required for additive manufacturing.

Sources: A.T. Kearney, Press Research; Wohlers Associates; Expert Interviews
Several high performance polymers have limited production in KSA and can be localized

<table>
<thead>
<tr>
<th>High Performance Polymers</th>
<th>PEEK</th>
<th>LCP</th>
<th>PI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical production:</td>
<td>Evonik, Victrex, Solvay</td>
<td>Celanese, Solvay, Sumitomo, Polymetrics</td>
<td>DuPont, Evonik, Ube America</td>
</tr>
<tr>
<td>&gt;200 KT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical growth rates:</td>
<td>BASF, Solvay, Sumitomo</td>
<td>SABIC</td>
<td></td>
</tr>
<tr>
<td>6-10% CAGR</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Engineering Resins</th>
<th>ABS</th>
<th>POM</th>
<th>PBT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical production:</td>
<td>SABIC, Covestro, Teijin, Mitsubishi</td>
<td>Celanese, DuPont, BASF, Polymetrics</td>
<td>SABIC, BASF, DuPont</td>
</tr>
<tr>
<td>&gt;20 MM T</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical growth rates:</td>
<td>LyondellBasell, Sadara, Japan PP, Borealis</td>
<td>Mitsubishi, Evonik, Sumitomo, SABIC</td>
<td>BASF, SABIC, DSM, Solvay</td>
</tr>
<tr>
<td>4-6% CAGR</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Available in KSA ✅ Not available in KSA ❌

Source: SRI, Nexant, Analyst reports, Saudi Aramco
While metals are available, there is no processing of metals to produce powders necessary for 3D Printing.

<table>
<thead>
<tr>
<th>Metals processors for 3D printing</th>
<th>HQ</th>
<th>KSA presence in 3D printing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Höganäs</td>
<td>Sweden</td>
<td>✗</td>
</tr>
<tr>
<td>HÖGANAES</td>
<td>USA</td>
<td>✗</td>
</tr>
<tr>
<td>CARPENTER</td>
<td>USA</td>
<td>✗</td>
</tr>
<tr>
<td>SANDVIK</td>
<td>Sweden</td>
<td>✗</td>
</tr>
<tr>
<td>TLS-Technik</td>
<td>Germany</td>
<td>✗</td>
</tr>
<tr>
<td>voestalpine</td>
<td>Austria</td>
<td>✗</td>
</tr>
</tbody>
</table>

From selling aluminum sheets to aluminum powders.

**Insights**

Chemical companies **will need to supply chemicals differently** to support 3DP adoption.

Source: Desktop research, Saudi Aramco
Key messages and next steps

<table>
<thead>
<tr>
<th>Key messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ 3D printing is taking off and has <strong>applications both in oil and gas and several other industries in KSA</strong> (e.g. manufacturing, medicine)</td>
</tr>
<tr>
<td>✓ <strong>~50% of the market</strong> is expected to comprise of <strong>3D printing services and 30% and 20% for 3D printers and materials respectively</strong></td>
</tr>
<tr>
<td>✓ On 3D printing materials, potential exists to localize manufacturing of <strong>high performance polymers</strong> (PI, POM, PEEK) and also <strong>metal powders</strong> (Aluminum, Titanium, Steel)</td>
</tr>
</tbody>
</table>

_In case you are interested in discussing this opportunity further, please contact_

Ahmed A Al-Faleh
Industrial Development & Strategic Supply Department
Saudi Aramco
falehaa@aramco.com

Source: Saudi Aramco analysis
Smart Sensor & Intelligent Devices
The Smart Sensor that is capable of modifying its internal behavior to optimize the collection of data from external world along with advance learning capabilities

Intelligent Devices is a solution that facilitate data processing at or near the source of data generation which know as Edge computing. For example, in the context of the Internet of Things (IoT), the sources of data generation are usually things with sensors or embedded devices.

![Diagram showing applications]

- Instrumentation
- Level
- Temperature
- pressure
- Intelligent Devices
- Edge Computing
- Network & Communication
- IoT Connectivity

Source: Saudi Aramco
Global SMART Sensors and intelligent devices Market is expected to reach $60 billion by 2022 grown at a CAGR of 19.2% (2016-2022)
Localization potential exists at most stages of the Intelligent Devices & Smart Sensor value chain

<table>
<thead>
<tr>
<th>Step</th>
<th>Hardware and equipment</th>
<th>Connectivity and system integration</th>
<th>Software and platforms</th>
<th>Production &amp; services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaps</td>
<td>There is a limited presence manufacture for sensor in general but not smart. No local manufacturer of intelligent devices in KSA - strong potential for local manufacturing</td>
<td>No manufacturing of boards, modules or processors in KSA.</td>
<td>Potential to localize software developer in KSA. Open software platform has high potential to be localized</td>
<td>Limited presence of players Intelligent Devices &amp; Smart Sensor services in KSA</td>
</tr>
</tbody>
</table>

Source: Desktop research, Saudi Aramco analysis
Market for IoT Devices in KSA is expected to grow at ~15% CAGR to reach a value of $18.62 Billion by 2025

Source: Saudi Aramco analysis
IoT & Automation
Industrial Robotics and IoT: Bridging the Cyber World and the Physical World

- Warehouse Robot
- Assembly Line Robot
- Autonomous Vehicle
- UAV for Inspection
- Collaborative Robot

- Asset Management
- Workflow Automation
- Distributed Sensing
- Digital Twin

- Decision Making
- Intelligence
- Network
- Perception

- Process Automation
- Intelligent Systems
- Smart Manufacturing
- Cyber-Physical Systems

- Industrial IoT System
- Network
- Perception

- Predictive Analysis
- Digital Twin
- IoT
- Industrial Robotics

- Bridging the Cyber World and the Physical World
Robot sales growth until 2020 is forecasted to be 8% driven by an industry and automation growth increase.

Industry market forecast: Long term development

Manufacturing industry sales
[8 main industries]
In real trillion USD, 1994-2012

Industrial robot sales
In 1,000 robots, 1994-2012

Manufacturing industry sales
[8 main industries]
In trillion USD, 1994-2020

Automation driven growth

Industrial robot forecast
In 1,000 robots, 1994-2020

Source: EIU, IFR, IHS
Industrial Highlight - Collaborative Robot
Future of work will require human-machine collaboration

The “what” (technology & automation), “who” (talent & the open talent continuum), and “where” (workplaces, physical location) of work are dramatically changing.

Physical proximity

Collaborative robots, known as co-bots, work alongside humans without the need for traditional safety cages.

Subdomain Market Growth of Collaborative Robots
2017-2026 (In $ Millions)

Source: GE Reports/Robotics

Source: Deloitte Consulting LLC

Source: Inkwood Research

Saudi Aramco
Engagement of Robotics in the middle east, from academia to industry

Saudi sovereign fund, Softbank plan robotic initiative

Source: Reuters, Saudi Aramco
Saudi Aramco: Company General Use

NEOM

A city of future equipped with robotics and connectivity

Robots to roam $500 billion Saudi city

RICHARD WACHMAN  |  Published — Tuesday 24 October 2017

The city will focus on up-and-coming industries such as biotech, digital sciences, advanced manufacturing and technology.

It will power itself solely with wind power and solar energy.

Could lead the way in the use and production of drones, driverless cars and robotics.

Will serve as the gateway to the proposed King Salman Bridge, which will link Egypt and Saudi Arabia.

26,500 square km (10,230 square mile) zone will be built on untouched land along Saudi Arabia’s Red Sea coastline near Egypt and Jordan.

A $500bn project which 70% of the world population can reach within 8 hours.

Investment sectors:
- Human civilization
- Energy and water
- Mobility
- Biotech
- Food
- Media
- Entertainment
- Advanced manufacturing
- Technological and digital sciences

Technologies:
- Automated driving and passenger drones
- Repetitive and arduous tasks carried out and handled by robots
- All services and processes are 100% automated
- Artificial intelligence, virtual reality and augmented reality technologies
- City powered by renewable energy
The energy industry is also actively investing in Robotics and IoT

<table>
<thead>
<tr>
<th>Situation</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Having challenges in acquiring 3D high density seismic data in hard-to-access onshore areas.</td>
<td>TOTAL is currently developing a <strong>robotic system</strong> (METIS), to revolutionize the land seismic survey operations using a combination of <strong>UAV</strong>, <strong>IoT node</strong>, <strong>airship</strong>, and <strong>unmanned vehicle</strong> technologies.</td>
</tr>
<tr>
<td>Inspection and monitoring jobs are dangerous and tedious in remote and unmanned oil and gas facilities.</td>
<td>In 2017, Shell deploys Sensabot, a <strong>mobile robot</strong> to perform inspection and monitoring tasks in extreme temperatures as well as within explosive and toxic atmospheres.</td>
</tr>
<tr>
<td>Exploration demand in remote and hard-to-access areas. Inspection of oil and gas facilities including large network of pipelines, columns, reactors, tanks and boilers.</td>
<td>Saudi Aramco has recently deployed 16 <strong>underwater AUVs</strong> for seismic survey in the Arabian Gulf. The company has also deployed a <strong>mobile robot</strong> equipped with ultrasonic <strong>sensors</strong> for tank inspection. In addition, <strong>UAV</strong> are being used in for geo 3D modeling and facility inspection.</td>
</tr>
</tbody>
</table>

Source: Press research, Saudi Aramco
Market for industrial robots in KSA is expected to grow at ~20% CAGR till 2030, reaching $6130MM
Localization potential exists at most stages of the Industrial Robotics and IoT value chain

<table>
<thead>
<tr>
<th>Step</th>
<th>Hardware and equipment</th>
<th>Connectivity and system integration</th>
<th>Software and platforms</th>
<th>Production &amp; services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source: Saudi Aramco analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gaps</td>
<td>No local manufacturer of control systems and imbedded systems for Robotics/IoT in KSA. Strong potential for local manufacturing</td>
<td>No local companies provide system integration in Robotics. Limited presence in IoT.</td>
<td>Potential to localize software developer in KSA. Open software platform such as robotic operating system (ROS) and associated platforms has high potential to be localized.</td>
<td>Limited presence of players manufacturing Robotics/IoT systems or offering associated services in KSA.</td>
</tr>
</tbody>
</table>
Key Messages

<table>
<thead>
<tr>
<th>Key messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Robotics and IIoT are fast growing technologies and has applications both industrial (oil and gas, manufacturing, transportation) and commercial applications (NEOM)</td>
</tr>
<tr>
<td>✓ The KSA market for Robotics is growing rapidly at <strong>20% CAGR to reach $6130MM by 2030</strong>.</td>
</tr>
<tr>
<td>✓ Investment, at Aramco and national level present great opportunities across the value chain.</td>
</tr>
<tr>
<td>✓ Demand on local service providers and system integrators on Robotics/IIoT systems.</td>
</tr>
</tbody>
</table>

In case you are interested in discussing this opportunity further, please contact

XXX

XXX

Saudi Aramco

XXX
Artificial Intelligence
Artificial Intelligence, Big Data and Advanced Analytics
Analytics vs. Advanced Analytics

From Reporting and monitoring to predicting and optimizing

- Reactive
- What happened
- Past performance
- Structured data

- Advanced Analytics
  - Proactive
  - What will happen
  - Future events
  - Structured data & unstructured data
Big data/analytics have several applications within Oil and Gas—there exists potential for local companies to offer these services.
<table>
<thead>
<tr>
<th>Situation</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ExxonMobil</strong></td>
<td>To drive optimization, ExxonMobil unified data storage to one huge data lake.</td>
</tr>
<tr>
<td><strong>BP</strong></td>
<td>BP recognized that it is underutilizing its data repository and needed to invest in data mining to fully leverage all available data.</td>
</tr>
<tr>
<td><strong>Dow Chemicals</strong></td>
<td>Dow Chemicals creates <em>enormous amounts of data in numerous silos</em> and wished to effectively utilize it to drive business efficiency.</td>
</tr>
</tbody>
</table>

Source: Press research, Saudi Aramco
Furthermore, several large enterprises in KSA are already embracing data analytics solutions

<table>
<thead>
<tr>
<th>Examples of Analytics deployment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saudi Aramco have been utilizing big data in its upstream business for years. Implemented several advanced analytics solutions ranging from operational predictive analytics to text and sentiment analysis. Currently piloting and testing several Advanced analytics and big data solutions.</td>
</tr>
<tr>
<td>SABIC selected ZEMA to meet its business users' requirements for a fully automated data collection, validation, and auditing tool that will easily integrate up-to-the-minute market data with SABIC’s downstream systems.</td>
</tr>
<tr>
<td>• Bahri identified 31 Big Data unique models to improve ROCE, 12 of which were implemented successfully in 2016, saving the company $200 MM.</td>
</tr>
<tr>
<td>• Leveraging Microsoft big data analytics solutions to enhance business efficiency e.g. route optimization, fuel management, streamlining of maintenance and enhanced performance reporting</td>
</tr>
</tbody>
</table>

Source: Desktop research, Microsoft, Saudi Aramco
Market for Advanced Analytics in KSA is expected to grow at ~42% CAGR to reach a value of $3200MM by 2025

Source: AT Kearney
Localization potential exists at most stages of the analytics value chain

<table>
<thead>
<tr>
<th>Step</th>
<th>Hardware and equipment</th>
<th>Connectivity and system integration</th>
<th>Software and platforms</th>
<th>Data Science Services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No local manufacturer of commodity storage, GPUs, and other server components in KSA - strong potential for local manufacturing</td>
<td>Several players already offering system integration services and players offering connectivity active in KSA. Potential to enhance services to cater to analytics applications. Potential to upgrade connectivity and infrastructure</td>
<td>Potential to localize platforms for advanced analytics in light of regulations limiting storage of data outside KSA. Vertical industry analytical solutions are required to exploit the large amounts of data amassed.</td>
<td>Development of predictive and prescriptive models for plant operations and business applications. Required specialities include data services, data analysis, modeling, optimization, data mining, and machine learning.</td>
</tr>
</tbody>
</table>

Source: Desktop research, Saudi Aramco analysis
Key messages and next steps

Key messages

✓ Advanced analytics is taking off and has applications both in oil and gas and several other industries in KSA (e.g. manufacturing)

✓ The KSA market for advanced analytics is growing rapidly at ~14% CAGR to reach ~$700 mn by 2025

✓ Saudi Aramco is also taking advanced analytics seriously with applications in hydrocarbon processing, support services, and other business domains.

Source: Saudi Aramco analysis

In case you are interested in discussing this opportunity further, please contact

XXX
YYY Dept.
Saudi Aramco
zzz@aramco.com
Advanced Materials
Advanced Materials are enablers to 4IR innovations and have applications across multiple industries

<table>
<thead>
<tr>
<th>4th Industrial Revolution</th>
<th>Oil and Gas</th>
<th>Other Industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robotics</td>
<td>Exploration</td>
<td>Military and Defense</td>
</tr>
<tr>
<td>IOT</td>
<td>Drilling</td>
<td>Energy</td>
</tr>
<tr>
<td>Big Data</td>
<td>Recovery</td>
<td>Food</td>
</tr>
<tr>
<td>AI</td>
<td>Production</td>
<td>Construction</td>
</tr>
<tr>
<td>High Performance Computing</td>
<td>Transport</td>
<td>Automotive</td>
</tr>
<tr>
<td></td>
<td>Refining</td>
<td>Aerospace</td>
</tr>
</tbody>
</table>

- Nanomaterials
- Carbon Nanotubes
- Composites
- Carbon fibers
- Polymers
- Thermoplastic
- Alloys
- Metal Powders
- Semiconductors
- Surfactants
- Metamaterials
- Graphene
- Exploration
- Drilling
- Recovery
- Production
- Transport
- Refining
- Energy
- Construction
- Automotive
- Aerospace
- Electronics
- Power
- Sports
The Global Market for Advanced Materials is expected to rise at a CAGR of 10.6% during 2015-2025

The opportunity in this market, which was worth $42.76 bn in 2015, rose to $51.5 bn in 2017 and is anticipated to rise to $115.2 bn by 2025.

Source: Saudi Aramco analysis
Market for 3D printing in KSA is expected to grow at 10% CAGR to reach a value of $1330MM by 2025

KSA 3D printing spend ($mm)

Source: AT Kearney
## Localization potential of Advanced Materials Value Chain

<table>
<thead>
<tr>
<th>Step</th>
<th>Feedstock</th>
<th>Science and Training</th>
<th>Production</th>
<th>Manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Petrochemicals</td>
<td>Expertise</td>
<td>Polymers</td>
<td>Products</td>
</tr>
<tr>
<td></td>
<td>Minerals</td>
<td>Labs</td>
<td>Surfactants</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Organic/inorganic compounds</td>
<td>Hans-on</td>
<td>Ceramics</td>
<td></td>
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<tr>
<td></td>
<td>Solvents</td>
<td>Instrumentation</td>
<td>Glasses</td>
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<tr>
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<td>Formulation</td>
<td>Polymers</td>
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<td>Composites</td>
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<td></td>
<td></td>
<td></td>
<td>Metals &amp; Alloys</td>
<td></td>
</tr>
</tbody>
</table>

### Gaps

- **Feedstock**: Low availability of specialty chemicals (organic and inorganic compounds and solvent).
- **Science and Training**: No enough skilled technicians, technologists, and hands-on training facilities. Majority of research and discovery efforts done OOK.
- **Production**: Large-scale synthesis plants. Limited presence of players developing advanced materials in KSA.
- **Manufacturing**: Specialized technicians. Market.

Source: Desktop research, Saudi Aramco analysis
In case you are interested in discussing this opportunity further, please contact

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Saudi Aramco
zzz@aramco.com

Key messages

- Advanced Materials industry allows other sectors to turn innovations into sophisticated products that enable digitalization.
- Advanced Materials industry is itself being transformed through digitalization.
- Advanced Materials are foundation to numerous products and applications across multiple industries.
- The KSA market is less than 1% CAGR of global market - opportunities are endless for KSA and Aramco.
- Knowledge transfer and hands-on training platforms are a high-potential localization opportunity.

Source: Saudi Aramco analysis
The End