Hype Cycle for Oil and Gas, 2021

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Oil and gas companies are intensifying the scale and scope of digital innovations to drive rapid change while maintaining efficiency. In the face of rapidly expanding technology choices, CIOs can use this Hype Cycle to align relevant technologies with goals and take action on them.

Analysis

What You Need to Know

Digital technologies are key enablers for oil and gas companies to achieve improved performance in innovative and agile ways without sacrificing efficient and reliable operations. Digital leaders face increasing demand for new capabilities and an overwhelming number of new technologies that are potentially usable, making it difficult to sort out the most relevant trade-off decisions regarding investment choices. Mastering the foundational technologies in the mature regions of the Hype Cycle is the key to achieving the cost-efficiency and reliability required to withstand more competitive commodity markets.

Selective adoption of the emerging technologies in central regions of the Hype Cycle opens up pathways to the performance and productivity improvements that business units need to achieve their objectives. Thoughtful experimentation with transformational technologies at the front of the Hype Cycle can unlock new business capabilities that are essential to survive energy decarbonization. CIOs and digital leaders should use this Hype Cycle as part of an innovation management process to improve awareness, develop alignment and focus action on the technologies most relevant to your company.

The Hype Cycle

Gartner research shows that, since 2020, oil and gas companies have elevated their focus on digital investment. Digital maturity is at the highest levels ever recorded in our survey. Projects are leveraging broader ranges of technologies. And following the success of shifting to remote work, most CIOs find themselves with greater influence and responsibility for driving progress. (See 2021 CIO Agenda: An Oil and Gas Perspective.)

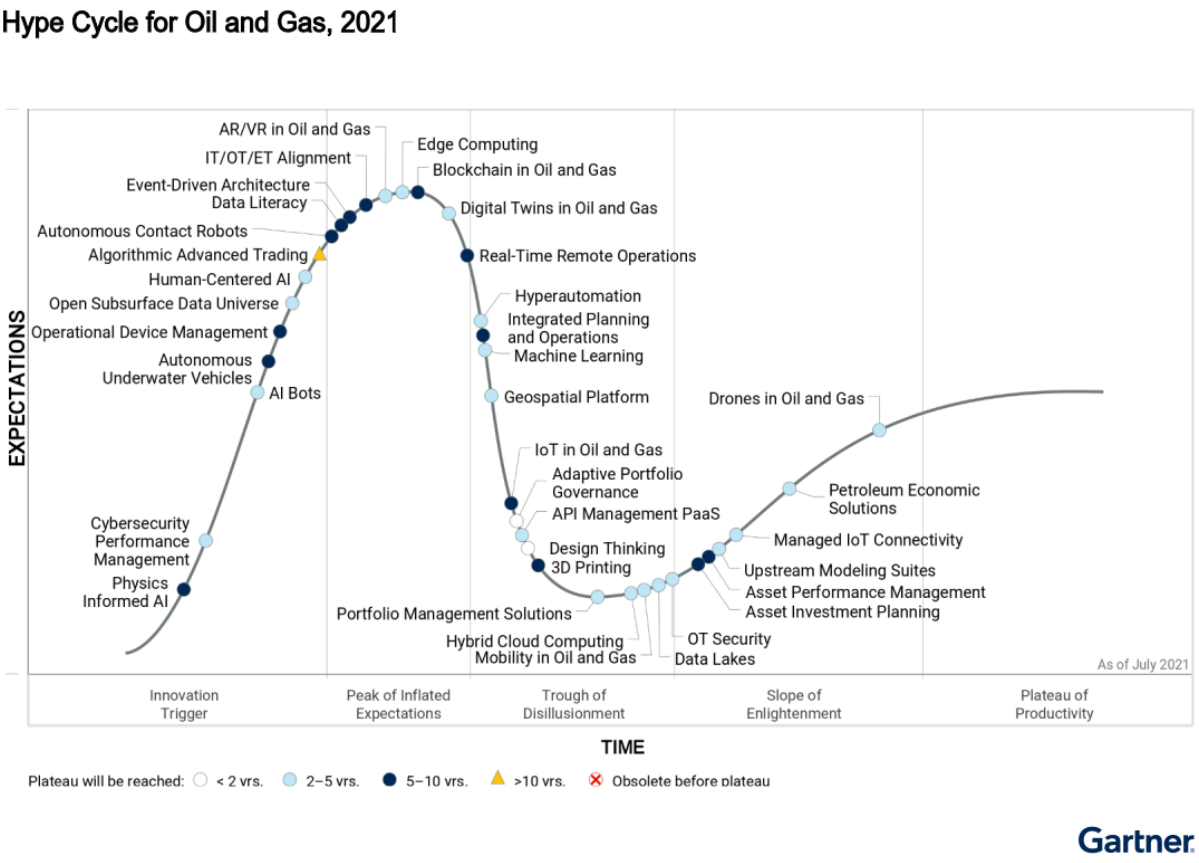
To be successful over the next decade, savvy CIOs and digital leaders are intensifying digital innovation efforts. It is more important than ever to have a clear and unbiased understanding of key digital technologies, the capabilities they enable, the implementation risks they carry and the potential business value they unlock. With leaner IT staff, the information in this Hype Cycle report can save digital leaders time and money.

Many of the mature technologies on this Hype Cycle located on the Slope of Enlightenment or the Plateau of Productivity can be classified as systems of record in a pace-layered architecture. [1] These technologies enable operational excellence in delivering core oil and gas capabilities and services (such as asset performance management and upstream modeling suites).

Technologies moving from the Peak of Expectations to the Trough of Disillusionment may be tricky to use but can be highly effective. Capabilities and technologies such as digital twin modeling and human-centric AI effectively increase worker productivity, digitalize processes and improve organization agility.

And those newly emerged capabilities and technologies that are moving toward the Peak of Expectations show promise in revolutionizing core operational capabilities and (sometimes) even business models. Profiles such as AI bots, physics-informed AI and algorithmic advanced trading hold great promise, but are underdeveloped and require important accommodations to use successfully.

Figure 1: Hype Cycle for Oil and Gas, 2021



Source: Gartner (July 2021)

Downloadable graphic: Hype Cycle for Oil and Gas, 2021

The Priority Matrix

The greatest change from the 2019 Hype Cycle is the accelerated pace that oil and gas companies are taking toward their digital innovation objectives. The industry is facing pressure from decarbonization, and rapid improvements in cost-efficiency are paramount (for more, see Top 10 Trends Driving the Oil and Gas Industry in 2021). Not surprisingly, 22 capabilities and technologies (59%) in this Hype Cycle will mature within the next five years. All but two (5%) will mature before 10 years. Some are being broadly adopted by all oil and gas companies, such as machine learning, mobility and OT security. Others, such as artificial intelligence (AI) bots, hybrid cloud computing and Open Subsurface Data Universe (OSDU) are realizing more selective uptake.

The heightened sense of urgency is amplified by technical opportunity as 30 capabilities and technologies (81%) offer transformation or high benefits. Several of these will work together to yield compounding impact, such as edge computing, human-centered AI and hyper automation. Digital strategies in 2019 were widening and investing in a growing number of technologies. However, the financial pressure of 2020 has focused today's strategies, and we have filtered out all but seven capabilities and technologies (19%) that offer moderate benefit. Yet, even these include essential foundational elements, such as data lakes and operational device management, that enable the rest of the digital innovation strategy.

Table 1: Priority Matrix for Oil and Gas, 2021

(Enlarged table in Appendix)

Benefit	*Years to Mainstream Adoption*			
↓	***Less Than 2 Years*** ↓	***2 - 5 Years*** ↓	***5 - 10 Years*** ↓	***More Than 10 Years*** ↓
Transformational	Adaptive Portfolio Governance	AI Bots in Oil and Gas Digital Twins in Oil and Gas Edge Computing Human-Centered AI Machine Learning Open Subsurface Data Universe	IoT in Oil and Gas Physics-Informed AI Real-Time Remote Operations	Algorithmic Advanced Trading
High	Design Thinking	AR/VR in Oil and Gas Cybersecurity Performance Management Drones in Oil and Gas Geospatial Platform Hybrid Cloud Computing Hyperautomation Managed IoT Connectivity Mobility in Oil and Gas OT Security Upstream Modeling Suites	Asset Performance Management Autonomous Contact Robots in Oil and Gas Autonomous Underwater Vehicles in Oil and Gas Blockchain in Oil and Gas Data Literacy Event-Driven Architecture Integrated Planning and Operations IT/OT/ET Alignment	
Moderate		API Management PaaS Data Lakes Petroleum Economic Solutions Portfolio Management Solutions	3D Printing in Oil and Gas Asset Investment Planning Operational Device Management	
Low				

Source: Gartner (July 2021)

Off the Hype Cycle

The previous Hype Cycle for oil and gas was published in 2019. Since that time, the portfolio of innovations on the oil and gas Hype Cycle has been updated. The following innovations have fully matured and have been rolled off the Hype Cycle:

- Cloud HPC for Upstream Modeling
- Cloud-Based Engineering Information Management
- Hydrocarbon Accounting Platforms

The following innovations were replaced by more up-to-date versions:

- API Management PaaS has displaced API Economy
- Hybrid Cloud Computing has displaced Cloud Computing
- Adaptive Portfolio Governance has displaced Digital Dexterity

These innovations were replaced with profiles that better reflect current industry priorities:

- Artificial General Intelligence
- Conversational User Interfaces
- DevOps
- Product-Centric Delivery Model
- Robotic Process Automation

On the Rise

Physics-Informed AI

Analysis By: Erick Brethenoux, Svetlana Sicular

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Physics-informed AI (PIAI) incorporates physical and analog principles, governing laws and domain knowledge into AI models. By opposition, purely digital AI models do not necessarily obey the fundamental governing laws of physical systems and first principles — nor generalize well to scenarios on which they have not been trained. PIAI extends AI engineering to complex system engineering and model-based systems.

Why This Is Important

As AI becomes critical, greater demand is placed on AI's ability to abstract problems and better represent its context. Digital-only AI solutions cannot generalize well enough beyond the training data, limiting their adaptability. PIAI instills a more reliable representation of the context and the physical product, yielding more adaptive systems. A better ability to abstract leads to greater physical consistency, reduced training time, improved data efficiency and better generalization.

Business Impact

PIAI can:

- Build physically consistent and scientifically sound AI models, significantly improving their applicability.
- Increase data efficiency, i.e., train models with fewer data points.
- Accelerate the training process, i.e., help models converge faster to optimal solutions.
- Improve the generalizability of models to make reliable predictions for unseen scenarios, including applicability to nonstationary systems.
- Enhance transparency and interpretability to make models more trustworthy.

Drivers

- Among many lessons, the pandemic has shown how brittle our traditional business modeling approaches were. That brittleness also comes from the fact that the digital building blocks making up our solutions cannot generalize well enough beyond their initial training data, therefore limiting the adaptability of those solutions. PIAI approaches can instill a more flexible representation of the context and conditions in which our systems operate, allowing developers to build more adaptive systems.
- Traditional AI techniques, particularly in the machine learning family, have been confronted with severe limitations — especially when it comes to causality and dependency analysis, context flexibility and memory retention mechanisms. Increasing demand on those techniques calls for new methods to overcome those limitations. PIAI approaches provide additional physical knowledge presentations, such as partial differential equations or active metadata, to guide or bound AI models. Asset-centric industries have already started leveraging these methods in physical prototyping, predictive maintenance or composite materials analysis also in conjunction with Augmented Reality/Virtual Reality implementations.
- Complex systems like climate and environmental issues, large scale digital-twin modelization and complex health science problems have been particularly challenging to model. Composite AI approaches have helped and provide more concrete answers and manageable solutions to those problems, but their engineering remains a significant challenge. PIAI can provide more immediate answers to some of those problems.
- The need for more robust and adaptable business simulation systems will also promote the adoption of PIAI approaches. With a better range of context modelization and more accurate knowledge representations techniques, simulations will be more reliable and account for a wider range of possible scenarios — all better anchored in reality.

Obstacles

- From a diagnostic perspective, the development of systematic tests and standardized evaluation for these models — across benchmark datasets and problems — could slow down the adoption of PIAI capabilities.
- Computationally, the scaling of the training, testing and deployment of complex PIAI models on large datasets — in an efficient manner — so they perform well in a rapidly changing computational landscape will also be an issue.

- Resource-wise, the collaboration across many diverse communities: physicists, mathematicians, computer scientists, statisticians, AI experts and domain scientists, will also be a challenge.

User Recommendations

- Encourage reproducible and verifiable models by starting with small-scoped problems; complex systems and environments are generally good candidates for this approach.
- Enforce standards for testing accuracy and physical consistency applicable to state-of- the-art physics and first-principles-based models of the relevant domain, while characterizing sources of uncertainty.
- Set realistic development objectives by identifying errors that cannot be reduced and discrepancies that cannot be addressed — including the quality of training or synthetic data.
- Promote model-consistent training for PIAI models and train models with data characteristics representative of the downstream application, such as noise, sparsity and incompleteness.
- Quantify generalizability in terms of how performance degrades with degree of extrapolation to unseen initial conditions, boundary conditions and scenarios.
- Build interpretable models and use semantics and active metadata to inform the context where models operate.

Sample Vendors

Google (Deepmind); MathWorks; NNaisense; NVIDIA

Cybersecurity Performance Management

Analysis By: Claude Mandy

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Cybersecurity performance management is a complex topic that can be split across two, nonsequential, but connected sets of activities. These activities are designed to continually assess the current performance of the cybersecurity function and dynamically plan a strategic and aligned approach to driving cybersecurity performance, particularly the reduction of cyber risk to the business.

Why This Is Important

Security and risk management (SRM) leaders are under pressure to both reduce risk and also demonstrate and communicate the value, efficiency and maturity of their security program to a broad range of stakeholders with differing and evolving expectations. After years of quarterly reporting on cybersecurity to boards, boards are asking for improved reporting on the value of the program and an understanding of what the security program has achieved after years of significant investment.

Business Impact

Cybersecurity performance management and supporting toolsets can help organizations demonstrate a more dynamic approach to their cybersecurity program. A performance management focus will allow cybersecurity functions to continuously improve, as well as adapt rapidly to changes in the business, technology and threat environments — monitoring and optimizing the performance of the security function over time.

Drivers

- Pressure from boards for improved, ongoing reporting on the return of investment in the cybersecurity program.
- Greater focus on the cost optimization of cybersecurity programs and the failure of rigorous, inflexible security programs to cope with the impact of the COVID-19 pandemic.
- Over-reliance on negative themes (scare statistics, inflated risk exposures and impending disasters) as the basis for security investment.

Obstacles

- Most industry standards and frameworks for risk and security reflect the development of capabilities with little guidance on how to address the performance and delivery of these capabilities.
- Technology risk and cybersecurity metrics are mostly trailing indicators of operational results, which are not useful in measuring the performance of the cybersecurity function through levels of protection or reduction of risk.
- The supporting toolsets are still emerging and attempting to differentiate themselves from broader more risk-focused integrated risk management (IRM) and IT risk management (ITRM) solutions.

User Recommendations

SRM leaders looking to adopt a cybersecurity performance management approach and relevant tools should:

- Establish an achievable, realistic vision for the security program that describes business, technology and environmental drivers.
- Utilize a combination of assessment approaches to assess the security program.
- Determine priorities and investments by facilitating informed conversations with executives and integrating risk, value and cost optimization into business cases, funding requests and board reporting.
- Develop clear links among objectives, gaps, specific projects and actions, and the vision statement to track and report on progress.
- Track outcomes through outcome-driven metrics with a direct line of sight to the level of protection required.
- Evaluate both stand-alone supporting tools and capabilities within IRM solutions based on their ability to enable a performance management approach (see Emerging Technologies: Critical Insights for Integrated Risk Management).

Sample Vendors

Blue Lava; ProcessUnity; TrustMAPP; V3 Cybersecurity

Gartner Recommended Reading

Security Strategy Planning Best Practices

AI Bots in Oil and Gas

Analysis By: Rich McAvey

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Gartner defines AI bots as instances of AI code created to consume broad forms of information, derive meaning, create predictions, make recommendations and/or initiate actions in complex environments. AI bots exist in many forms, such as features in vendor software, SaaS services or proprietary software. The distinguishing characteristic of AI bots is that they are small, modular and have a narrowly defined scope.

Why This Is Important

AI bots are proliferating rapidly within oil and gas companies. They significantly augment and redefine the workstreams of humans. In some cases, they fully displace humans. Unlike large integrated software packages from trusted vendors, AI bots come from multiple sources and have no natural guarantee of interoperability. While they are essential technology components for achieving critical business objectives such as cost efficiency, automation and productivity, they also introduce new forms of risk.

Business Impact

AI bots significantly increase the quality and speed of decision making. They enable more extensive workflow integration and automation. Their distinctive value flows from their low-cost of creation, ease of reuse and ability to scale quickly. AI bots are typically created to provide specific performance improvement to local managers. Over time, more bots are created, resulting in more optimizing decisions happening more frequently at all levels of operations.

Drivers

- Externally developed AI bots are offered via multiple channels, including SaaS as well as elements within traditional software solutions, providing easy access to a wider array of solutions than could be developed internally.
- For more complex challenges, coding methodologies such as design thinking, minimum viable product and agile development, along with scalable cloud-based development platforms, make AI bots fast and economical to build.
- AI bots can be combined in an endless variety of ways and with other technologies, such as mobility and natural language inquiries to improve business performance of virtually all oil and gas workstreams.

Obstacles

- The concept of AI bots is still new within oil and gas, and management practices for creating, deploying and sustaining them over time are not yet mature.
- The state of data and metadata curation in most oil and gas companies is not yet compatible with large-scale AI bot consumption, and will limit their deployment.
- Few technical standards for AI bots have been established, and their ultimate manifestation will require more time and experimentation.

User Recommendations

- Prepare business leaders to manage the plethora of AI bots that will emerge over the coming years by developing a strategy and communications plan. The key mindset to establish is that AI bots start small (as rapidly developed, low-cost decision support tools for narrow use cases), but their modularity drives reuse as essential elements in large-scale solutions over time.
- Educate users on the criticality of consistent and reliable data feeds into autonomously acting AI bots. Develop enterprise standards, artifacts (such as APIs), policies, and compliance requirements to evaluate and manage risks.
- Develop capabilities within IT to facilitate development of new AI bots collaboratively with business leaders. Also develop design capabilities to promote reliable, low-risk interoperability as well as methodology for curating portfolios of bots over their life cycle.

Sample Vendors

Belmont Technology; Beyond Limits; BHC3; SparkCognition; Swim; Windward

Gartner Recommended Reading

Use Digital Factories to Drive Deep Optimization Across the Enterprise

Autonomous Underwater Vehicles in Oil and Gas

Analysis By: Simon Cushing

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

The oil and gas industry uses the term “ROV” (remotely operated vehicle) to describe unmanned remote-controlled underwater vehicles for subsea facilities’ construction and inspection. Autonomous underwater vehicles (AUVs) are the next generation of ROVs with self-guiding capabilities. AUVs do not require a physical link between the vehicle and operator and can carry out a wider range of missions than traditional ROVs.

Why This Is Important

Traditional ROVs are controlled by operators on surface vessels or facilities via umbilical cables providing power and communications. Providers are developing AUVs using advances in communication technologies and robotics to give higher levels of autonomy, allowing systems to operate without tethering, remain on station longer, and perform more complex tasks including equipment operation and maintenance.

Business Impact

AUVs have major potential to improve safety and efficiency in oil and gas offshore construction and production operations. Patrolling sites for long periods of time, they can provide unprecedented levels of situational awareness about subsea asset condition and performance. Programmed to make decisions autonomously, they can provide early detection of risks to asset structure and integrity, and rapidly undertake operations to maintain or make them safe. Efficiency and safety can be improved with lower environmental impact.

Drivers

- ROV usage is predicted to increase in the next five years. One market analysis forecasts a compound annual growth rate (CAGR) of over 5% from 2020 to 2025 (see AUV & ROV Market — Growth, Trends, COVID-19 Impact, and Forecasts [2021-2026]). AUV adoption is expected to be the biggest driver of this growth.
- Increasingly, to reduce capital and operating costs, offshore facilities use subsea completion designs that allow wellheads to be tied back to host platforms many miles away. ROVs are critical in inspecting and maintaining these facilities.
- ROV use is not confined to offshore oil and gas installations. Any offshore construction can make use of them, and growing investment in offshore wind generation by oil and gas companies and others is likely to provide momentum for use and development. The same is true of rising decommissioning requirements in aging offshore oil and gas provinces.
- Providers are developing AUVs using advances in communication technologies and robotics to give higher levels of autonomy, allowing systems to operate without tethering, remain resident on station, and perform more complex tasks including equipment operation and maintenance. These advances also enable ROV piloting from remote control centers.
- In the longer term, AUVs have the potential to become a key data acquisition tool in the future technology platforms for operational control and optimization of offshore assets.

Obstacles

- Commercial AUVs have come to market; however, operational deployments of fully autonomous vehicles are limited and exploratory.
- Development will be incremental along a scale of increasing autonomy. The complexity of providing fully autonomous capability along with the need to manage risk in inaccessible subsea environments will moderate the pace of adoption.

User Recommendations

- Anticipate increased need to integrate AUV data streams with lines of business and enterprise systems, and work with stakeholders in engineering and asset operations to understand the planned scope of AUV deployment in your enterprise.
- Add value by proactively supporting initial AUV deployment with data aggregation and analytics tools.
- Monitor the development of AUV communications, and data transfer technologies and standards, and ensure platform development roadmaps include the ability to integrate AUV data, when required.

Sample Vendors

Houston Mechatronics; Liquid Robotics (Boeing); Lockheed Martin; Oceaneering; Teledyne Marine

Operational Device Management

Analysis By: Lloyd Jones

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Utilities need to manage sensors, actuators and controllers in the operational technology domain. Operational device management brings asset, configuration and data management capabilities together to create a comprehensive management platform to mitigate operational risks.

Why This Is Important

As the energy transition accelerates, utilities need to accurately sense real-time performance to maintain system stability. Utilities deploy a wide range of operational technology (OT), such as sensors, actuators, controllers, gateways, protection devices, and their connectivity and configuration, to measure and control power system resources. The lack of integrity of the operational fabric constrains measurement and control, and thus the performance of the power system.

Business Impact

Regulatory audit requirements around OT are tightening in response to avoidable incidents triggered by OT device failures. OT devices are IP-connected and are vulnerable to cyber attack. Yet utility OT asset management practices are lagging primary assets, leaving utilities exposed through unmanaged firmware and configurations. Operational device management capabilities allow OT devices to be maintained and safeguarded across their life cycle.

Drivers

- Energy systems are vulnerable to disturbances. OT devices span a wide range of technologies including phasors, protection, reclosers, tap changers and radios to detect and control the network to manage disturbances. Traditionally, OT devices were wired, but today are IP-enabled and software-driven. Consequently, OT devices need to be managed, maintained, calibrated, configured and updated by operational device management capabilities.

- An ODM capability supports multiple device protocols across a wide range of OEM suppliers, and retains appropriate asset management records including the ability to collect/optimize/update device configurations remotely.

- Operational device management capabilities will reduce operational costs, reduce unexpected failures and improve the visibility of the power system with accurate, timely measurements that can be trusted to support operations.

Obstacles

- The majority of OT devices started their asset life cycle spreadsheets, with the associated data quality and audit risks. Some utilities have had limited success with legacy EAM systems to do basic asset management such as inventory, inspection and battery management. But they are unable to support configuration, connectivity and data capabilities.
- Legacy practices with narrow verticals for some OT devices such as meter headend systems and data management are unique to specific device manufacturers, leaving much of OT unmanaged.
- A generic data model that abstracts OT devices and their configurations are often unique to a device manufacturer, creating significant complexities for generic OT device management tools.
- Legacy protocols from legacy device manufacturers create a raft of specialized use cases to connect to and configure a specific manufacturer device through a unique physical connector, limiting over-the-air capabilities.

User Recommendations

- Avoid neglecting OT device management as it will compromise the operational performance of the power system.
- Design the implementation of an ODM by OT device class. Protection devices are early obvious candidates that would benefit with management of multiple configurations matched to various network topologies. But auditability in the case of maloperation can be challenging if the configurations are not accurately version managed and time stamped.
- Establish an ODM as a system of record for OT devices, but not necessarily for the handling of the data streams from the OT devices.
- Consider IoT platforms as an alternative to an ODM platform if the provider can support your legacy OT device inventory and required protocols.

Sample Vendors

Oracle; IPS GmbH; Microsoft

Gartner Recommended Reading

How Utility CIOs Can Use Intelligent Operations to Achieve Resilience During the Energy Transition

Innovation Insight for Digital Platform Conductor Tools

Critical Capabilities for Industrial IoT Platforms

Open Subsurface Data Universe

Analysis By: Simon Cushing

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

The Open Subsurface Data Universe (OSDU) is an open-source, cloud-native data architecture for subsurface data, developed and released by the Open Group OSDU Forum. The stated aim of the OSDU Forum is to develop a common data platform on global, public cloud services with standard, public APIs that facilitates data access across upstream workflows.

Why This Is Important

Reliable hydrocarbon reservoir models are core to upstream companies' value chains. Legacy technologies impede modeling through difficult data access. Seamless data access and interoperability of modeling tools could transform the process, decreasing cycle times and improving outcomes. The industry has undertaken past standards and data model initiatives with these aims, without fully achieving them. The OSDU Forum has wide membership and has maintained momentum since inception in 2018, showing signs of promising progress toward these goals.

Business Impact

Subsurface modeling drives competitive advantage for upstream companies. It depends on an array of specialist tools and large volumes of disparate data that is costly to acquire and maintain. The process generates large output that can quickly become unmanageable, resulting in lost or duplicated effort, inefficiency, and higher cost. Widespread usage of a standard data architecture would radically transform the model of upstream modeling capability acquisition and reshape the market for these applications.

Drivers

- Upstream operating companies seek to flexibly deploy their optimum choice of tools, maintain access to the knowledge held in past models and minimize the cost of data management.
- To achieve these goals, some operating companies have repeatedly pushed for application interoperability, common data models and standards in the industry.
- OSDU represents an effort to provide these capabilities based on modern software delivery approaches and crucially by using a provider-agnostic, cloud-native platform. Cloud adoption is growing in the industry and public cloud along with it.
- In recent years, leading vendors have increased the openness of their offerings, offering open source, APIs and applications marketplaces. These changes point to great acceptance, and adjustment to the principles and approaches with which OSDU is aligned.
- OSDU initial releases focus on exploration and production data. Its ambitions go beyond the subsurface, however, to encompass renewable and other energy businesses with the potential to facilitate oil and gas companies' responses to energy transitions.

Obstacles

- Most oil and gas companies acquire upstream modeling capability by buying commercial off-the-shelf (COTS) products from specialist vendors. Historically, the differing requirements of operators for openness versus vendor drivers for competitive advantage have acted to slow interoperability standards progress.
- OSDU will require vendors to adjust business models and potentially transform competition in the market. Given the market's specialist nature and small number of vendors, operating companies have not totally succeeded in reshaping vendor offerings around data sharing and interoperability requirements.
- Operators will need to sustain a united effort behind standardization in the face of other priorities and evolving application functionality.
- Previous efforts have been challenged by the customization demanded by operators and real-world implementation complexity. To become widespread, OSDU will need to show it is robust, reliable, easy to configure and maintain, and can meet the widely varying requirements of individual companies, as well as offering sufficient benefit over current vendor platforms.

User Recommendations

Upstream operating companies should:

- Engage with OSDU by joining the OSDU Forum and actively participate in its activities.
- Conduct proof of concept and, if successful, pilot evaluation of the current release making some investment in the technical feasibility to do so, if necessary.
- Develop upstream modeling portfolio management plans based on these evaluation results.

Upstream modeling suite vendors should:

- Engage with OSDU by joining the OSDU Forum and actively participating in its activities.
- Demonstrate to clients a clear position with respect to OSDU, and for all other stances than "wait and see," design a product roadmap for current or future compatibility.

- Adopt product strategies that recognize the possibility of industrywide adoption, considering the competitive ramifications and preparing by identifying potential business model challenges and new opportunities.

Human-Centered AI

Analysis By: Svetlana Sicular

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

Human-centered AI (HCAI) is a common AI design principle calling for AI to benefit people and society. It assumes a partnership model of people and AI working together to enhance cognitive performance, including learning, decision making and new experiences. HCAI is sometimes referred to as “augmented intelligence,” “centaur intelligence” or “human in the loop,” but in a wider sense, even a fully automated system must have human benefits as a goal.

Why This Is Important

HCAI, when AI serves human and societal goals, continues to emerge as a design approach to deliver the most value from AI. An early idea that AI is simply a neutral technology is passing. Organizations see that HCAI allows them to manage the AI risks, to be ethical and more efficient with automation, while complementing AI with a human touch and with common sense. Many AI vendors have also shifted their positions to the more impactful and responsible HCAI approach.

Business Impact

HCAI compensates for human limitations and expands the possibilities for AI in the following key scenarios:

- Certain job tasks are done by AI, and the rest are done by people.
- People complete the job started with AI when AI reaches the limits of its capabilities or resources.
- Assistive AI develops and expands people’s skills and talents.

- Innovation when neither AI nor people can accomplish the task without each other.
- Fully automated or autonomous systems where humans have an override capacity.

Drivers

- AI solutions must support human goals and objectives. This includes nonhuman, beneficial to people, ways of optimizing a process or solving a problem in order to arrive at new and different results, taking advantage of machine learning working differently from human learning.
- People are the ones who adopt AI (they can sabotage it too). It is human nature to use what we like, understand and trust. AI can remove many avoidable limitations, biases and blind spots. However, there are many intrinsically human irrationalities that we admire and want to preserve as a society. People do not want to be treated as robots. These people are your employees and your customers, and they are the key to AI adoption.
- More organizations are turning to the HCAI approach where they lead an ongoing discussion about what's right and wrong to do with AI before and during the progress of AI projects.
- HCAI is an intentional approach that questions and validates AI optimization goals. AI systems that solely focus on optimizing for a single business metric, like making customers click on the next news item or video, lead to dangerous societal outcomes and damage reputation in the eyes of customers, partners and employees.
- AI is probabilistic: It means that AI's mistakes are unavoidable. AI-related opportunities promise to do what only people could do in the past — diagnose diseases, play games and maintain cogent conversations. Some results could be (egregiously) incorrect, although most of them are amazingly accurate. AI mistakes without a human in the loop lead to unintended consequences.
- People's flexibility compensates for automation's limitations. Properly orchestrated autonomy makes AI impactful, for example, when AI substitutes a human in harsh working conditions. But unattended automation may lead to a misappropriation of investment and often presents insurmountable complexity.

Obstacles

- Many data science and AI teams include exclusively technical reviews for AI projects, while the resulting human impact might invalidate the entire project.
- AI systems often make decisions and take actions, but miss a feedback loop or include it as an afterthought. This doesn't mean that a human must validate every single decision, but there must always be a review and override possibility for decisions. For example, autonomous vehicle design is centered on human safety and always includes a possibility of giving control to a human driver.
- It is hard to define what AI solution is socially beneficial and human-centered. Not everything that is socially beneficial is human-centered — for instance, a social credit system.
- Anthropomorphizing AI does not mean it is human-centered. For example, virtual assistants might not give users enough understanding and control over AI-enabled answers, thus impairing AI adoption.

User Recommendations

- Establish HCAI as a key principle and a design approach. Always determine who will benefit from an AI solution. Implement AI to focus human attention where it is most needed in order to accelerate organizational competencies that fulfill your vision for digital transformation.
- Create an AI oversight board that reviews your AI plans from the HCAI position as part of its charter. Make AI goals explicit and a decision process about AI planning and validation transparent. Ensure all people can voice their concerns.
- Ensure human safety — for example, for AI moderation in social media.
- Include user experience design to facilitate HCAI. This design could be abstract (software, services, digital) or in the physical space (physical robots).
- Maximize the effects of AI-augmented roles via ongoing education, experience labs, AI-enabled just-in-time training and other methods, so the company, ecosystem and the entire society can take on more exceptional and forward-looking work.

Gartner Recommended Reading

A Human-Centric Approach to Data and Analytics: Introducing the Homo Analyticus

AI Ethics: Use 5 Common Guidelines as Your Starting Point

The Chief Data Scientist Role Is Key to Evolving Advanced Analytics and AI

AI Development Must Embrace Empathy or Face a Human Uprising

Take a Human-Centric Approach to Empower the Workforce With AI

Algorithmic Advanced Trading

Analysis By: Sruthi Nair, Rich McAvey

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Energy trading has evolved and requires capabilities to manage intraday trading capabilities such as algorithmic and automated trading. Algorithmic trading tools assist energy companies in creating and executing trades using trading strategies and approaches that are continuously being improved by the algorithm. Automated trading assists in automation of the trades that are being executed, based on a clear set of trading rules by traders.

Why This Is Important

Reduced fossil fuel dependency and renewables growth cause demand and supply to constantly shift, causing volatile energy markets and a significant increase in short-term interval and intraday trading markets. Trading in such markets requires advanced algorithmic and automated trading capabilities. The signals occur in shorter intervals than ideal for human traders. Algorithmic trading platforms enable rapid testing, deployment and refinement of automated strategies, but come with new risks.

Business Impact

The primary impacted business domains are the trading teams — front, middle and back office, the risk teams and the supply chain teams. This is because there would be a requirement for enhancing the capabilities of the existing energy trade and risk management (ETRM) platforms or investing in platforms exclusively for algorithmic and automated trading.

Drivers

- The growing oil price volatility and the uncertainties around renewable energy trading have created substantial demand for short-term position management trading solutions, which have automated and algorithmic trading capabilities.
- For the risk management team, the unpredictable nature of renewables output makes hedging and speculative trading solutions complex, requiring algorithmic trading to navigate through such uncertainties.
- There is an increasing need for identifying spot changes and trends in various markets, concurrently combined with the requirements of unparalleled forecasting, trade information management and balancing and settlement tools for intraday trading markets.
- Volatilities caused due to oil pricing and renewables require access to real-time market feeds, monitoring product portfolio, but also monitoring the liquidity and difference in spreads.

Obstacles

- New technology adoption poses risks to the existing ETRMs and other risk management processes. Challenges around integration of algorithmic and automated trading capabilities with the existing ETRM and/or other internal systems cannot be overlooked.
- Additionally, in cases of deploying a stand-alone algorithmic trading platform, this will compound hindrances around cost and other implementation dependencies and, most importantly, adoption and acceptance of traders who are used to legacy trading platforms.

User Recommendations

- Build a long-term roadmap to support the implementation of algorithmic and automated trading capabilities by partnering with IT, trading and risk teams to evaluate current capabilities against advanced trading requirements.
- Evaluate the comprehensive functionalities required for enhancement of the existing trading platform with algorithmic and automated trading capabilities.
- Prioritize the business outcome capabilities of the algorithmic trading platform by aligning it to enterprise-level risk management strategies and measuring performance with project investment cash flows.
- Observe the evolving flexibility of market specialists by exploring the solutions' capabilities, and conducting pilot projects or POCs. Keep a keen eye on the functionality gaps and, if possible, collaborate with your existing ETRM vendor.
- Expand the capabilities of the existing ETRM by working with your ETRM vendor, and if expansion seems impossible, choose a stand-alone algorithmic trading platform.

Sample Vendors

Likron; NODES; Powel; Trayport

Gartner Recommended Reading

Market Guide for Energy Trade and Risk Management Systems

At the Peak

Autonomous Contact Robots in Oil and Gas

Analysis By: Simon Cushing

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Autonomous mobile robots are automated electromechanical machines or vehicles that maintain contact with the ground or physical structure, while moving to carry out tasks programmed or governed by human operators.

Why This Is Important

Oil and gas assets are hazardous environments, often in difficult and remote locations. Inspection, maintenance and operation of these assets are expensive and require extensive risk mitigation. Robots hold major promise of reducing cost while improving safety and environmental performance through continuous inspection, monitoring and operation of asset facilities without the need for an on-site human workforce.

Business Impact

With autonomous robots patrolling and operating oil and gas facilities, safety, asset integrity, equipment performance and asset efficiency could be radically improved while dramatically lowering risk to people and from human error. The human resources required to safely operate a plant (remotely as well as on-site) could be drastically reduced.

Drivers

- Production efficiency and cost optimization are key drivers for oil and gas companies today. Operators pursue improved asset uptime and safely extended asset life at lower, incremental cost.
- Fully implemented, unmanned operations may significantly reduce operating expenses compared to equivalent, permanently manned facilities at similar or reduced capital expenditure and with high availability.

- Autonomous robots with limited degrees of freedom, such as for pipeline inspection, corrosion removal and surface treatment, are in operation. A few major operators have test deployments of autonomous robots patrolling production facilities.
- Academic and commercial robotics research continues to advance. For example, recent advances in legged robot performance show high potential for oil and gas use. Some operators now have prototype robots certified for use in explosive risk environments.
- Collaboration between operators and academia (for example, in industry robotics initiatives, such as Total's ARGOS Challenge and the U.K.'s ORCA) is bearing fruit. The number and range of capability demonstrations continue to grow.

Obstacles

- Progress will be incremental. The engineering and computing challenges to safe, fully autonomous operation in complex or extreme environments of many oil and gas installations are extensive.
- Unique configurations and remoteness of many oil and gas facilities mean that fully autonomous robots are likely to be tailored, either in hardware or software.
- Cost and the lack of standardization are likely to slow adoption and constrain widespread deployment.
- The vast majority of existing oil and gas facilities have been designed and built without consideration for robotics use, and are highly complex for robots to navigate. While a few forward-looking companies may now consider robotic use in future automated facilities, the industry is years away from designing new assets with robot autonomy as a high priority.
- On most existing assets, robots will need to share space with people for the foreseeable future. This will limit their scope of use, slow cost reduction and moderate adoption until and unless major breakthroughs in robotics science generate game-changing capabilities.

User Recommendations

- Anticipate the need for secure and robust Wi-Fi and communications infrastructure to support robotics operations, where necessary factoring upgrade and investment into future budgets. Operational robots in oil and gas are being designed to use the cloud for noncritical processing and software updates can be done remotely.

- Understand the status of enterprise or business-unit robotics initiatives. Identify and assess the impact of any connectivity and technology maintenance requirements particularly, and ensure these can be addressed in alignment with applicable corporate technology governance frameworks.
- Factor autonomous robotics into scenario planning and likely outcomes into IT strategic thinking. While autonomous robotics remain far from maturity in the industry, the ramifications of future widespread use are considerable.

Sample Vendors

AMBPR; ANYbotics; Boston Dynamics; National Robotics Engineering Center; Sonomatic; Taurob

Data Literacy

Analysis By: Noha Tohamy

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Data literacy is the ability to read, write and communicate data in context, with an understanding of the data sources and constructs, analytical methods, and techniques applied. It is the ability to describe the use-case application and resulting business value or outcome.

Why This Is Important

With increased complexity, the need for data-driven decision making is pervasive across supply chains. Yet, organizations continue to cite lack of talent and cultural readiness as major hurdles for returns on investment. Data literacy offers the staff the requisite foundational principles in data and analytics to support more adoption. This spans their knowledge of data constructs and analytics approaches. With higher levels of literacy, organizations are more successful at leveraging data and analytics to maximize their value.

Business Impact

The ability of the supply chain organization to embrace and leverage data and analytics is critical for supply chain digitalization. Data literacy allows the staff to understand the data elements needed to represent supply chain conditions. A data literate organization appreciates the role of analytics in turning data into insights. Data literacy training drives organizational change by helping the users articulate the business value generated by data and analytics.

Drivers

- A majority of supply chain organizations have been actively investing in digital technologies that rely on data and advanced analytics.
- To support their organization's digital readiness, leaders are investing in their staff's overall digital competencies.
- Supply chain organizations seek to increase the adoption of data and analytics initiatives by educating their staff on how to leverage data and analytics insights in their decisions.
- There is a growing realization by supply chain leaders that the lack of data literacy is at the root of unsuccessful data and analytics initiatives.
- As analytics become pervasive in supply chain decision making, foundational understanding of analytics techniques and their role in use cases enable business users to effectively leverage data and analytics while still capitalizing on their domain expertise.
- Analytics leaders' need for building a business case for additional funding depends on the users' ability to articulate business value, which is one of the tenets of data literacy.

Obstacles

- Data literacy initiatives intended to drive organizational change can be overwhelming to immature organizations still focused on building the technical foundation for data and analytics.
- A piecemeal approach to data literacy training and certification.
- Lack of initiatives to address cultural and data literacy challenges within strategies and programs
- Lack of support and sponsorship of business leaders, focusing more on short-term, more critical supply chain priorities.
- Lack of understanding of the required scope of data literacy training programs and how to measure their efficacy.
- Lack of clarity of scope of services from external service providers, whose data literacy programs can range from training on visualization to fostering curiosity in data and analytics..
- Weak governance of data literacy training program with lack of clarity on ownership among supply chain, HR, and data and analytics functions.

User Recommendations

- Connect data literacy to improved supply chain performance and business outcomes.
- Tailor data literacy training programs to different user persona and business roles.
- Use data literacy assessments to evaluate current data literacy levels and desire to participate.
- Partner with HR to create a comprehensive curriculum, align and connect to competency models, role description, and career paths.
- Define data literacy as a required competency to future supply chain jobs.
- Identify service providers that have a defined data literacy training offering or partner with trusted service providers to develop a tailored training program.
- Go beyond vendor product training to focus on people's other role-related skills.
- Use a mix of training delivery methods (classroom, online, community, on the job) to improve overall learning effectiveness.
- Ensure a top-down executive sponsorship to evangelize the need for data literacy.
- Track and measure the efficacy of data literacy programs to refine content and methodology.
- Build communities of practice to share knowledge, best practices and lessons to keep staff engagement, and create a fun learning experience.

Gartner Recommended Reading

Unlock Supply Chain Digitalization With Data Literacy

Toolkit: Assessment of Data Literacy in the Supply Chain

Roadmap for Data Literacy and Data-Driven Business Transformation: A Gartner Trend Insight Report

Data Literacy Providers Will Accelerate the Time to Value for Data-Driven Enterprises

Event-Driven Architecture

Analysis By: Yefim Natis, Paul Vincent

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Event-driven architecture (EDA) is a style of application design in which application components communicate indirectly by passing event notification messages via an intermediary (an event broker). EDA is a long-standing architecture model. The demands of digital business, including IoT, continuous intelligence and contextual decisions, are reintroducing EDA as newly relevant to the current generation of mainstream application designers and planners, and placing it back onto the Hype Cycle.

Why This Is Important

EDA provides advanced opportunities for scale, extensibility and resilience in applications through its asynchronous, intermediated, pub/sub design model. Monitoring business and technical events in real time enables continuous analysis of context for advanced intelligence in decision management. Organizations that are interested in digital business innovation will inevitably discover event stream analytics and EDA as powerful components of their application design.

Business Impact

EDA is a key enabling architecture pattern for a number of leading trends in digital business. An event-aware organization is more responsive in its ecosystem, more empathetic in its customer experience and more intelligent in its decision making than a purely transaction-centric business. Competence in EDA accelerates transition to digital business. Lacking event awareness, organizations may struggle to support business at competitive speeds, agility, continuous innovation and cost-efficiency.

Drivers

- Digital business demands real-time context awareness through stream analytics to support intelligent business decisions. Applications that adopt EDA become sources of such context and empower their business decision makers.
- Cloud-native application architectures, often using microservices principles, frequently use EDA to implement more flexible and scalable interservice communication.
- The popularity of Apache Kafka is creating greater awareness of EDA among mainstream organizations and their software engineering leaders.
- Many major application vendors, including Salesforce and SAP, upgraded support of EDA to their applications and application platforms in recent years, enabling more intelligent monitoring of business processes.
- IoT applications use EDA to monitor states of devices. As the use of IoT software continues to increase, so does the adoption of EDA.
- All cloud hyperscalers have added or upgraded their support for EDA by adding and extending their messaging and event brokering services.
- Application integration continues to gain adoption in mainstream organizations, and EDA is a popular model for integration design.

Obstacles

- The lack of productivity and governance tools dedicated to EDA limits the design of EDA-based applications to more advanced engineering teams, and thus delays broader adoption
- The diversity of protocol and API formats and standards for event processing limits adoption and increases implementation costs.
- The design principles of EDA are less well-understood by most development teams, in part because of the familiarity bias in favor of the common and ubiquitous request/reply model, often implemented using REST APIs.
- Event-driven communications can deliver only eventual consistency. Applications that require synchronization of distributed database updates must choose a different architecture.

User Recommendations

- Develop an inventory of EDA-related technologies and practices currently deployed; consolidate and extend EDA capabilities in technology, skills and policies.
- Aim for a pragmatic mixed use of request-driven APIs following the SOA model and EDA, including application design, software life cycle and production management.
- Adopt EDA gradually, as the industry develops required standards, best practices, and improved productivity design and management tools.
- Aim to establish EDA, along with SOA, as the common and complementary architecture patterns, both considered for all application initiatives.
- Work with business stakeholders to coordinate the discovery and analysis of business events; aim for synergy in business and technical modelling of event-driven solutions.
- Manage and mediate event channels aggressively, and understand that their value represents an in-motion view of key business processes and happenings.

Gartner Recommended Reading

Innovation Insight for Event Thinking

Innovation Insight for Event Brokers

Maturity Model For Event Driven Architecture

The Impact of Event-Driven IT on API Management

Choosing Event Brokers: The Foundation of Your Event-Driven Architecture

IT/OT/ET Alignment

Analysis By: Kristian Steenstrup, Marc Halpern

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

IT/OT/ET alignment refers to the orchestration of information technology (IT), operational technology (OT), and engineering technology (ET) through shared standards and governance. Each plays a complementary but mutually reinforcing role to the other two technologies. While IT records transactions and business processes, OT operates and monitors industrial assets (e.g., SCADA), and ET is used to define, design, simulate, analyze, visualize and validate those assets (e.g., GIS, CAD/CAM).

Why This Is Important

For asset intensive industries such as manufacturing, system interoperability is improved when OT-enabled machines and ET and IT systems share infrastructure. As a result, Gartner sees organizations implementing common architecture plans and common standards for the components acquired, and increasingly looking for vendors that support this direction. Most companies are beginning this exercise and are more aware of the benefits while still conscious of the obstacles and problems.

Business Impact

We see movement of IT/OT/ET alignment with clients who are working through the complexities of culture and politics. This change follows the realization of technology commonality, its opportunities and benefits, and the risk of doing nothing.

The impact of IT/OT/ET alignment is mainly focused on two aspects:

1. More efficient use of technology support resources across IT, OT and ET investments

2. Easier sharing of data from design documents (ET) to operational systems (OT) and business administration

Drivers

- Cost reduction by not duplicating licensing, maintenance and support for common software components.
- Cost reduction by consolidating and collocating servers and back-end hardware in a common data center.
- Agility by being able to start new hybrid IT/OT/ET projects quicker and reacting to changes in a consistent way.
- Risk avoidance by aligning security, patching, disaster recovery and upgrading processes.
- Benefits of using the same support and configuration tools, support contracts and purchase processes.
- Easier access to ET and OT data for IT analysis such as predictive maintenance and production optimization.
- Leverage of OT performance data in product development using ET systems.
- Design of ET systems that better cater to OT effectiveness and future OT system support and data acquisition.

Obstacles

- Possible increase in cost on the OT or ET side initially, as purchases are made to bring software up to the IT standard/version and to deal with any license compliance gaps.
- Common for software asset management (SAM) to involve significant resources in the early stages, with savings being identified once the software position has been baselined accurately and compliance issues resolved.
- The benefits in terms of cost savings tend to be medium or long term, not short term.
- The entrenched separate positions and practices associated with OT and ET systems and their criticality, safety and stability, means that realignment takes time.
- Different cultures and approaches of IT departments, manufacturing/operations and design/engineering, which will have to be orchestrated.

User Recommendations

- Examine technology management processes to determine how much IT process is applicable to OT and ET, how the unique needs of OT and ET must be recognized and supported, and how to get them aligned by design, not as an afterthought.
- Include OT and ET requirements in enterprise risk management by adopting an integrated security strategy across IT, OT, ET, physical security and CPS for greater visibility.
- Create combined hardware platform and architecture policies to ensure compatibility between IT, OT and ET systems by formulating compatible governance for software, communications and infrastructure.
- Use RACI analysis to help manage this transition and to map out organizational responsibilities for different parts of the technology environment.

Sample Vendors

Bentley Systems; PTC; Siemens

Gartner Recommended Reading

2020 Strategic Roadmap for IT/OT Alignment

Innovation Insight for Engineering Technology: Why ET, IT and OT Are More Than the Sum of Their Parts

How IT Standards Can Be Applied to OT

Alternative Organizational Models for IT/OT Alignment

AR/VR in Oil and Gas

Analysis By: Nicole Foust

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Virtual reality (VR) and augmented reality (AR) are two different yet related technologies. VR technologies create computer-generated 3D environments to immerse users in a virtual environment. AR technologies overlay digital information on the physical world in order to enhance it and guide action. AR and VR are experienced through a display device that can provide either video feed or direct view of the real world. Audio, text, gesture recognition or handheld controllers may be incorporated.

Why This Is Important

Current AR/VR technology is best-suited for purpose-built, specialized solutions. Oil-and-gas-specific AR/VR are emerging technologies that support a range of workflow redesign initiatives, such as crew location, visual display, training and video recording. They also provide a new way to leverage asset information. Following the pandemic, companies are accelerating adoption of AR/VR technologies such as Microsoft HoloLens for remote activities, such as site inspections.

Business Impact

AR/VR can supplement existing systems, especially the systems of record that are used to manage the life cycle of their assets and infrastructure. Site planning, engineering design, pipeline operations, asset management, field service, and property management will be impacted. AR/VR can help in providing ways for the oil and gas organization to be more productive and efficient through improved location capabilities, enabling safer work environments with visual display and training capabilities.

Drivers

- The global pandemic coupled with advancing consumer-grade computing has raised the bar more than ever before, which is influencing oil and gas user expectations and requirements for industrial applications.
- Product maturity will continue to accelerate significantly over the next five years. For example, emerging vendors are offering head-mounted displays (HMDs) that are based on consumer models but are designed to target specific industry use cases.
- Vendors are gaining traction targeting specific oil and gas use cases such as training and checklists for training and maintenance or for remote telestration in see-what-I-see video collaborations.
- In addition, advancements in HMD hardware (lighter, more durable, safer, etc.) will provide more compelling hands-free use cases for AR as well.
- Health risk mitigation for remote sites and cost efficiency objectives have reenergized interest in using AR/VR to diminish the need for humans to work in remote and dangerous environments.

Obstacles

- No comprehensive solutions are currently available for oil and gas industry adoption meaning that AR/VR are still classified as emerging technologies.
- VR and AR markets are fragmented, and oil and gas applications, while expanding, are still emerging.
- These markets are currently struggling with mismatched expectations (as in, vendors promising solutions beyond current capabilities) and poor implementations (e.g., solutions delivered without immersive development knowledge or workflow integration, or mapped to business value or need).
- B2C implementations are still struggling to show value to consumers. Better and more transparent hardware, coupled with more compelling use cases, is needed before further progress can be made.
- Oil and gas CIOs are limited to working with a small number of industrial-grade AR/VR vendors (which can be used anywhere but have weak technical/workflow integration) or a larger number of rapidly developing, consumer-based AR/VR devices.

User Recommendations

- Work with engineering and operations teams to determine what business problems or issues can be solved with AR/VR.
- Restrict initial trials to a specific task or goal.
- Set benchmarks against unaugmented solutions to understand risks and benefits.
- Set the business goals, requirements and measurements for your AR/VR implementation before choosing a provider. Rich and robust offerings can bring value only if you have a clear intention for the deployment.
- Explore AR and VR benefits and identify use cases by initiating proof-of-concept trials with a collection of HMD devices and AR/VR applications.
- Develop innovative vendor partnerships by focusing initially on the asset performance management (APM), enterprise asset management (EAM) and geospatial information systems (GIS) application domains.
- Use AR and VR opportunities to build your Mode 2 delivery capabilities by empowering small teams to fail fast and often, while accelerating your organization's learning.

Sample Vendors

Apple; EON Reality; Google; Kopin; Microsoft; Oculus; Samsung

Gartner Recommended Reading

Market Guide for Enterprise Asset Management Software

Market Guide for Geospatial Information Systems for Energy and Utilities

Top 10 Trends Driving the Oil and Gas Industry in 2021

Edge Computing

Analysis By: Bob Gill, Philip Dawson

Benefit Rating: Transformational

Market Penetration: 20% to 50% of target audience

Maturity: Adolescent

Definition:

Edge computing describes a distributed computing topology in which data storage and processing are placed in an optimal location relative to the location of data creation and use. Edge computing locates data and workloads to optimize for latency, bandwidth, autonomy and regulatory/security considerations. Edge-computing locations extend along a continuum between the absolute edge, where physical sensors and digital systems converge, to the "core," usually the cloud or a centralized data center.

Why This Is Important

Edge computing has quickly become the decentralized complement to the largely centralized implementation of hyperscale public cloud. Edge computing solves many pressing issues, such as unacceptable latency and bandwidth requirements, given the massive increase in edge-located data. The edge-computing topology enables the specifics of the Internet of Things (IoT), digital business and distributed IT solutions, as a foundational element of next-generation applications.

Business Impact

Edge computing improves efficiency and cost control through processing close to the edge (e.g., better automation and quality control), and more business opportunities and growth (e.g., customer experience and new real-time business interactions). Early implementations have succeeded in enterprises that rely on operational systems and data outside core IT, such as the retail and industrial sectors.

Drivers

Drivers to the adoption and implementation of edge computing include:

- Growth in cloud adoption has exposed the disadvantages of extreme centralization. Latency, bandwidth requirements, the need for autonomy, and data sovereignty or location requirements may be optimized by placing workloads closer to the edge and data produced at the edge, rather than centralizing in a hyperscale data center.
- Data growth from interactive applications and systems may not be economically funneled into the cloud.
- Applications featuring customer engagement and analysis favor local processing for speed and autonomy.

- IoT use cases are expanding from the industrial sector to other verticals, driving a move toward a hierarchical and distributed model.

Obstacles

- Extreme diversity of devices and application types amplify complexity issues
- Widespread application of the topology and explicit application and networking architectures are not yet common outside vertical applications, such as retail and manufacturing
- Lack of understanding of benefits/use cases
- Lack of standards
- Although the physical infrastructure for edge is maturing rapidly, the overall management and orchestration challenges of distributed applications are beyond vendor-supplied, component management offerings. The tasks of managing, securing, maintaining and updating the physical infrastructure, software and data requires considerable development before management and orchestration can be considered mature.

User Recommendations

- Create and follow an enterprise edge strategy by focusing first on business benefit and holistic systems, not solely pointing to technical solutions or products.
- Establish a modular, extensible edge approach through the use of emerging edge frameworks and architectures, which allow for the mixing and matching of technologies based on enterprise direction, not simply “what comes with the vendor solution.”
- Accelerate time-to-benefit and derisk technical decisions through the use of vertically aligned system integrators (SIs) and independent software vendors (ISVs) that demonstrate an understanding of and ability to implement and manage the full orchestration stack from top to bottom.
- Evaluate the deployment of “edge as a service” options, which promise to deliver “business-outcome-based solutions” that adhere to specific SLAs, while shifting deployment, complexity and obsolescence risk to the provider.

Gartner Recommended Reading

2021 Strategic Roadmap for Edge Computing

Cool Vendors in Edge Computing, 2021

Blockchain in Oil and Gas

Analysis By: Rich McAvey

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

A blockchain is an expanding list of cryptographically signed, irrevocable, transactional records shared by all participants in a network. Each record contains a time stamp and reference links to previous transactions. With this information, anyone with access rights can trace back a transactional event, at any point in its history, belonging to any participant. A blockchain is one architectural design of the broader concept of distributed ledgers.

Why This Is Important

Distributed ledgers can improve the efficiency, reliability and accuracy of oil and gas operations. Of high interest are identity assurance, workflow automation, data provenance, autonomous transactions via smart contracts and reliable track-and-trace across supply chains. There is significant interest in the potential for blockchain to improve item/inventory tracking accuracy, physical commodity and asset authentication, reconcile-less settlement and payment processes, and dispute minimization.

Business Impact

Blockchain offers enterprise leaders the opportunity to imagine new kinds of operating models and business strategies. Blockchain-enabled solutions offer network participants an immutable shared record of events across multiple contributing organizations, where no single organization is in control of the network. This immutable audit trail supports trust among participants, because they each have identical distributed ledgers of all transactions that transpired.

Drivers

- Pursuit of higher levels of automation by means of platforms that leverage blockchain capabilities for straight-through transaction processing. One example is the VAKT consortium that operates a permissioned blockchain platform focused on the processes of physical commodity trading.
- Provision of data provenance that immutably identifies the data source and a complete record of its movement along supply chains and reporting channels. Deployment of blockchain solutions has become easier as cloud hyperscalers now offer integrated tools.
- Reduction of high-cost, resource-intensive workflows through a consortium of operating companies that come together to define a new, blockchain-enabled solution and collaboratively hiring vendors to build, deploy and operate a solution. The Blockchain For Energy consortium is the leading example of this approach.

Obstacles

- While awareness of blockchain is growing among business leaders, it is still poorly understood by most oil and gas business executives. The full benefits of distributed ledgers can be difficult to visualize and achieve, sustaining interest in alternative approaches despite their lower value.
- Excessive vendor hype initially created inaccurate expectations of the technology capabilities.
- The value of blockchains requires a network of users, and oil and gas culture makes the effort to build a sufficiently large network significant.
- Blockchain data is cryptographically secured, it does not mean that the data is legitimate. There are several ways that bad actors can compromise the security of blockchain applications and data without cracking the cryptography.
- Insufficient cybersecurity protocols can enable user accounts to be hacked and data inaccuracies. API vulnerabilities can lead to incorrect smart contract execution. And off-chain data vulnerabilities can lead to data compromise.

User Recommendations

- Begin the journey to create a multi-company blockchain consortium by addressing the inherent awkwardness. Focus your efforts on internal data provenance solutions that do not require an external network. Or join a digital ecosystem to collaboratively create and deploy blockchain solutions among member companies.
- Assess the effectiveness of your effort to protect blockchain users, technical interfaces, off-chain data, and other security risks. Identify your most important risk priorities, then invest in mitigating vulnerabilities before moving blockchain applications into production.
- Continue to educate executives and senior leaders about those blockchain opportunities and challenges that are most critical for your business. Expect different industry domains (upstream, midstream, downstream and marketing) and functional areas (such as commodity trading, international cash management, field supply chains and data integrity) to adopt blockchain along different timelines.

Sample Vendors

AVEVA; Amazon Web Services (AWS); Microsoft Azure; BlockApps; Blockchain For Energy; Data Gumbo; GuildOne; Mavennet; VAKT; Xpansiv

Gartner Recommended Reading

Emerging Technologies: Implementing Blockchain Smart Contracts in a Business Process

Garbage In, Garbage Forever: Top 5 Blockchain Security Threats

Digital Twins in Oil and Gas

Analysis By: Simon Cushing

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Digital twins are a design pattern for a class of enterprise software system that produces a digital proxy for a physical “thing” (object, person or process). They facilitate management and optimization of the thing by virtually representing it to other software systems and people. In oil and gas, defining characteristics of digital twins include a model unique to the thing, data aggregation and continuity through the life of the thing.

Why This Is Important

Digital twins can improve asset operators’ situational awareness and optimize asset performance by modeling dynamic behavior. As a focal point system for asset operations, digital twins have significant potential to improve oil and gas companies’ asset and business performance. The oil and gas industry is already a leading adopter of digital twins with aggressive adoption plans.

Business Impact

Digital twins are transformational in oil and gas, being key to radical optimization of asset operations. They can:

- Provide new ways to oversee and visualize assets, giving operators and field workers a unified and visually intuitive way to quickly access information about assets at all levels of detail.
- Improve workforce productivity by enriching information provision and optimizing tasks.
- Optimize asset performance by analyzing past performance, and simulating and predicting future asset status.

Drivers

Three foundational capabilities for digital twins have emerged in the industry:

- **Monitoring** — Providing information on the operating state versus optimized state of devices, equipment or systems.
- **Visualization** — Providing intuitive points of access to disparate data on actual asset condition and performance by using visual renderings of the asset.
- **Simulation** — Predicting and optimizing asset care and performance by modeling behavior using a range of techniques, including machine learning and physics-based approaches.

- By combining these capabilities oil and gas companies can solve problems faster, and operate assets with greater economic efficiency and operational reliability.
- Executed well, digital twins unify existing siloed capabilities through a single system of access, facilitating faster joint decision making with greater input.
- The operational intelligence and enhanced decision-making capability enable greater organizational agility and resilience.

Obstacles

- Digital twin definitions, architectures and use cases all span a wide range in the industry. Progress can be slowed because conversations between stakeholders and technology enablers bog down in different conceptions and approaches.
- The digital twin design patterns for different use cases and the software to create them, can differ considerably making standardization and scaling difficult.
- As digital twin adoption grows, oil and gas CIOs will be drawn into developing a complex landscape of different types for different needs. Many different software applications can act as sources of data for a twin, or components of them, or both. The constituency of digital twin users and use cases is varied, and will expand and diversify as use increases.
- Digital twins quickly grow into software assets shared by many in the enterprise, but tailored to individual use cases. Many oil and gas IT departments need new governance mechanisms to manage this kind of software asset over extended time periods.

User Recommendations

- Develop, design and implement digital twins with an overriding focus on the purpose of the twin and the business outcomes expected from its deployment.
- Create a common language of concepts and definitions for digital twins in the enterprise. Make digital twin design plans jointly with business stakeholders, including subject matter experts, using the language and concepts appropriate for their goals.
- Reduce duplication, technical complexity and costs, and enable digital twins to expand over time and be shared among multiple business units by using a module approach to their design and integration.
- Expect digital twins to grow in complexity and business value. Plan for frequent and regular updates as the twinned physical entity changes and work to automate these as much as possible.

Sample Vendors

AVEVA; Ansys; Cognite; Dassault Systèmes; Emerson; GE; Kongsberg Maritime; Microsoft; Siemens

Gartner Recommended Reading

What to Expect When You're Expecting Digital Twins: A Guide for the Oil and Gas CIO

Top 10 Trends Driving the Oil and Gas Industry in 2021

Real-Time Remote Operations

Analysis By: Simon Cushing

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

Definition:

Real-time remote operations (RTROs; titled Remote Operations previously) provide real-time oversight of on-site operations by centralized experts in locations distant from the asset. RTRO systems use specially designed architectures that organize field devices, control systems, communications technologies and analytics to allow surveillance, control and some automation of on-site activities from remote operations centers (ROCs). Typically, ROCs are purpose-built facilities in company offices.

Why This Is Important

Remote oversight and decision support of drilling and production operations in upstream oil and gas are mature and have been in use for decades. However, use of continuous real-time oversight remains highly variable. Some companies have used it for many years, while others not at all. Following the disruptions of 2020, oil and gas companies have reinvigorated efforts to reduce the size of field workforces aiming to reduce costs, and improve efficiency and safety.

Business Impact

RTRO enables upstream companies to reduce the size of their workforces in field environments, improving safety and reducing risk. It allows wider expertise to be applied to decision making, can reduce operating costs and improve cycle times. Reduced on-site worker accommodation and infrastructure can lower facilities' capital costs. In the most advanced forms, RTRO can enable companies to dynamically optimize field performance through remote control and increased automation.

Drivers

- In recent years advances in communications and technology, the advent of IoT, AI, ML, digital twins, wearable technologies and augmented reality have extended the scope and scale of RTRO.
- With these technologies, real-time surveillance becomes more comprehensive and can reliably include higher levels of remote control or automation. At the same time, remote operations themselves can become distributed across locations away from the ROC.
- Industrial process control and Industrial Internet of Things (IIoT) vendors have operationalized solutions for field remote control and automation.
- Despite the high cost, innovation leaders have implemented high levels of remote facility control for some fields and are planning solutions that integrate all facility and field management operations for higher levels of automation.
- Newer, advanced remote control for offshore platforms have been planned at the design stage and implemented on greenfield projects.

Obstacles

- The unique nature of most oil and gas assets and company legacy systems' environments means remote operations architectures are highly tailored to the circumstances of the operating company. Consequently, while highly automated remote operation solutions offer transformational benefits to create value, they need to replace or integrate with legacy operational technology (OT) systems.
- Control system and industrial process automation vendors have created solutions that are increasingly open, while still secure. Such solutions will continue to develop for many years. However, broad adoption will be limited by cost, and lack of APIs and standards built into legacy technology.
- The need to replace or upgrade legacy infrastructures that are insufficiently robust and resilient will also curtail the pace of development.

User Recommendations

IT is drawn into involvement as the scope, complexity and level of integration of remote operations systems grows. The need for greater edge computing, extended secure communications and data transfer with enterprise systems involves IT leaders in systems design and implementation.

- Work collaboratively with technical and business leaders to build the specialized combinations of IT and OT required.
- Clarify any ongoing ambiguity of governance of OT systems and clearly define, with the business, the responsibilities for long-term sustainability of newly implemented systems.
- Introduce design standards, system management processes, system integration capabilities and enterprise data standards.
- Ensure IT architects have the appropriate skills to engage decision makers outside of IT, and guide them to a more standardized, consolidated and secure platform.

Sample Vendors

ABB; Emerson; Baker Hughes (GE); Honeywell; Rockwell Automation; Schneider Electric; Siemens

Sliding into the Trough

Hyperautomation

Analysis By: Stephanie Stoudt-Hansen, Frances Karamouzis, David Groombridge

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Emerging

Definition:

Hyperautomation involves the orchestrated use of multiple technologies, tools or platforms (inclusive of, but not limited to, AI, machine learning, event-driven software architecture, RPA, iPaaS, packaged software and other types of decisions, and process and/or task automation tools). Business-driven hyperautomation is a disciplined approach that organizations use to rapidly identify, vet and automate as many business and IT processes as possible.

Why This Is Important

Leveraging multiple best-of-breed tools and processes allows providers to deliver more rapid, complex and successful automation, and allows clients to deliver orchestrated automation outcomes that distinguish them from competitors. Hyperautomation not only is about automation technologies products or services, but also is the approach of combining business process design, IT architecture deployment, governance and greater business agility to drive high competitive advantage.

Business Impact

As organizations demand greater efficiencies and outcomes from service providers, providers are leveraging hyperautomation for greater outcomes and to distinguish themselves.

- The level of efficiency that providers have achieved through automation in areas such as service desk management, hybrid infrastructures and reduction of incidents ranges from 40% to 80%.
- Gartner estimates that by 2024, organizations will lower IT and business operational costs by 30% through hyperautomation solutions.

Drivers

- Hyperautomation initiatives have grown and investment continues to increase. There was a demand prior to the pandemic and the crisis has served to accelerate the growth, as organizations seek to automate for future resilience.
- The pandemic has broken down business barriers to some employees' resistance to automation, based on the abundance of legacy, disconnected systems and suboptimal processes, creating an urgency to digitalize.
- Organizations trying to automate using a single solution, such as RPA, were failing because RPA alone can only automate tasks, not processes. They need the full suite of hyperautomation tools to achieve process automation and functional orchestration.
- Organizations are looking up to service providers for hyperautomation solutions, which draw on the orchestration of interrelated automation technologies and processes to streamline their environments and achieve greater outcomes.
- The hyperautomation approach integrates and orchestrates automation using AI, machine learning, event-driven software architecture, RPA, iPaaS, packaged software and other automation tools.
- Leveraging multiple best-of-breed tools and processes allows providers to deliver more rapid, complex and successful automation, and allows clients to deliver outcomes that distinguish them from competitors.

Obstacles

- Gartner estimates over 85% of enterprises have dozens of automation initiatives underway. These have varying degrees of success, as organizations' traditional build-up of technical debt and a patchwork of technologies have made the move to automated and hybrid environments challenging.
- Hyperautomation tools are currently immature with vendors who started from different baseline solutions (RPA, BPM and low code/no code), all descending on the same destination with a hotchpotch of tools with differing levels of maturity and integration.
- Many of the solutions are horizontal in nature being sold to a wide variety of industries, and lack the process knowledge and rules requiring investment in configuring and training the tools.

- RPA, AI and iBPMS vendors often lack the combination of technology solutions to create the best process to meet customer requirements. As a result, buyers struggle to integrate disparate complex technologies to achieve their automation goals.

User Recommendations

- Establish a mixologist approach to automation tools to avoid being overly obsessed with one technology. Avoid incorrect use by identifying vendor solutions for RPA, BPM, chatbots and optical character recognition (OCR) that can be combined to achieve the desired business outcome.
- Determine a litmus test on what needs to be automated and work with your providers to determine where you will gain your greatest ROI. Also, discuss the value of their proprietary offerings versus being vendor agnostic to avoid lock-in.
- Collaborate with your provider to create a blueprint, and continuously work to update your environments based on the hyperautomation technologies and processes that will create the greatest leverage.
- Develop automation disciplines, governance and structure within your organization by starting small with simpler automation tools such as RPA or BPM to build the foundations for wider automation.

Sample Vendors

Accenture; HCL Technologies; Hexaware; IBM; T-Systems; Wipro

Gartner Recommended Reading

Competitive Landscape: Hyperautomation Service Providers

Predicts 2021: Accelerate Results Beyond RPA to Hyperautomation

Emerging Technologies and Trends Impact Radar: Hyperautomation

Tech CEOs Must Use Hyperautomation to Enhance Offerings

Communicate the Value of Hyperautomation Using ROI

Integrated Planning and Operations

Analysis By: Rich McAvey

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Adolescent

Definition:

Integrated planning and operations (IPO) solutions enable comprehensive planning, optimization and execution of operational activities from concept to implementation with a high degree of transparency and a low degree of data administration. These solutions optimize business or functional performance, reduce unplanned outages, and improve safety.

Why This Is Important

As traditional oil and gas markets grow more competitive, companies must make decisions that better optimize their business performance in real time. The expansion of analytics, machine learning and artificial intelligence has greatly advanced the quality of operational decisions within individual business units. What is needed now are solutions that promote enterprise-level optimization by easily integrating decision data, tools and methodology across multiple business units and functions.

Business Impact

IPO solutions improve business and engineering performance by optimizing resource use, reducing disruptions, and minimizing the need for urgent efforts. In exploration, IPO improves field management and leads to higher oil recoveries from legacy fields. In plant operations, IPO enables companies to test multiple scenarios in virtual environments and make better trade-off decisions. And IPO improves the integrated performance of hydrocarbon value chains and supply chain procurement decisions

Drivers

- Analytics, ML and AI are rapidly expanding the portfolio of performance-optimizing capabilities within all operating oil companies.
- When empowered with AI, IPO capabilities mitigate harm from unexpected volatility in oil and gas markets by enabling companies to rapidly test alternative response strategies and select an optimal approach.
- Vendors understand the need for better integration and are modifying their solutions to reduce fragmentation.
- Quorum Software continues an aggressive pace of acquisition of oil-and-gas planning tools that, if ultimately integrated, could form the basis for an enterprise-level planning backbone.

Obstacles

- The weak state of data standardization with companies and across the industry continues to hamper integrated planning efforts.
- The lack of standard planning processes across the industry prevents vendors from developing solutions that can easily scale across multiple companies.
- Most companies rely on a mix of custom-built planning tools, spreadsheets and a disjointed portfolio of vendor capabilities as their planning backbone.
- Many low-level technical challenges, such as nontransparent data and manipulations in spreadsheets, inhibit progress. It can take much time to clarify and simplify internal logic.
- Governance of planning solutions reflects the siloed structure of oil and gas companies, resulting in ambiguous demand for highly integrated solutions.
- Composite solutions remain too manual (slow, expensive and error-prone), too rigid (custom-coded systems with little dynamic interaction with core systems) or too complex (poorly documented data repositories and spreadsheets).

User Recommendations

- Approach planning solution enhancement with an attitude of patience and determination. Each legacy solution, custom planning program and spreadsheet will require updating over the next decade.
- View each change as an opportunity to put in place new solutions that are compatible with a comprehensive enterprise-level planning environment.
- Make communications a priority, and ensure executives understand IPO capabilities and support improvement investments as an essential strategic priority.
- Establish governance for a comprehensive planning architecture and roadmap to avoid moving from one form of fragmentation to another.
- When deconstructing current planning tools, use strong change management to minimize unintended errors and risks that can arise from changes to the complex web of ambiguous code.

Sample Vendors

AspenTech (Aspen PIMS); IBM (Maximo Asset Management); Oracle (Primavera); Quorum Software; SAP; Schlumberger (Merak and Avocet)

Gartner Recommended Reading

Top 10 Trends Driving the Oil and Gas Industry in 2021

Machine Learning

Analysis By: Farhan Choudhary, Carlie Idoine, Shubhangi Vashisth

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Machine learning is an AI discipline that solves business problems by utilizing statistical models to extract knowledge and patterns from data. There are three major approaches that relate to the types of observation provided. These are supervised learning, where observations contain input/output pairs (also known as “labeled data”); unsupervised learning (where labels are omitted); and reinforcement learning (where evaluations are given of how good or bad a situation is).

Why This Is Important

According to Gartner’s 2019 AI in Organizations survey, machine learning (ML) is the AI initiative for which more POCs and production systems are conducted. Over the past few years, ML has gained a lot of traction because it helps organizations to make better decisions at scale with the data they have. ML aims to eliminate traditional trial-and-error approaches based on static analysis of data, which is often inaccurate and unreliable, by generalizing knowledge from data.

Business Impact

Machine learning drives improvements and new solutions to business problems across a vast array of business, consumer and social scenarios like:

- Automation
- Price optimization
- Customer engagement
- Supply chain optimization
- Predictive maintenance
- Fraud detection

Machine learning impacts can be explicit or implicit. Explicit impacts result from machine learning initiatives. Implicit impacts result from products and solutions that you use without realizing they contain machine learning.

Drivers

- As organizations continue to adopt these technologies, we recently see focus on aspects that relate to ML explainability and operationalization. Augmentation and automation (of parts) of the ML development process improve productivity of data scientists and enable citizen data scientists in making ML pervasive across the enterprise.
- In addition, pretrained ML models are increasingly available through cloud service APIs, often focused on specific domains or industries.
- Data science and machine learning education is becoming a standard at many academic institutions, therefore fueling the supply of newer talent eager to venture into this space.
- There's always active research in the area of machine learning in different industries — manufacturing, healthcare, corporate legal, defense and intelligence. Thus, its applicability is far and wide.
- Newer learning techniques such as zero, one, few or end shot learning are emerging that take away the burden of having high volumes of quality training data for ML initiatives. This lowers the barrier to entry and experimentation for organizations.
- New frontiers are being explored in synthetic data, new algorithms (e.g., deep learning variations) and new types of learning. These include federated/collaborative, generative adversarial, transfer, adaptive and self-supervised learning, all aiming to broaden ML adoption.

Obstacles

- The triggers of its massive growth and adoption have been growing volumes of data, advancements in compute infrastructure and the complexities that conventional engineering approaches are unable to handle.
- Even though ML is one of the particularly popular AI initiatives in the last few years, it is not the only one. Organizations also tend to rely on other AI techniques such as rule-based engines, optimization techniques, physical models to achieve decision augmentation or automation.
- A significant portion of ML models at an organization doesn't make it into production, therefore adding to technical debt and risks mistrust in the initiative, often delaying value realization from ML at organizations.
- The application of ML is often oversimplified as just model development but it's not so. Several dependencies which are overlooked, such as data quality, security, legal compliance, ethical and fair use of data, serving infrastructure, and so forth, have to be considered in ML initiatives.

User Recommendations

- Build up and extend descriptive analysis toward predictive and prescriptive insights, which can be excellent candidates for machine learning.
- Assemble a (virtual) team that prioritizes machine learning use cases, and establish a governance process to progress the most valuable use cases through to production.
- Utilize packaged applications if you find one that suits your use case requirements. These often can provide superb cost-time-risk trade-offs and significantly lower the skills barrier.
- Explicitly manage MLOps and ModelOps for deploying, integrating and monitoring analytical, ML and AI models.
- Adjust your data management and information governance strategies to enable your ML team. Data is your unique competitive differentiator, and adequate data quality, such as the representativeness of historical data for current market conditions, is critical for the success of ML.

Sample Vendors

Amazon Web Services (AWS); Databricks; Dataiku; DataRobot; Domino; Google Cloud Vertex AI; H2O.ai; Microsoft Azure; SAS; TIBCO Software

Gartner Recommended Reading

Magic Quadrant for Data Science and Machine Learning Platforms

Critical Capabilities for Data Science and Machine Learning Platforms

Toolkit: RFP for Data Science and Machine Learning Platforms

3 Types of Machine Learning for the Enterprise

Understanding MLOps to Operationalize Machine Learning Projects

Geospatial Platform

Analysis By: Nicole Foust, Lloyd Jones

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Geospatial platforms include platform as a service (PaaS) and data-as-a-service offerings in the context of spatial data processing, such as web mapping, mobile geospatial apps, location services, imagery services, analytics and geoevent processing. They also include other features such as digital marketplaces with subscription-based licensing and revenue-sharing mechanisms for partner- and customer-generated apps and content.

Why This Is Important

Location and time is an important item of information for contextualizing operational, transactional, mobile and sensor data. Analyzing operational data in the context of location can uncover spatial trends, dependencies and patterns that are otherwise undetectable. Asset-intensive organizations (especially those with spatially distributed assets) are looking for capabilities to manage and optimize spatial location data essential for the optimization of an enterprise.

Business Impact

A geospatial platform will help energy and utility IT organizations implement a pace-layered strategy, deploying innovative applications that leverage time-stamped locational transactions. GIS developers in IT organizations along with “citizen developers” in business units can easily develop web and mobile applications that access geospatial services. Maps can be easily expressed as services and put to business use in an agile delivery model, improving transactional data quality and timing. User experience is similar to the broadly available consumer mapping and geosearch experiences.

Drivers

- Energy and utility organizations are realizing the value of location to understand and engage customers, optimize supply chains and asset usage, and improve operational efficiencies.
- Investments in the Internet of Things (IoT) are driving greater adoption, broader utilization and new technologies and services. In these investments, ecosystem partners are building capabilities to augment platform products and expanding the capabilities and opportunities further.
- Geospatial platforms are foundationally a spatial information system of record. Often, the business use of data in the GIS is limited outside of its original mapping purpose. Access to data in legacy GIS can be difficult without the help of GIS analysts, and the cost of application development and maintenance can be substantial. Core geospatial functions are expressed as web services, and interfaces are expressed as restful application programming interfaces (APIs) and HTML5-based apps that consume these services. The web map has become the digital expression and real-time operational view of geospatial content.
- Geospatial platforms can support real-time modeling; visualize electrical, gas, and/or water and pipeline networks; model geological and surface feature relationships; and depict the relationship between assets and the environment. These can support the creation and management of the geospatially referenced plant and network models necessary for the planning, design, construction, and operations of the locations and the specification of assets.
- Energy and utility organizations are acquiring geospatial platforms because they reduce the time to value for geospatial application development and simplify end-user collaboration across departmental or company boundaries. In addition, geospatial platforms are evolving faster than industry-specific GIS applications, making them ideal for organizations that are adopting a pace-layering approach to geospatial application development.

Obstacles

- The quality of spatial data can be a challenge for many organizations. However modern applications leverage geoprocessing workflow capabilities with low-cost, commercial data layers such as land features, satellite imagery and aerial photogrammetry and mobile GPS.
- Business and software silos have been an ongoing challenge in digitalization journeys. Increasingly, public, private or hybrid GIS deployment options are available, which create significant collaboration opportunities both inside and outside the enterprise.
- Mobile applications, when integrated with geospatial and enterprise systems, can further improve data quality and business performance.
- Supplementing a GIS with improved land-based data, aerial photography, location-based services and customer engagement applications can extend the usefulness of GIS for a wider variety of users.

User Recommendations

- Identify a comprehensive geospatial platform that meets the geospatial application requirements of multiple business units and that supports cross-enterprise collaboration and workflow.
- IT leaders and enterprise architects should resolve barriers to geospatial platform adoption by addressing licensing, security, architecture and information governance early on. Cloud-based deployments may be appropriate for managing the sharing of maps and metadata outside the organization.
- CIOs and IT leaders must evaluate the benefits and costs at an ecosystem level when concerns about vendor lock-in and pricing arise. As with other software platforms, the investment and relationship are with the overall ecosystem, not just the platform provider. Business owners can explore subscription licensing and business partner relationships that can lower the total cost of ownership.

Sample Vendors

CARTO; Esri; Supergeo; QGIS

Gartner Recommended Reading

Market Guide for Geospatial Information Systems for Energy and Utilities

Top Practices for Utility CIOs Evaluating Enterprise Asset Management Software

Market Guide for Asset Performance Management Software

Market Guide for Mobile Workforce Management Software for Utilities

How Utility CIOs Can Use Intelligent Operations to Achieve Resilience During the Energy Transition

Top 10 Trends Driving the Utility Industry in 2021

Top 10 Trends Driving the Oil and Gas Industry in 2021

3 Practices Utility Company CIOs Should Include in an Integrated EAM-GIS Solution Strategy

IoT in Oil and Gas

Analysis By: Nicole Foust

Benefit Rating: Transformational

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Internet of Things (IoT) is the network of dedicated physical objects with embedded technology to communicate and sense/interact with their internal states and/or the external environment. IoT enables digital business and is a core building block of digital platforms. It comprises an ecosystem of assets and products, communication protocols, applications and data and analytics. In oil and gas (O&G), IoT is used to optimize cost, operations and assets, increase engagement and conserve resources.

Why This Is Important

IoT is essential for digital business transformation initiatives as O&G companies progress through a decade of deep redesign. O&G organizations have shifted to IoT in favor of a business-operations-centric approach. Use cases are found in all parts of the business (e.g., field remote control and automation, and asset operations). IoT is transforming the entire value chain from seismic data capture, through modeling/analytics and workflow automation, all the way to retail/wholesale marketing.

Business Impact

With more things connected, the information IoT provides will transform all O&G operations to:

- Optimize costs: energy reduction, lower inventory spoilage and theft
- Optimize operations: improved productivity, efficiency, logistics and coordination
- Optimize assets: Asset utilization, health monitoring, reliability and maintenance
- Increase engagement: Improved customer and partner experience
- Conserve resources: Energy efficiency and pollution reduction

Drivers

- IoT in O&G will continue toward the Trough of Disillusionment due to several factors including its transformational impact on the entire O&G value chain and, consequently, organizations' competitive position, product development strategies and internal operations. According to the O&G respondents to Gartner's 2021 CIO Survey, IoT is one of the top six investment technologies, with 40% respondents planning to spend more on it (see 2021 CIO Agenda: An Oil and Gas Perspective).
- Larger organizations have ongoing IoT-enabled initiatives for various use cases, ranging from incremental benefits (e.g., asset optimization) to transformative benefits (e.g., dynamic automated remote operations).
- IoT adoption is expanding in O&G on account of better and less expensive technologies, vendor proliferation, growing understanding of diverse IoT value propositions and ease of experimentation.
- General-purpose IoT technologies are already established, creating additional opportunities in O&G. Additionally, traditional OT vendors have incorporated IoT into their products and roadmaps, and new opportunities for tactical use of stand-alone IoT (such as drones, augmented reality/virtual reality and wearables) are adolescent and in the early mainstream.
- The drive toward improved resilience, triggered by a combination of factors such as the recent pandemic, climate change concerns and the energy transition, is contributing to IoT adoption.
- Recently, IoT has also been enabling the proliferation of digital twins and we expect this to continue driving the technology further along the Hype Cycle.

Obstacles

- Vendor marketing creates confusion as most vendors leverage IoT in delivering IoT-enabled business solutions but rely on IoT platforms.
- IoT technical complexity, security, end-to-end integration challenges and alignment to meet specific business outcomes remain barriers to scale.
- Benefits are offset by the need for high levels of reliability and safety of legacy SCADA.
- Proprietary technologies, deployed in custom-engineered solutions with limited interoperability, are expensive and difficult to secure.
- Many enterprises approach IoT projects as technology projects, instead of business projects using IoT platforms to achieve business outcomes.
- Legacy investment in OT approaches may carry technical debt, increasing investment costs.
- Bridging cultural divides, between IT and operations as well as across business units and value chains, is a challenge.

User Recommendations

- Acknowledge IoT is not a single technology or solution; rather, it is an ecosystem of technologies.
- Evaluate existing operations for opportunities to leverage IoT (e.g., drones for infrastructure inspection and wearables for worker safety monitoring).
- Assess IoT initiatives in view of KPIs and alignment with specific business objectives.
- Track the adoption of IoT by customers to identify opportunities for improved services and specific programs.
- Incorporate IoT into your industry vision as an enabler of composable business. Educate business stakeholders on the potential of IoT.
- Participate in or track the Open Process Automation Forum.
- Foster the development of new IoT skills, such as fast prototyping with Arduino technology and cloud-based data management.
- Establish champions and superusers to help adapt business processes and culture based on data generated by IoT.
- Invest in skills and technology to support IoT, data integration, analytics and security solutions.

Sample Vendors

Blue Pillar; Detechtion Technologies; GE Digital; Itron; Microsoft; SAP; Siemens

Gartner Recommended Reading

Top 10 Trends Driving the Oil and Gas Industry in 2021

Predicts 2021: Oil and Gas — The End of “Standard” Oil

Energy Companies Are Facing a Decade of Deep Redesign and Need Strong CIO Leadership

Use Digital Factories to Drive Deep Optimization Across the Enterprise

Magic Quadrant for Industrial IoT Platforms

Adaptive Portfolio Governance

Analysis By: Sarah Davies

Benefit Rating: Transformational

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Adaptive portfolio governance is the organizational capability that utilizes adaptive governance styles and mechanisms to support the planning and prioritization activities required to deliver business outcomes in any given context. Portfolio managers must understand that different styles of governance help orchestrate the desired outcomes or performance within different portfolio contexts.

Why This Is Important

Increasingly, program and portfolio managers are managing a changing variety of portfolio activities to deliver the right outcomes or value. Portfolio management has an important role, as well-governed portfolios lead to superior performance, with an increased (2.5x) likelihood of achieving their outcomes. Portfolio governance is becoming more frequent and diverse as roles evolve with the maturity of digital, and organizations manage increasing change and uncertainty.

Business Impact

Digital business acceleration challenged traditional governance practices in many organizations. The need to mature a variety of governance styles and mechanisms to balance across their portfolios is apparent. Each style allows for specialization and refinement, while moving up the complexity and maturity ladder. As different styles emerge, some organizations will struggle to balance the adoption of changes needed to become adaptive with short-term primacy “shareholder value.”

Drivers

- Decisions made within the portfolio (“portfolio governance”) are becoming more frequent and diverse as roles evolve with the maturity of digital and organizations manage increasing change and uncertainty.
- Business and IT leaders must understand how different governance styles will better facilitate and support integrated portfolio direction across diverse portfolio practices and contexts.
- Adaptive portfolio governance has been accelerating in popularity as a result of the digital dexterity increase and will reach plateau within two years as the need to adapt overcomes former objections.

Obstacles

- In order to adopt adaptive portfolio management, the systems and processes used for portfolio management — those that have been in place to support processes to date — need to be able to adapt to multiple governance styles or postures. If process change is not supported by in-situ tools, adoption will be difficult to sustain.
- Any change in decision models, including those within the portfolio, will provide cultural and political food for thought. The perceived lack of “enough” control by those formally engaged in traditional portfolio governance, if unanswered, will provide a barrier to full adoption in the long run.

User Recommendations

- Evolve your organization portfolio governance by reviewing the differences between traditional and adaptive governance. Update your governance style by adopting adaptive capabilities that improve your agility and support digital business acceleration.
- Review your performance metrics as your portfolios diversify. As organizations mature, performance focus shifts toward outcomes or key results when dynamic business processes and risk appetite changes. Scaling this discipline may take time.
- Apply continuous improvement to various checkpoints across portfolio practices. As the business introduces digital technologies, shifting from project to product portfolios and automated data analytics, opportunities to change governance styles emerge.
- Introduce adaptive governance when it presents a better fit for your organization. Governance improvements require the right level of empowered adaptive portfolio governance roles.

Gartner Recommended Reading

Use Adaptive Governance Styles for Portfolio Management

6 Practices for Effective Portfolio Management

Succeed With Digital Business Through Adaptive Governance

Use Our Decision Model to Optimize Risk, Value and Cost in Governing Portfolios

Adapting Governance to Your Innovation Journey

API Management PaaS

Analysis By: Mark O'Neill

Benefit Rating: Moderate

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

API management PaaS (APIM PaaS) takes an on-demand approach to the delivery of API management. It provides an alternative to the purchase and installation of stand-alone, full life cycle API management software. APIM PaaS manages API access via provider-hosted API gateway services, with the option of on-premises API gateways, as well as providing an API developer portal. It is typically designed to be used with other PaaS services such as function PaaS (fPaaS) and integration PaaS (iPaaS).

Why This Is Important

APIs are increasingly built on cloud platforms and using platform as a service (PaaS), so it is natural for API management to also be delivered as-a-service. APIM PaaS takes full advantage of cloud benefits, such as autoscaling, resiliency and robust security. It also allows some vendors to offer per-API-call pricing. APIM PaaS may include the ability to deploy on-premises API gateways, to enable hybrid API management architecture with APIs on-premises and cloud-based API management.

Business Impact

APIM PaaS allows costs to scale with the business value of APIs, reducing the impact of a large outlay as an API program scales up. It enables APIs to be managed effectively when API traffic is unpredictable and potentially very large. APIM PaaS also brings business benefits when an APIM PaaS offering is provided as part of the PaaS platforms already in use by an organization, through unified procurement and billing.

Drivers

- APIM PaaS is driven by migration to and adoption of cloud platforms.
- Function PaaS (fPaaS) can act as a major driver for APIM PaaS. This is because fPaaS offerings can make use of API management on their associated cloud platforms. In some cases, they can automatically populate API gateways with endpoints so that fPaaS functions can be called via REST APIs.
- iPaaS and aPaaS are also drivers toward the need for API management provided by PaaS platforms.
- Since many organizations are building APIs in the cloud, APIM PaaS is also increasingly used in hybrid scenarios and multicloud scenarios.
- Automation is also a driver for APIM PaaS. This is because APIM PaaS also includes APIs into the API management platform itself. These are used to automate the creation and management of APIs, often as part of a DevOps pipeline, as well as for customizing the developer experience (DX) provided by an API developer portal.

Obstacles

- Perceptions of network latency can impact on the uptake of APIM PaaS for managing on-premises APIs.
- Data residency concerns, such storage of API payloads that may contain private information, are also an obstacle to the uptake of APIM PaaS for managing on-premises APIs.
- APIM PaaS can result in higher-than-expected pricing as API traffic grows.
- Architecting a hybrid or multicloud API PaaS architecture is nontrivial (see Comparing Architectures for Hybrid and Multicloud API Management).
- APIM PaaS solutions from cloud hyperscalers are generally tied to their larger PaaS platforms, and are not portable for use on other PaaS platforms.

User Recommendations

- Apply API mediation and prioritize the use of APIM PaaS to provide a cost-effective means of providing API management, even when your APIs are on-premises.
- Compare the pricing of APIM PaaS vendors, since not all provide consumption-based pricing (see How Are API Management Platforms Priced?).
- Include API PaaS as part of your API strategy, since it can accelerate time to market for mission-critical digital initiatives.

Sample Vendors

Alibaba Cloud; Amazon Web Services; Google (Apigee); IBM; Microsoft Azure; Oracle; VMware

Gartner Recommended Reading

Magic Quadrant for Full Life Cycle API Management

Critical Capabilities for Full Life Cycle API Management

Ensure Your API Management Solution Supports Modern API Trends Such as Microservices and Multicloud

Toolkit: RFP Template for API Management Platforms

Comparing Architectures for Hybrid and Multicloud API Management

Design Thinking

Analysis By: Brian Prentice, Irving Tyler

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Design thinking is an ideation methodology extracted from the broader, multidisciplinary design process used in the creation of physical and digital products.

Why This Is Important

Design thinking within innovation management is an ideation methodology extracted from the broader, multidisciplinary design process, and generally delivered through a workshop format. It promotes investment in empathetic learning of the customers/stakeholders as the key step to ensure the right problems are defined before innovative actions are taken to deliver solutions. Design thinking ensures a human-centered approach, and works to minimize uncertainty and risk in innovation efforts.

Business Impact

Design thinking directs the focus of innovation teams toward the human aspects of any given challenge or opportunity. Design thinking helps business innovators explore multiple solutions and to incorporate different perspectives throughout the innovation effort. It is particularly useful in tackling what are known as “wicked problems” — these are issues that are difficult to solve because of incomplete, contradictory and changing factors that are not easily recognized.

Drivers

- People-centricity — Design thinking starts with people. It’s oriented to see an organization’s business process through the lens of its stakeholders rather than seeing these stakeholders as nodes in a process diagram or users of technology. This simple reorientation in perspective leads to dramatically different insights, and applies to both customer-facing and internal operational innovations.

- Diversity of perspective — The quality of output from design thinking increases in line with the diversity of the people participating in the effort. Different perspectives added significant value in interpreting people-centric data and drawing accurate conclusions.

- Outside-in orientation — Design thinking, if done properly, forces participants to look beyond the obvious spans of control or attention. Design thinking helps organizations see how they fit within the broader context of their customer’s goals or see the organization’s operations through the eyes of people at the frontlines.

- Integration with design practices — While design thinking isn't contingent on making a new product or service, when it does, there is seamless integration into a broader design process. In fact, most design thinking occurs through workshops run by members of design teams who understand the connection between design thinking as an ideation methodology, and design as a process of producing products and services to solve problems for people.

Obstacles

- Cutting corners on research — Design thinking is a process of applying unique analysis techniques to data coming from usage reports and, more importantly, observational research. This data can be time-consuming and expensive to produce. Too often, workshops proceed without any research. Such workshops quickly devolve into empathy sessions, which are more likely to echo existing biases than to create an accurate picture of reality that is needed to drive innovation.

- Design confusion — A common pitfall is to conflate design thinking with the design process. Design thinking, then, ends up as a training program instead of a repeatable ideation technique. The hope is that running staff through a couple of days in a design thinking workshop will mean no incremental investments are needed building internal design capability or retaining design agencies. The end result are design thinking workshops that have neither any follow-through activity nor any hope for design capability.

User Recommendations

- Direct design thinking toward clearly articulated business problems where stakeholders can be identified, and business value can be measured. Complex, “wicked” problems are fine; however, without proper grounding, design thinking can result in very creative insights that are unactionable.
- Don’t skip observational, “empathetic” research — ensure research work proceeds any design thinking initiative.
- Establish high diversity within design thinking participants for robust resulting insights.
- Leverage the investments in internal design talent to establish an ongoing program of applied design thinking and to ensure qualified designers are leading design thinking workshops.
- Link, where possible, design thinking workshops to broader design initiatives in order to increase the chances of ideation moving into an actual production process.

3D Printing in Oil and Gas

Analysis By: Rich McAvey

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Definition:

3D printing (3DP) is an additive technique that uses a device to create physical objects from digital models. In oil and gas, 3DP is used in the design, development and prototyping of engineered equipment; the modeling of natural resources; and the creation of tools, components, dies and molds that cannot be manufactured by other means. Managed 3D print service providers (M3DPS) take responsibility for printing devices, consumables, and enabling software for on-site and/or off-site services.

Why This Is Important

3D printing technologies and services continue to improve while costs continue to decline. However, modest levels of industry spend can only support a limited number of 3DP equipment and service providers. The early promise of widescale supply chain disruption still seems far off. However, several specialized use cases continue to move forward. 3DP's position in the Hype Cycle has been recalibrated to reflect the current, more modest, expectations for this technology.

Business Impact

3DP continues to provide value to a limited range of specialized use cases. 3DP-generated reservoir models allow geoscientists to better understand the nature of a natural asset. 3DP construction aids can simplify site manufacturing, improve safety and reduce risks associated with large, heavy and complex tasks. 3DP also allows component manufacturers to design items with complex geometries that yield better engineered qualities (such as nozzles, tubing, heat exchangers and separation shields).

Drivers

- Rapid prototyping has always been a solid use of 3DP and remains a stronghold for the technology. Nonoperational prototypes provide value as an aid during product design and marketing.
- Alternative engineering leverages 3D printing to make unique components that improve the efficiency of conventional manufacturing.
- On-site manufacturing and repair, which eliminates fabrication and delivery delays to remote locations, is being done selectively.
- Construction models, which allow the physical visualization of the interactions among the components of a complex oil and gas asset during construction, are gaining in popularity.
- Additive metal manufacturing is slowly increasing the types of materials and the size of components that can be manufactured, incrementally increasing the number of attractive use cases in oil and gas.

Obstacles

- The opportunity space for 3DP is expanding very slowly, making it a lower priority than other technologies.
- Unresolved regulatory, safety and maintenance issues complicate every use of 3DP, increasing costs and slowing deployment times.
- Industry certification standards are underdeveloped and inconsistent across global markets.
- Intellectual property rights for 3DP designs are ambiguous, raising concerns over unintended legal action.

User Recommendations

- Invest only in simple solutions that have strong business support and offer immediate benefit.
- Make engineering, operations and maintenance leaders accountable for developing a portfolio of the most interesting 3DP opportunities, over time. Prioritize expanding awareness and adoption of applications where 3DP has already proven its value in the oil and gas industry.
- Develop relationships with M3DPSPs to stay current on capabilities without incurring significant cost or resource commitments. Focus on capabilities in geographies important to your company and technologies in which conventional manufacturing solutions are restricted.
- Update your security architecture, intellectual property (IP) policies, and enterprise technology standards to guide and facilitate broad 3D printing adoption over time.

Sample Vendors

ExOne; GE Additive; Stratasys Direct Manufacturing; Xometry

Gartner Recommended Reading

The Manufacturing CIO's Role in Adopting and Scaling 3D Printing

Portfolio Management Solutions

Analysis By: Rich McAvey

Benefit Rating: Moderate

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Portfolio management solutions capture historical and forecast data on operating assets, in-flight capital projects and potential future investments to create a comprehensive, high-level forecast of future financial performance. These solutions include analytic capabilities to evaluate future performance under a variety of scenarios.

Why This Is Important

Industry specific portfolio management solutions cannot yet provide comprehensive capabilities for the full range of traditional oil and gas investments and are inadequate for alternative energy investments. While general purpose portfolio management solutions can address basic aspects of a broad range of investments, they lack the tools necessary to address the complex technical aspects of oil and gas operations to efficiently keep individual assets current as market conditions change.

Business Impact

Volatile markets make rapid optimization of large portfolios of existing and potential capital projects a critical business capability. In addition, decarbonization of energy now requires companies to balance investments in new energy assets against traditional oil and gas investments. Comprehensive and agile portfolio management solutions are needed to enable oil and gas companies to integrate and optimize their global capital programs and keep them in alignment with dynamic market conditions.

Drivers

- The need for oil and gas companies to integrate and optimize their global capital programs and keep them in alignment with dynamic market conditions is defining new requirements for enterprise portfolio management solutions.
- Increasing near-term volatility in commodity markets combined with longer-term uncertainty from global decarbonization regulations is forcing oil and gas companies to consider multiple what-if situations, investment trade-offs, economic constraints and asset impairment risks.
- More frequent, comprehensive and interactive management of capital programs is needed as increasing competition within traditional oil and gas markets requires more comprehensive and interactive management of incremental investments.
- Requirements extend beyond the need to accommodate new types of energy investments, based on reliable simulation of risks and future business performance.
- Portfolios of diverse energy investments need to be consistently risk-assessed against a broader range of parameters in near real time to maintain business relevancy as technology and regulatory development reshape investment attributes.
- Demand is increasing for holistic enterprise portfolio planning solutions to reduce the effort required for conditioning out-of-date information to produce trustworthy, detailed investment scenarios.
- Traditional portfolio management vendors are building better data management and analytic capabilities into their solution suites.

Obstacles

- There are no market solutions with sufficient capability, connectivity and industry-oriented functionality to provide oil and gas companies with comprehensive and easy-to-use portfolio management.
- Vendors remain more narrowly scoped than the typical enterprise-level portfolio of modern oil and gas companies. Existing solutions are focused on investment subsets, such as hydrocarbon reservoirs, greenfield asset investments or supplemental investments in legacy business assets.
- Demand for comprehensive, enterprise-level portfolio management solutions is immature and vendor ability to deliver such solutions lags years behind vision.
- Only incremental progress is being made as traditional domain-centric vendors improve their data and analytic capabilities. Furthermore, data management remains overly compartmentalized, particularly for companies with a broad range of oil and gas assets.

User Recommendations

- Customize your technology roadmap for your company's specific priorities, as the approach for portfolio management varies widely among oil and gas companies. Strategies depend on company culture and the types of oil and gas assets within the portfolio.
- Pivot your focus toward enterprise-level optimization of old and new classes of energy investment. Decarbonization realities in oil and gas have made more comprehensive, flexible and fast portfolio management capabilities a fundamental requirement for effective strategy development.
- Focus efforts in the short term on reducing the cost and cycle time of portfolio planning by consolidating the tools and methods used across business asset and project teams.
- Update your roadmap in the midterm to leverage new solutions that provide better data centralization, more complete portfolio analytics, faster scenario assessments, and support more granular investment levels.

Sample Vendors

AspenTech; Halliburton (Landmark DecisionSpace 365); Oracle (Primavera); SAP; Schlumberger (Merak Peep); Quorum Software (Aucerna)

Hybrid Cloud Computing

Analysis By: David Smith, Milind Govekar

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Hybrid cloud computing comprises one or more public and private cloud services that operate as separate entities, but ones that are integrated. A hybrid cloud computing service is automated, scalable and elastic. It has self-service interfaces and is delivered as a shared service using internet technologies. Hybrid cloud computing needs integration between the internal and external environments at the data, process, management or security layers.

Why This Is Important

Hybrid cloud theoretically offers enterprises the best of both worlds — the cost optimization, agility, flexibility, scalability and elasticity benefits of public cloud, in conjunction with the control, compliance, security and reliability of private cloud. As a result, virtually all enterprises have a desire to augment internal IT systems with external cloud services.

Business Impact

Hybrid cloud computing enables an enterprise to scale beyond its data centers to take advantage of the public cloud's elasticity. Therefore, it is transformational, because changing business requirements drive the optimum use of private and/or public cloud resources. This approach improves the economic model and agility. It also sets the stage for new ways for enterprises to work with suppliers and partners (B2B) as well as customers (B2C).

Drivers

- The key driver for hybrid cloud is a desire to evolve data centers to become more cloud-like and therefore have a private cloud that has cost and other characteristics that are more like a public cloud, while maintaining “in-house” infrastructure for key privacy, security, data residency or latency needs.
- As more providers deliver hybrid cloud offerings, they increasingly deliver a packaging of the concept. “Packaged hybrid” means you have a vendor-provided private cloud offering that is packaged and connected to a public cloud in a tethered way. Azure Stack from Microsoft is a good example of this packaging, but there is another approach as well. We call these two main approaches “like-for-like” hybrid and “layered technology” hybrid (spanning different technology bases). Packaged hybrid cloud is a key component of the distributed cloud concept.
- The solutions that hybrid cloud provides include service integration, availability/disaster recovery, cross-service security, policy-based workload placement and runtime optimization, and cloud service composition and dynamic execution (e.g., cloudbursting).
- Hybrid cloud computing is different from multicloud computing, which is the deliberate use of cloud services from multiple cloud providers for the same general class of IT service.
- Note that internally run, virtualized environments are often recast as “private clouds,” and then integrated with a public cloud environment and called a “hybrid cloud.” Hybrid cloud assumes that the internal environment is truly a private cloud. Otherwise, the environment is hybrid IT.

Obstacles

- Hybrid cloud computing complements multicloud computing. Although most organizations are integrating applications and services across service boundaries, we believe that few large enterprises have implemented hybrid cloud computing beyond this basic approach — and for relatively few services. Most companies will use some form of hybrid cloud computing during the next two years, but more advanced approaches lack maturity and suffer from significant setup and operational complexity.
- Hybrid cloud is different from hybrid IT, which is where IT organizations act as service brokers as part of a broader IT strategy, and may use hybrid cloud computing. Hybrid IT can also be enabled by service providers focused on delivering cloud service brokerage, multisourcing, service integration and management capabilities. These services are provided by vendors, such as Accenture, Wipro and TCS, and other service providers and system integrators.

User Recommendations

- When using hybrid cloud computing services, establish security, management, and governance guidelines and standards to coordinate the use of these services with public and private services.
- Approach sophisticated cloudbursting and dynamic execution cautiously, because these are the least mature and most problematic hybrid approaches.
- Create guidelines/policies on the appropriate use of the different hybrid cloud models to encourage experimentation and cost savings, and to prevent inappropriately risky implementations.
- Coordinate hybrid cloud services with noncloud applications and infrastructure to support a hybrid IT model.
- Consider cloud management platforms, which implement and enforce policies related to cloud services.
- Consider using hybrid cloud computing, if your organization implements hybrid IT, as the foundation for implementing a multicloud broker role and leveraging hybrid IT services and service providers to complement your own capabilities.

Gartner Recommended Reading

Top Strategic Technology Trends for 2021: Distributed Cloud

‘Distributed Cloud’ Fixes What ‘Hybrid Cloud’ Breaks

Predicts 2021: Building on Cloud Computing as the New Normal

Mobility in Oil and Gas

Analysis By: Rich McAvey

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Gartner defines mobility in oil and gas as the integrated application of software, hardware and connectivity to improve the productivity of connected workers by presenting relevant information, offering decision support, enabling remote workflows, and facilitating real-time collaboration irrespective of location.

Why This Is Important

Oil and gas investment in mobile solutions is high and growing. Most leaders are now aware of the value offered by well-designed mobile solutions, elevating demand and increasing support for eliminating barriers to progress. Over the last few years, the market for mobile products, development capabilities and technologies have all matured substantially. New solutions are aware of historical technical challenges and are designed to work around the limitations they present.

Business Impact

Spending on mobility is increasing in pursuit of higher worker productivity, enhanced customer experience, and increased safety. Mobility provides impact at multiple organizational levels. Some operate at a small scale, such as phone-based guidance for plant work in real time. Others operate at enterprise scale, such as dynamic AI optimization of work schedules. Benefits include increased productivity, reduced errors, greater agility, reduction of mundane tasks, and a more satisfied workforce.

Drivers

- Integrated collaboration centers (which consolidate and share operating data) provide field and expert workers with reliable operational transparency.
- The costs for mobile devices and fixed field hardware, including intrinsically safe devices, are falling.
- The market is growing for oil and gas SaaS solutions that are created for access by all connected workers.
- Better UX designs that are designed for mobile use are improving worker training and making it easier to apply that training in actual field conditions.
- Economical commercial connectivity is increasing to most locations, enabling greater AI-based optimization of workflows across organizational silos.
- Stronger edge computing is providing workers in remote locations with access to embedded AI decision support.
- Ongoing integration of IT and OT computing is providing access to a vast amount of relevant information on current operating conditions, engineering designs and historical maintenance actions.

Obstacles

- Legacy workflow solutions provide the greatest technical barrier as they make it difficult to integrate information, limiting the ability to integrate workflows across systems and frustrating efforts to implement productive UX designs.
- Limited and expensive connectivity options to a large percentage of operating locations restricts expansion of interactive and collaborative mobile workflows.
- Harsh environmental conditions in exotic locations, such as the arctic or deserts, present challenges to remote device operation and inhibit worker's ability to interact. While availability of intrinsically safe devices is still an issue, the number of compliant devices continues to expand.
- Pockets of strong cultural resistance to mobility solutions remain in most companies, requiring a change management solution that is not technology focused.

User Recommendations

- Define enterprise-level metrics to measure the spread of mobility solutions and to quantify their business impact.
- Establish a shared governance approach to prioritize mobility investments, as individual solutions tend to provide value to multiple organizational units.
- Establish UX leadership in IT to promote interoperability and sustain productivity across the large number of mobility projects that business units will create.
- Reflect mobility solutions in data management architecture to ensure reliable data is maintained to each solution.

Sample Vendors

Aegex Technologies; Fieldbit; Microsoft; Mobideo; Siemens

Gartner Recommended Reading

Use Digital Factories to Drive Deep Optimization Across the Enterprise

Data Lakes

Analysis By: Philip Russom, Henry Cook

Benefit Rating: Moderate

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

A data lake is a concept constituting a collection of storage instances of various data assets combined with one or more processing capabilities. Data assets are stored in a near-exact, or even exact, copy of the source format and in addition to the originating data stores. Structured and semistructured data may also be held.

Why This Is Important

Data lakes are important because they enable advanced analytics and complement traditional data warehouses. For example, the massive repository of source data that typifies a data lake supports broad, flexible and unbiased data exploration, which is required for data mining, statistics, machine learning and other analytics techniques. Furthermore, a data lake can provide scalable and high-performance data acquisition, landing and staging for data to be refined and loaded into a data warehouse.

Business Impact

A data lake can be a foundation for multiple forms of business analytics. For example, data science is a common first use case for a data lake, which leads to predictive analytics that help a business retain customers, execute impact analyses and anticipate issues in maintenance, logistics, risk and fraud. Similarly, using a data lake for self-service data access is a growing business use case that contributes to programs for business transformation and digitization.

Drivers

- **User organizations are increasingly driven by data and analytics.** This is so they can achieve their goals in business transformation, digitization, data democracy, operational excellence and competitiveness. A data lake provides data and supports analytics for these high-value goals.
- **Organizations need to expand their analytics programs.** Established forms of analytics will continue to be relevant, namely reports, dashboards, online analytical processing (OLAP) and statistical analysis. Hence, organizations must maintain these while expanding into advanced forms of analytics, such as data mining, natural language processing (NLP), machine learning, artificial intelligence and predictive analytics. A data lake provides the scale, structure-agnostic storage and processing options that advanced analytics require.
- **Data exploration has become a common practice.** This is true for many user types, from data scientists and analysts to business end users who are capable of self-service data prep. To achieve their productivity and discovery goals, each type of user needs massive volumes of broadly collected data that is in a condition suited to their skills and analytics techniques. A data lake, when designed properly, can provision data for the diverse exploration requirements of multiple user types and use cases.
- **Data warehouses continue to be relevant, but only when modernized.** Many legacy data warehouses were designed primarily for reporting, dashboards and OLAP. Instead of redesigning a warehouse to accommodate the massive stores of detailed source data that advanced analytics demands, many organizations prefer to build a data lake for advanced analytics. In these cases, the warehouse and lake are integrated by shared datasets, platform infrastructure (DBMS brands and storage, whether on-premises or cloud) and architecture components (data landing/staging). Hence, a data lake can modernize a data warehouse, to extend its investment, relevance and life cycle.

Obstacles

- **Data lake best practices are still evolving.** There is still much confusion about how to design and govern a data lake, as well as how to optimize a lake's data without losing its purpose as a repository for data science and advanced analytics. An emerging best practice is to design the internals of a data lake to include multiple data zones for business use cases (data science, exploration and self-service) and technology architectural components (data land/staging and special data structures or latencies).
- **Today's cloud data lake differs from the old Hadoop data lake.** The first data lakes were built on Hadoop, for data science only, and they lacked metadata, relational functionality and governance. If you build that kind of data lake today, it will fail. Today's data lake is on cloud, and it supports multiple analytics techniques (not just data science). For example, self-service data prep on a data lake requires business metadata, SQL for ad hoc queries and data curation.

User Recommendations

- Build a competency in data science and advanced analytics by first building a data lake as a foundation.
- Staff the data lake for maximum value by hiring data scientists and analysts who have the skills required to conduct data exploration and analytics with the lake's data.
- Create business value by designing a data lake that addresses multiple high-value business use cases, such as data science, analytics, self-service data access, customer 360, data warehousing and operational intelligence.
- Enable broad data exploration, multiple analytics techniques, and machine learning by populating a data lake with broadly collected data in various structures, formats and containers.
- Modernize a data warehouse by extending it with an integrated data lake and/or a logical layer.
- Keep each data lake from becoming a data swamp by governing the use of data in the lake, curating the data allowed into the lake, and documenting data via metadata and other data semantics.

Sample Vendors

Amazon Web Services (AWS); Cazena; ChaosSearch; Databricks; Dremio; Google Cloud Platform; Infoworks; Microsoft; Snowflake

Gartner Recommended Reading

Building Data Lakes Successfully — Part 1 — Architecture, Ingestion, Storage and Processing

Building Data Lakes Successfully — Part 2 — Consumption, Governance and Operationalization

Metadata Is the Fish Finder in Data Lakes

Data and Analytics Essentials: Data Warehouses, Data Lakes and Data Hubs

Best Practices for Designing your Data Lake

Market Guide for Analytics Query Accelerators

OT Security

Analysis By: Katell Thielemann, Ruggero Contu

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Operational technology (OT) security is the practice of protecting critical production and operational systems and services in asset-centric enterprises. OT security addresses industrial control systems and use cases where physical state changes depend upon secure, safe and reliable function. As digital transformation efforts increasingly target operational and mission-critical environments, OT security is evolving into cyber-physical systems security, with security disciplines converging.

Why This Is Important

Once disconnected from IT networks, the convergence of OT and IT systems driven by business needs has created new security risks. They are compounded by remote connections from original equipment manufacturers (OEMs). Because operational systems are the centers of value creation, OT security is of major relevance to asset-centric organizations, such as those considered to be part of national critical infrastructure, and to any other industrial verticals with operations-centric environments.

Business Impact

Whether nation states targeting critical infrastructure (e.g., the 2015 attack on Ukraine) and intellectual property (manufacturing is often targeted for cyber espionage), or financially motivated hackers deploying ransomware, the number of attacks on OT systems has steadily increased over the past five years. The impact of operational disruption can range from mere annoyance to hundreds of millions of dollars, as well as reliability and safety impacts.

Drivers

- Whether because of attacks or an overall heightened awareness of the increased risks they face, asset-centric organizations are increasingly focusing their attention on the security risks they face outside of enterprise IT. At the same time, a growing number of vendors are offering specialized security platforms to help enhance situational awareness of assets, network topology and vulnerabilities, as well as to help with threat detection and mitigation.
- International standards, such as IEC 62443, European NIS and NIST 800 series, are also emerging to provide guidance; and in some industry verticals, security mandates such as NERC-CIP are already in place. Given the close relationship between critical infrastructure and national security, and the growing concerns of targeted attacks, government-led efforts are also likely to increase, adding to the growing list of existing national legislations.
- A converged cyber-physical systems (CPS) security discipline is emerging, driven by organizations paying more attention to the basics of OT security (e.g., firewalls, network segmentation), while adding “greenfield” new robotics or IIoT systems with modern technologies that introduce new risks across a cyber-physical continuum of threats.

Obstacles

- Because of their history of OT deployments disconnected from IT systems, organizations working on expanding their security and risk efforts outside of enterprise IT often face cultural, governance and security control challenges that prevent a one-size-fits-all approach to security. For instance, operations often run 24/7 and cannot be stopped at will.
- OEMs often contractually connect remotely into OT systems to maintain and update them. If not done securely with consistent policies, this creates additional risks. In some cases, OEMs also control the deployment of any updates, which hampers security efforts.
- Most OT systems have important safety and reliability requirements that prevent deploying security controls at will.
- Organizations also continue to face acute and growing shortages of OT security skills to foster and support IT/OT integration, and securely support digital transformation efforts.

User Recommendations

- Initiate risk discussions between IT security and OT teams, and determine the current extent of OT security efforts.
- Deploy OT asset discovery, inventory and network mapping security platforms.
- Determine immediate gaps, such as flat OT networks, lack of firewalls, open ports, vulnerable and unpatched operating systems, shared password, etc.
- Accelerate security awareness and skills training for converging IT and OT infrastructures.
- Focus on organizational and cultural trust challenges between IT and OT personnel.
- Collaborate with your procurement team to demand OEMs of OT systems ensure that their (future) systems are secure by design.
- Prepare for a future where CPS security emerges as a centralizing discipline for securing converging IT, OT, and IoT systems and bringing together asset-centric cybersecurity, physical security and supply chain security best practices.

Sample Vendors

Barracuda; Claroty; Dragos; Nozomi Networks; SCADAfence; Verve Industrial

Gartner Recommended Reading

Market Guide for Operational Technology Security

Establish Successful Executive Security Governance in an Integrated IT/OT Environment

OT Security Best Practices

Emerging Technologies and Trends Impact Radar: Security in Manufacturing

Climbing the Slope

Asset Investment Planning

Analysis By: Nicole Foust, Kristian Steenstrup

Benefit Rating: Moderate

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

Definition:

Asset investment planning (AIP) is a decision support tool that produces plans for investing capital in large-scale physical infrastructure, such as utilities, oil and gas, and transportation systems, over extended time horizons. AIP takes data from asset management systems on asset condition, failure forecasts, maintenance costs, criticality, budgets and risks, and analyzes it to identify optimal investment plans, including asset upgrades, refurbishment, replacement or new infrastructure.

Why This Is Important

With AIP, organizations can improve and optimize investment plans by assessing the risk of equipment and infrastructure failure, and incorporate this analysis into reliability forecasting and budgeting.

Client benefits and use cases include defendable asset investment plans and short- and long-range investment requirement to:

- Maintain reliability
- Optimize investments
- Balance budgets, rate impact and risk tolerance
- Align asset investments with strategic corporate objectives

Business Impact

- AIP informs better asset investment decisions based on asset condition data, maintenance costs, criticality, budgets and risks

- It analyzes the data to produce capital investment plans over extended time horizons as opposed to rules of thumb or past experience
- It also provides consistent processes and methodology for organizations to prioritize capital and maintenance spending to align with corporate strategies, giving stakeholders a common understanding of the business risk effects of cost-cutting initiatives

Drivers

- Capital investment decisions to rethink or replace critical business assets often have relied on historical practice, rules of thumb and manufacturers' recommendations put into spreadsheets. These legacy processes are increasingly ineffective: too expensive, too slow and often leads to the wrong answer, and may introduce more risk.
- This is particularly important for both larger organizations with a significant asset base, and regulated entities whose long-term capital investment plans must be submitted and approved well before implementation. This is critical for organizations such as utilities, since regulators increasingly scrutinize capital investment as it impacts utility rates. Proving that you have explored alternatives makes it easier to obtain approval for capital investment in asset replacement. AIP can support better asset investment decisions assuming good quality data, which could lead to more accurate estimates of project costs. It can help prioritize spending plans, and identify and communicate the associated risk arising from unfunded projects.
- AIP continues to expand across utilities with higher adoption rates and maturity and is proliferating to other industries, such as oil and gas, transportation, facilities and telecom. Market awareness of AIP has increased in recent years in part spurred by complementary technologies advancing, such as APM and EAM solutions. In addition, advanced analytics provide more insights, allowing organizations to adjust their asset management strategies using tools such as AIP software.
- Unlike generic tools, AIP incorporates asset condition and criticality, impacts of time, and other factors to create alternative investment scenarios. In many regions, regulators favor performance- or outcome-based systems, forcing organizations to rethink the way they manage their asset base.

Obstacles

- **Data quantity and quality** — These elements are subjective, but critical to define when deciding whether to go with a COTS or custom implementation solution.
- **Degradation models** — Some organizations create these in-house; others outsource them or buy COTS.
- **Change management** — Organizations must assess the value of their data input, such as mitigating risk, creating value, staff and talent improvements, and other nontechnical aspects of implementing AIP solutions.
- **Vendors (asset-centric vs. project-centric)** — Many vendors focus primarily on asset management, while others concentrate on project and portfolio management (PPM), which can include asset planning. Clients, then, are challenged to decide which side of AIP is best for their organization.
- **A well-implemented EAM system** — high-quality asset data is foundational and typical for all effective AIP deployments. Ideally, the EAM system is populated with extensive historical data, however if it is not, a data cleansing initiative may be required.

User Recommendations

- Create a systematic and repeatable investment planning process using AIP tools. AIP is becoming a core system of record for capital investment decisions within many industrial companies.
- Discern whether the AIP tools focus on an asset-centric approach to investment planning or come from the PPM continuum. Asset-centric AIP helps understand what decision should be made then handed over to the project-centric AIP side or a PPM tool for execution and optimization of projects.
- Ensure project success by assessing AIP solutions against business goals, project success prerequisites and business outcomes.
- Help business owners optimize asset-related capital spending by evaluating and investing in appropriate AIP tools to create a systematic, repeatable investment planning process.
- Choose the appropriate AIP solution (rethinking versus replacing) by educating yourselves on current offerings and vendors in light of your specific organization requirements.

Sample Vendors

Arcadis; CGI; Clevest; Copperleaf; Cosmo Tech; PowerPlan

Gartner Recommended Reading

Optimize Utility Capital Expenditures With Asset Investment Planning Solutions

Market Guide for Enterprise Asset Management Software

6 Critical Changes That Affect the Future of Asset Maintenance

Market Guide for Asset Performance Management Software

Asset Performance Management

Analysis By: Nicole Foust, Kristian Steenstrup

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

APM are business applications for optimizing reliability and availability of operational assets (such as plant, equipment and infrastructure) essential to the operation of an enterprise. It uses data capture, integration, visualization and analytics to improve asset maintenance activities. APM includes capabilities and functionality to support asset strategy, risk management, predictive maintenance, reliability-centered maintenance, and financially optimized maintenance activities.

Why This Is Important

APM has become an important core competency for asset-intensive and asset-centric organizations. Organizations invest in APM tools and technologies to reduce unplanned repair work, improve asset availability and safety, minimize maintenance costs, and reduce the risk of failure for critical assets. Realizing the business can move beyond the key use case of equipment reliability, organizations are leveraging APM to improve overall business operations.

Business Impact

- APM is an important investment area for asset-intensive industries, including manufacturing, mining, oil and gas, transportation, telco, and utilities.
- Successful APM deployments can deliver measurable improvements in availability, as well as reduce maintenance and inventory carrying costs.
- Benefits such as improved uptime and cost savings can be substantial, typically delivering benefits measured in millions of dollars per year.

Drivers

- Organizations need better solutions to deliver enhanced asset insights.
- Those that depend significantly on availability of their assets, such as manufacturing, utilities and natural resources industries, tend to be further along in their asset management capabilities and strategy, and invest more heavily in APM.
- Innovation in enabling technologies such as cloud, IoT and AI/ML are widening the scope and decreasing the deployment cost, aiding more awareness and use of APM.
- As operations take advantage of newer sensors (e.g., acoustic), drones and bots, APM has access to increased data volumes of better quality and granularity (or reduced latency) and accuracy yield richer use cases and more robust capabilities.
- Business processes supported by APM software are becoming an important core business capability for asset-intensive organizations. CIOs are increasingly realizing benefits which aid the market transition beyond the use of APM focused on equipment reliability to increasingly leveraging APM to also help improve overall business operations.
- Most APM projects are executed on the premise that data-driven decisions will improve equipment reliability and, therefore, reduce operational risk.
- The potential of reduced maintenance cost and downtime, coupled with higher levels of operational reliability is attracting other industries, however, all are progressing at a varied pace.

Obstacles

- Limited availability of good-quality and consistent asset data to support a more advanced maintenance capability.
- Limited adoption of asset management standardization such as ISO 55000.
- Digital business immaturity constrains organizational ability to support advanced asset maintenance capabilities.
- Market confusion from conflicting vendor claims overlaps with complementary products. These comprise Industrial Internet of Things (IIoT) platforms, EAM systems that also provide CbM and beyond, APM included as a part of digital twins, and OEMs including predictive analysis support.
- Whether the vendor and product have proven capabilities for your desired asset maintenance activities and classes of assets within your industry, and if they align with your asset management strategy.
- Importance of EAM in APM success: (1) there must be an interface to your EAM to be able to execute APM recommendations directly in the transactional EAM system; (2) your EAM systems must have good quality data; (3) some EAM vendors also have APM capabilities which may require significant customizations or may limit use with only their offered EAM product.

User Recommendations

- Assess the maturity of your EAM system and have a sustainable integration plan with your APM before investing in APM. Although newer EAM products include APM capabilities, CIOs should not expect to get all APM capabilities from the EAM vendors themselves.
- Identify a combination of asset maintenance capabilities to support a variety of asset types and situations across the business through a toolbox approach. Most vendors do not offer all levels of APM maintenance capabilities, across all industries and asset types. Thus organizations may need more than one APM product, depending on the complexity of their businesses, the types of assets and their asset maintenance goals.
- Ensure IoT and operational technology (OT) systems compatibility with the technical and process needs of reliability systems by getting involved in the planning of IoT monitoring of plants and equipment.
- Source good data — that is, historical service and operational data — organizations looking to invest in APM should also expect to make investments in information management infrastructure to capture operational data where it doesn't exist today.

Sample Vendors

AspenTech; AVEVA; Bentley Systems; GE Digital; Hitachi ABB Power Grids; IBM; SAP; SAS; Uptake

Gartner Recommended Reading

Market Guide for Enterprise Asset Management Software

Top Practices for Utility CIOs Evaluating Enterprise Asset Management Software

Market Guide for Asset Performance Management Software

Optimize Utility Capital Expenditures With Asset Investment Planning Solutions

Mapping a Route to Asset Management and Reliability

Upstream Modeling Suites

Analysis By: Simon Cushing

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Upstream modeling is the development of a virtual model that describes the physical characteristics and future performance of subsurface hydrocarbon reservoirs, predicting their future performance and economic value. Upstream modeling suites (UMS) consist of bundles of complementary software that increase productivity by integrating the data, applications and workflows necessary to build and maintain upstream models.

Why This Is Important

Accurate understanding of the reservoir is critical to optimizing drilling and field development, and to optimize production over an asset's lifetime. Reservoir models are complex to build and the data they need costly to acquire. Their interpretation needs expert judgment and can require extensive and high-end computing resources. As a critical but cost-intensive set of technologies, initial high expectations of UMSs have moderated and they have matured considerably in relation to customer requirements.

Business Impact

Outside facilities construction, drilling and seismic data acquisition represent exploration and production (E&P) companies' major costs. Better upstream modeling capability creates competitive advantage among upstream companies. Reduced cycle times and subsurface uncertainties, extended simulation scope, and increased automation and predictive power contribute to cost-optimized well construction and success rates, along with improved reservoir performance in production.

Drivers

- Oil and gas companies seek to optimize return on investment in UMSs, driven by their relatively high cost and comparatively slow rate of output. Subsurface workflows are complex, involving interrelated first-principle analysis in specialist tools. E&P companies continually balance modeling fidelity against portfolio cost and cycle time.
- Initially dominated by best-of-breed point solutions, UMSs are now characterized by integrated solutions where data sharing and workflows are streamlined. Major UMS vendors' suites are now more or less integrated, reducing the need for data transfer, facilitating established business and user-defined workflows.
- In recent years, a newer platform-based pattern for UMSs has emerged with leading vendors competing to offer integrated collaborative earth modeling environments, including combinations of cloud infrastructure, high-performance computing and advanced analytics.
- More modular and more open, such platforms promise increased productivity and collaboration through seamless integration across reservoir characterization, well delivery, development planning, and production operations workflows.
- UMS platforms offer the potential for extended benefits using modern techniques to reduce reservoir uncertainty, automate aspects of the modeling workflow and facilitate efficient collaboration at scale.
- Driven by the potential efficiencies of seamless access to large stores of data across the subsurface, in 2018, a group of oil and gas companies began the Open Subsurface Data Universe (OSDU). The OSDU platform is now released and compatibility requirements may be a major driver of UMS evolution in the next few years.

Obstacles

- Oil and gas companies typically have upstream modeling portfolios that include best-of-breed solutions and integrated UMSs. As vendor offerings expand, companies fear loss of specific important workflow capabilities and/or lock-in with a single vendor.
- Overlapping functionality, challenges in data sharing and model update still remain in some upstream modeling workflows in many companies. Solution rationalization can be complex and prohibitively costly, impeding uptake of integrated solutions.
- Concerns about performance, security and the maturity level of solutions moderate the pace of adoption of cloud-based solutions.
- CIOs seeking continued cost and efficiency benefits across their UMS portfolio have the added choice of emerging UMS platforms. However, these are still relatively immature and the costs and benefits of adoption are not fully clear.

User Recommendations

- Continue to seek benefits through continued applications rationalization and simplification across the UMS portfolio.
- Prioritize integration and workflow efficiency in UMS adoption or update efforts. At the same time, assess the cost benefit of current advanced best-of-breed functionalities (such as machine learning features), adopting these where the business case is sound.
- Closely monitor development of UMS platforms and cloud solutions. Conduct feasibility studies or proofs of concept to learn more and guide UMS portfolio roadmaps or strategies.
- Join or closely monitor the OSDU initiative. Understand and assess vendor partners' stance and plans in relation to OSDU and factor these into UMS portfolio planning.

Sample Vendors

CGG; CMG; Cegal; Emerson (Paradigm); GE (Baker Hughes); Halliburton (Landmark); IHS Markit; LMKR; Schlumberger

Managed IoT Connectivity

Analysis By: Pablo Arriandiaga

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Managed connectivity for IoT or machine-to-machine (M2M) services encompass connectivity hardware, software, and network and IT services that are generally bundled and managed by a third-party provider. These services enable enterprises to connect, monitor and control business assets and processes over a fixed or wireless connection. These services are key to informing and integrating purpose-built and stand-alone telematics systems, IoT platforms or legacy back-end IT and OT systems.

Why This Is Important

The market for cellular-based-managed IoT connectivity services, field-area networks (FANs) and satellite is mature, but enterprises are demanding a number of capabilities that are still quite nascent in this market:

- NB-IoT and LTE-M
- eSIM and iSIM
- 5G technology and its role in mobile edge computing
- Integration with hyperscalers
- Consumer or industrial connected products as most of managed connections are for connected commercial products such as automotive
- Bring-your-own connectivity scenarios

Business Impact

- Critical role in IoT solutions to support managing the complexity of endpoints and connectivity types, even though managed connectivity services are a small component of the end-to-end IoT solution
- Support broader IoT initiatives by ensuring use of appropriate and rightsized solution components, including edge devices and gateways, connectivity to the cloud, flexibility to encompass a variety of connectivity providers in a seamless way through technologies such as eSIM

Drivers

- NB-IoT and LTE-M: Expected adoption of NB-IoT and LTE-M has reduced dramatically the cost of the IoT connectivity and modules continue to accelerate due to national deployments in big countries such as China with NB-IoT or the U.S. with both networks. Roaming agreements, mainly for LTE-M, have grown significantly during this last year. Enterprises look for guarantees in terms of standard and broadly adopted connectivity for devices and sensors that could have a lifetime of 10 years versus proprietary technologies such as Sigfox or LoRa WAN.

- Platform of platforms: Multinational companies where IoT connectivity is a critical element of their strategy for connecting their products and assets in a secure way. As IoT connectivity commoditizes, managed IoT connectivity services and platforms increase relevance to be connectivity agnostic and provide flexibility to multinationals. This can be achieved with a sustainable managed IoT connectivity platform strategy that can be integrated with the rest of the IoT infrastructure without the risk of changing the connectivity provider. This is what Gartner calls the platform of platforms.

- Connected industrial products are starting to emerge with the convergence of IT/OT, and most of the vendors on the market are shifting priorities to serve the manufacturing industry beyond their traditional play in connected vehicles. Apart from traditional industry verticals in the managed IoT connectivity services market like transportation or utilities, other industry verticals like healthcare, insurance or retail that were underserved by this market are getting relevance as they are accelerating their digital transformation.

- Edge compute, 5G and private mobile networks in IoT will accelerate the adoption of managed IoT connectivity services as enterprises and providers are increasing the number of use cases being tested across different industry verticals for their digital transformation initiatives.

Obstacles

- Lack of understanding of the benefits of 3GPP and non-3GPP LPWA networks by enterprises and its availability, where many times it is confused with 5G. 3GPP and non-3GPP LPWA networks provide low revenue for connectivity to vendors that have a lack of end-to-end skills in industry verticals where these technologies could scale and don't promote it.
- 3GPP LPWAN global deployments needing roaming and interoperability that will need at least one year to mature.
- eSIM: MNOs are still reluctant to deploy eSIM for IoT and open their networks to third parties, allowing enterprises better mechanisms to bring-your-own-connectivity scenarios.
- Integration with hyperscalers and IoT platform providers is in very early stages, so enterprises can't access a seamless management of connectivity and devices under a single pane of glass. This splits the purchasing process of managed IoT connectivity services as a separate part of the IoT solution.

User Recommendations

Companies that are considering managed IoT connectivity services should consider the following recommendations:

- Identify vendors that could add more value on top of connectivity. Assess whether bundled solutions can be more cost-effective when including point solutions. Verticals that are well-served in this market are automotive, transportation and logistics, utilities or smart cities but increasingly manufacturing, retail and healthcare, as well.
- Evaluate cellular and 3GPP LPWAN capabilities by requesting specific agreements with local providers, global points of presence to avoid latency and flexibility through multi-IMSI, eSIM and iSIM to add third-party connectivity into vendors' managed IoT connectivity platforms (platform of platforms).
- Assess the evolution of the vendors' roadmaps and ecosystem by ensuring they include edge and cloud integration, APIs availability natively integrated with hyperscalers, and roadmap for 5G and private mobile networks.

Gartner Recommended Reading

Magic Quadrant for Managed IoT Connectivity Services, Worldwide

Critical Capabilities for Managed IoT Connectivity Services, Worldwide

Tech Providers 2025: Edge Ecosystems Will Challenge CSPs' Dominance in Managed IoT Connectivity Services

Petroleum Economic Solutions

Analysis By: Rich McAvey

Benefit Rating: Moderate

Market Penetration: More than 50% of target audience

Maturity: Mature mainstream

Definition:

Petroleum economic solutions integrate physical and technical data from hydrocarbon asset management systems (e.g., drilling programs and production rates) with investment data from portfolio/project models and economic data from financial systems (e.g., exchange rates, cost of capital and risk premiums). They create comprehensive economic models that can be evaluated in a wide variety of potential future scenarios.

Why This Is Important

Oil and gas organizations need economic models that integrate directly into asset management, project management, operations planning and economic forecasting systems. Ideally, changes made within any of these systems should be reflected in a comprehensive forecast. Petroleum economic solutions continue to mature; however, progress is slow and incremental. Companies requiring integrated solutions now must build customized hybrid solutions.

Business Impact

Petroleum economic solutions help oil and gas companies overcome challenges in collecting, transforming, integrating and analyzing up-to-date data from a variety of management, engineering, operational and commodity pricing systems. These solutions create complex models that produce cohesive hydrocarbon production estimates, operating cash flow forecasts, ultimate recovery estimates and overall financial projections under various scenarios.

Drivers

- Applying enterprisewide data to enhance production and reserve forecasting for operations, engineering and business teams
- Improving accuracy via consistent cost modelling from concept to detailed engineering to make better decisions early and increase the reliability of capital cost estimates
- Driving efficiency with fully informed decision making for faster project completion through consolidated data management (and reuse), insightful analytic visualizations and integrated benchmarking capabilities
- Accelerating analysis by means of reusable templates and configurable reports to decrease estimation time and increase transparency
- Achieving higher engineering productivity through integrated analytic capabilities such as history matching and uncertainty modeling
- Improving field productivity from integrated and automated workflows from geosciences to production
- Improving collaboration by connecting data across the enterprise and providing users with actionable information
- Finding greater efficiency by integrating data and workflow for revenue accounting, joint venture accounting, fractional revenue, capital planning and financial reporting

Obstacles

- Legacy solutions are overly compartmentalized and not integrated at the data and workflow levels. In addition, the analytic capabilities of legacy solutions are typically less mature than required.
- Virtually no vendor solution covers the requirements for the full range of oil and gas assets, thereby forcing companies to construct hybrid solutions.

User Recommendations

- Explore practical ways to create agility from petroleum economic solutions to respond to volatile market conditions.
- Use lean thinking to design a simple hybrid platform consisting of multiple vendor point solutions, custom-built integrations, complex workflows and compartmentalized analytic models.
- Explore benefits and trade-offs when deciding how and when to invest.
- When possible, defer investment in petroleum economic solution upgrades by filtering out all but the most required changes to enable business optimization.

Sample Vendors

AspenTech; Emerson; Halliburton; P2 Energy Solutions; Schlumberger

Drones in Oil and Gas

Analysis By: Simon Cushing

Benefit Rating: High

Market Penetration: More than 50% of target audience

Maturity: Early mainstream

Definition:

Unmanned aerial vehicles (UAVs, commonly known as drones) are small rotary-wing, fixed-wing or hybrid aircraft with no onboard human pilot. Piloted remotely, with varying degrees of autonomy, they carry sensor payloads to acquire visual and other data at remote locations. Depending on their type, they can hold a stationary position, follow predefined routes or patrol freely within geographic boundaries. The degree of autonomy varies from minimal (entirely remote controlled) to fully autonomous.

Why This Is Important

Drones can perform inspection and other tasks faster, and more safely, frequently and consistently than human workers, gathering more and better-quality data. Increasing autonomy and residency, global remote drone operation, swappable sensor payloads and integration with other technologies are expanding mission capabilities. However, drone systems largely remain unintegrated into oil and gas company operational technology or IT systems. Increasing sophistication and use will need better integration of data and systems.

Business Impact

Drones can acquire data more reliably and rapidly in inaccessible or hazardous environments than on-site humans, improving:

- Asset inspection and surveillance performance, and safety and operational efficiency at reduced cost.
- Field service costs by lowering site visit frequency.
- Planning efficiency from site surveys.
- Regulatory compliance and sustainability by reducing emissions.
- Situational awareness in emergencies.
- Continuous or regular site surveillance.

Drivers

Renewed pursuit of greater safety, efficiency and cost-effectiveness continues to drive oil and gas companies to reduce the number of human workers on-site at assets and field locations. Drone use cases continue to expand in scope and scale.

- Autonomous drones can be programmed to conduct regular surveys of defined areas.
- Tethered drones can provide continuous observation.
- More time on station, wider ranges of sensors and greater autonomy will enhance capabilities and expand use cases, especially as regulation becomes more permissive.

- Some commercial providers now offer remote drone control from global locations, reducing the number of drone operators, as well as inspection personnel, needed in the field.
- Combining drones with IoT, AI, cloud and edge technologies will increase their ability to fly in complex environments.
- Drone service provider offerings are maturing and growing in sophistication. Some now offer a level of integration with enterprise IT systems, such as ERP.

Obstacles

- In most jurisdictions, drone use is tightly regulated. Civilian drone size, range and payloads are restricted, limiting operational capability without special permission. Generally, flight permits (and pilot qualifications) must be obtained, adding effort and cost to missions.
- Drones can be used maliciously to damage assets or disrupt operations. Drone malfunctions or failures also have the potential to harm people, assets and the environment, and these risks must be mitigated.
- Data acquisition and transmission must be made secure against hacking and cyberthreats.
- Autonomous, resident and integrated drone systems are new, complicated and require more complex technologies, increasing risks and costs.
- Drones deliver most value from automated data processing and the use of analytics on acquired data. Provider cloud hosting allows access to data and results without interaction with enterprise IT systems. Accordingly, business users often make adoption decisions outside the purview of IT.

User Recommendations

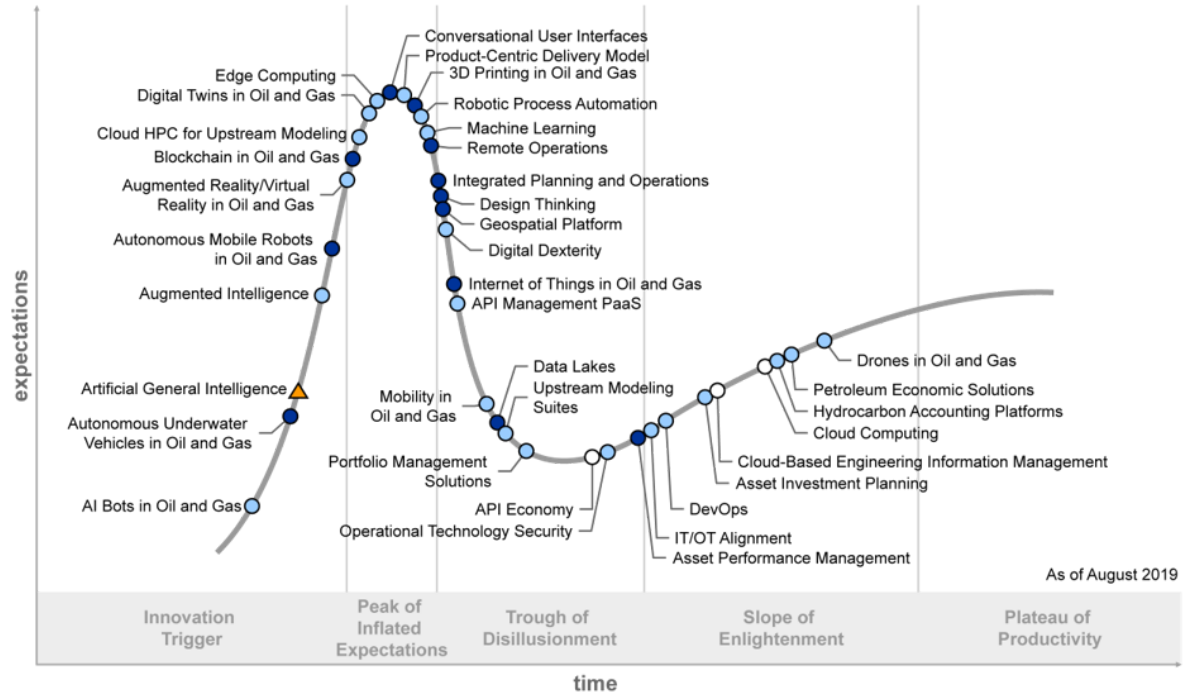
- Engage with business asset and engineering teams to forecast likely usage and understand evolving needs for data aggregation, analytics and other IT system integration.
- Provision tools to support data analysis along with governance and security guidelines, especially where there is any integration with enterprise systems.
- Lay long-term plans, monitoring the regulatory environment for changes that may accelerate adoption, outlining architectures for integrated data processing and analytics for drone survey data, and reviewing IT governance policies and standards for fitness to maximize the operational benefits while minimizing risks.
- Recognize that drones deliver most value from automated data processing and the application of analytics to acquired data. Provider hosting of data in the cloud allows access to data and results without interaction with enterprise IT systems. Accordingly, business and/or engineering managers often make adoption decisions outside the purview of IT.

Sample Vendors

Cyberhawk; GE (Baker Hughes); Motorola (Cape Aerial Telepresence); PrecisionHawk; Sky-Futures

Appendixes

Figure 2. Hype Cycle for Oil and Gas, 2019



Source: Gartner
ID: 370358

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Hype Cycle Phases, Benefit Ratings and Maturity Levels

Table 2: Hype Cycle Phases

(Enlarged table in Appendix)

Phase ↓	Definition ↓
Innovation Trigger	A breakthrough, public demonstration, product launch or other event generates significant media and industry interest.
Peak of Inflated Expectations	During this phase of overenthusiasm and unrealistic projections, a flurry of well-publicized activity by technology leaders results in some successes, but more failures, as the innovation is pushed to its limits. The only enterprises making money are conference organizers and content publishers.
Trough of Disillusionment	Because the innovation does not live up to its overinflated expectations, it rapidly becomes unfashionable. Media interest wanes, except for a few cautionary tales
Slope of Enlightenment	Focused experimentation and solid hard work by an increasingly diverse range of organizations lead to a true understanding of the innovation's applicability, risks and benefits. Commercial off-the-shelf methodologies and tools ease the development process.
Plateau of Productivity	The real-world benefits of the innovation are demonstrated and accepted. Tools and methodologies are increasingly stable as they enter their second and third generations. Growing numbers of organizations feel comfortable with the reduced level of risk; the rapid growth phase of adoption begins. Approximately 20% of the technology's target audience has adopted or is adopting the technology as it enters this phase.
Years to Mainstream Adoption	The time required for the innovation to reach the Plateau of Productivity.

Source: Gartner (July 2021)

Table 3: Benefit Ratings

Benefit Rating ↓	*Definition* ↓
Transformational	Enables new ways of doing business across industries that will result in major shifts in industry dynamics
High	Enables new ways of performing horizontal or vertical processes that will result in significantly increased revenue or cost savings for an enterprise
Moderate	Provides incremental improvements to established processes that will result in increased revenue or cost savings for an enterprise
Low	Slightly improves processes (for example, improved user experience) that will be difficult to translate into increased revenue or cost savings

Source: Gartner (July 2021)

Table 4: Maturity Levels

(Enlarged table in Appendix)

Maturity Levels	Status	Products/Vendors
Embryonic	In labs	None
Emerging	Commercialization by vendors Pilots and deployments by industry leaders	First generation High price Much customization
Adolescent	Maturing technology capabilities and process understanding Uptake beyond early adopters	Second generation Less customization
Early mainstream	Proven technology Vendors, technology and adoption rapidly evolving	Third generation More out-of-box methodologies
Mature mainstream	Robust technology Not much evolution in vendors or technology	Several dominant vendors
Legacy	Not appropriate for new developments Cost of migration constrains replacement	Maintenance revenue focus
Obsolete	Rarely used	Used/resale market only

Source: Gartner (July 2021)

Evidence

[1] For more on pace layering, see What Is Gartner's Pace-Layered Application Strategy and Why Should You Use It?

Document Revision History

Hype Cycle for Oil and Gas, 2019 - 6 August 2019

Hype Cycle for Oil and Gas, 2018 - 2 August 2018

Hype Cycle for Oil and Gas Technologies, 2017 - 8 August 2017

Hype Cycle for Upstream Oil and Gas Technologies, 2016 - 21 July 2016

Hype Cycle for Upstream Oil and Gas Technologies, 2015 - 4 August 2015

Hype Cycle for Upstream Oil and Gas Technologies, 2014 - 28 July 2014

Recommended by the Authors

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2021 CIO Agenda: An Oil and Gas Perspective

How Energy Executives Can Get Ahead of Environmental Risks With Strong Greenhouse Gas Commitments

What Is Gartner's Pace-Layered Application Strategy and Why Should You Use It?

Table 1: Priority Matrix for Oil and Gas, 2021

Benefit ↓	*Years to Mainstream Adoption*			
	Less Than 2 Years ↓	***2 - 5 Years*** ↓	***5 - 10 Years*** ↓	***More Than 10 Years*** ↓
Transformational	Adaptive Portfolio Governance	AI Bots in Oil and Gas Digital Twins in Oil and Gas Edge Computing Human-Centered AI Machine Learning Open Subsurface Data Universe	IoT in Oil and Gas Physics-Informed AI Real-Time Remote Operations	Algorithmic Advanced Trading
High	Design Thinking	AR/VR in Oil and Gas Cybersecurity Performance Management Drones in Oil and Gas Geospatial Platform Hybrid Cloud Computing Hyperautomation Managed IoT Connectivity Mobility in Oil and Gas OT Security Upstream Modeling Suites	Asset Performance Management Autonomous Contact Robots in Oil and Gas Autonomous Underwater Vehicles in Oil and Gas Blockchain in Oil and Gas Data Literacy Event-Driven Architecture Integrated Planning and Operations IT/OT/ET Alignment	

Benefit ↓	*Years to Mainstream Adoption*			
	Less Than 2 Years ↓	***2 - 5 Years*** ↓	***5 - 10 Years*** ↓	***More Than 10 Years*** ↓
Moderate		API Management PaaS Data Lakes Petroleum Economic Solutions Portfolio Management Solutions	3D Printing in Oil and Gas Asset Investment Planning Operational Device Management	
Low				

Source: Gartner (July 2021)

Table 2: Hype Cycle Phases

Phase	*Definition*
Innovation Trigger	A breakthrough, public demonstration, product launch or other event generates significant media and industry interest.
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