Gartner Research

Hype Cycle for Oil and Gas, 2023

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Initiatives: Energy and Utilities Digital Transformation and Innovation; Energy and Utilities Technology Optimization and Modernization

Digital innovation at scale is essential to developing resiliency and surviving market volatility, fragmented geopolitics and energy transition. CIOs can use this Hype Cycle to understand which technologies to focus on in order to align their investments with strategic business goals.

More on This Topic
This is part of an in-depth collection of research. See the collection:

- 2023 Hype Cycles: Deglobalization, AI at the Cusp and Operational Sustainability

Analysis

What You Need to Know

All sectors of oil and gas are rapidly pivoting their business strategy. Some pivots emphasize environmental performance — for example, upstream methane reduction, refinery conversion to biofuels, or new revenue from renewable power. Others focus on creating agility to sustain traditional hydrocarbon margins under future market conditions. Companies see digital investment as critical to achieving their goals.

There are plenty of options and a wide array of emerging technologies to choose from. High industry profits in 2022 have attracted new vendors. Unfortunately, technology selection in today's environment is tricky as every digital investment raises complex trade-off decisions. For example, how quickly should an organization invest in emerging technologies like generative AI? This research is a foundational tool that provides the essential information and insight required to connect the most interesting technology profiles with your strategic business objectives.

The Hype Cycle

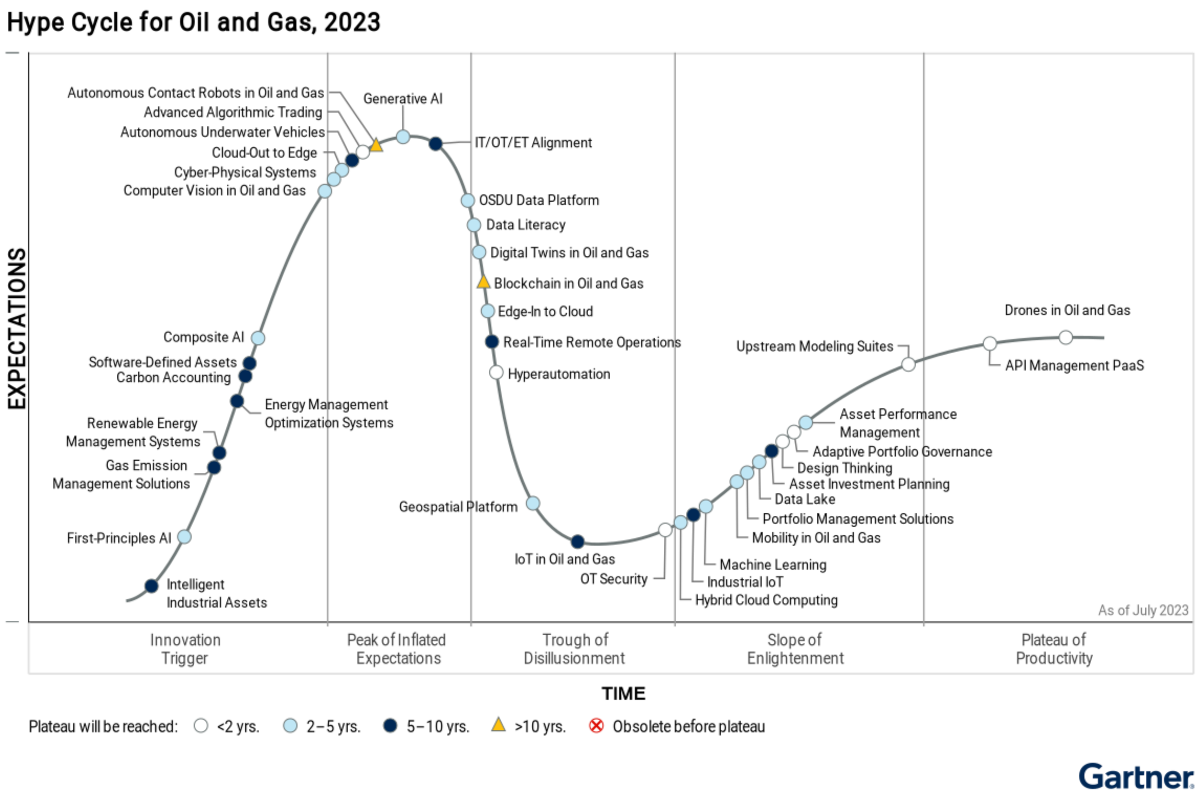
This Hype Cycle addresses the requirements of traditional oil and gas domains (for example, upstream, midstream and downstream), alternative energy markets (for example, offshore wind, hydrogen and carbon capture) and new adjacent service domains (for example, intelligent assets, emission management and energy management). Digital investments in these domains are being driven by the need for automation and integration, AI for operational optimization, and more agile environmental responses.

Our 2023 Hype Cycle is well-balanced, with important innovations positioned at all stages. Strategically essential technologies introduced in 2022 (such as gas emission management and renewable energy management) continue to climb toward the Peak. In 2023, a new, game-changing technology (intelligent industrial assets) joins them. Just over 38% of the technologies in the Hype Cycle are newly emerged and rising toward the Peak.

Concurrently, familiar innovations (such as edge computing, IT/OT integration, hyperautomation, and data management) continue making difficult, but steady progress in the Trough. Our latest analysis of these technologies balances the specific technical and nontechnical challenges each technology faces. Progress is being made despite challenges. In fact, over 35% of the technologies have cleared the Trough and are working toward full maturity. Success is difficult to achieve, but there has been steady advancement.

Gartner's 2023 CIO and Technology Executive Survey for Oil and Gas provides further evidence for solid progress, [1] but also shows worrying evidence of systemic underfunding of IT. If this trend continues, it may risk future progress, just as modernization becomes essential. To sustain momentum, companies must achieve strong payback on every technology investment. It is more critical than ever to have a clear and unbiased understanding of key digital technologies, the capabilities they enable, and the implementation risks they carry. CIOs can use this research to guide their strategy.

Figure 1: Hype Cycle for Oil and Gas, 2023



The Priority Matrix

Following many years of steady progress, eight technologies (21%) are nearing full maturity and are expected to mature within two years (including upstream modeling suites, drones and adaptive portfolio governance) . With the oil and gas industry focusing on near-term impact, it is not surprising that 17 of the technologies (44%) in this Hype Cycle are anticipated to mature within the next two to five years. A further 12 (31%) will mature in five to 10 years. Only two (5%) will require more than 10 years to mature. This demonstrates the very fast pace of development.

The industry is facing pressure from multiple disruptive forces (for example, decarbonization, energy transition, inflation, demand uncertainty and future hypercompetition). It must now rapidly deliver maximum impact from digital investments (see Research Roundup: Top Digital Trends Shaping the Oil and Gas Industry in 2023). AI, intelligent industrial assets and enterprise data management are the foundations that enable other transformational technologies. This Hype Cycle shows that progress is in line with these high expectations — 34 of the technologies (87%) will deliver transformational or high impact. The five technologies (13%) offering moderate benefits are essential components required to enable the others.

Table 1: Priority Matrix for Oil and Gas, 2023

(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 Hyperautomation	Composite AI Cyber-Physical Systems Data Literacy Digital Twins in Oil and Gas First-Principles AI Generative AI Machine Learning OSDU Data Platform	Intelligent Industrial Assets IoT in Oil and Gas Real-Time Remote Operations Renewable Energy Management Systems	
High	Design Thinking Drones in Oil and Gas OT Security Upstream Modeling Suites	Asset Performance Management Cloud-Out to Edge Computer Vision in Oil and Gas Edge-In to Cloud Geospatial Platform Hybrid Cloud Computing Mobility in Oil and Gas	Autonomous Underwater Vehicles in Oil and Gas Carbon Accounting Energy Management and Optimization Systems Gas Emission Management Solutions Industrial IoT IT/OT/ET Alignment Software-Defined Assets	Autonomous Contact Robots in Oil and Gas Blockchain in Oil and Gas
Moderate	API Management PaaS	Data Lake Portfolio Management Solutions	Asset Investment Planning	
Low	Advanced Algorithmic Trading			

Source: Gartner (July 2023)

Off the Hype Cycle

The industry continues to experience significant operational and business disruption. However, the technologies driving progress in this turbulent environment have remained remarkably stable. The following changes to the technologies contained in this research have been made since the 2022 Hype Cycle for Oil and Gas:

- **Cyber-physical systems** has overtaken and replaced **cybersecurity performance management.** Oil and gas companies conduct their business using large, complex and loosely connected business assets (such as offshore platforms, refineries, liquefied natural gas [LNG] trains and pipelines). This change reflects the growing connectivity between the computer systems controlling these assets and the IT systems enabling all other operations. Companies are expanding interoperability to improve operational transparency, broaden optimization and strengthen risk mitigation across their entire business footprint. Addressing the risk issues of software (cyber) and plants and equipment (physical) is increasingly crucial.
- **Industrial Internet of Things (IoT)** has replaced **managed IoT connectivity** to provide a broader and more relevant perspective covering IoT in manufacturing and other asset-intensive industries. Understanding developments in these markets is becoming more important for those responsible for digital in oil and gas as there is growing overlap in functionality and vendor solutions across industry domains. This Hype Cycle retains the technology of **IoT in oil and gas,** as it provides an industry-centric perspective on development in industrial IoT. Collectively, these technologies provide greater visibility into the IoT overlaps and differences across industry domains.
- **Intelligent industrial assets** has replaced **operational device management** as business ambitions for stronger operational technologies have grown substantially over the past year. This change recognizes a shift in emphasis from infrastructure-level management to more expansive enterprise-level impact for operational technologies.
- **Generative AI** has replaced **event-driven architecture** to reflect a very recent emerging trend that has the potential to reshape AI strategies across the industry. As above, this reflects a shift from infrastructure-level focus to enterprise performance optimization.
- **Computer vision** has replaced **AI bots** as it has grown into a very popular use case for custom algorithm developments. The majority of other AI bots are covered within the remaining AI technologies.

On the Rise

Intelligent Industrial Assets

Analysis By: Rich McAvey, Lloyd Jones

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Gartner defines intelligent industrial assets (IAAs) as those with fully accessible and compatible datasets that support lean, automated and end-to-end processes that simultaneously optimize operations, engineering, maintenance, planning and economic performance for current market conditions.

Why This Is Important

Long-lived physical business assets, such as offshore rigs, refineries, pipelines, powerlines and generators, are the foundation for value in asset-intensive energy systems. Never-ending market turbulence and the demands of the energy transition mean new assets need fit-for-the-future designs that can be changed remotely through reconfiguration and orchestration. Intelligent assets can respond to changes in the external environment by intelligently coordinating to modify operations.

Business Impact

IIAs are strategic focal points that shape future digital investments. Future profitability relies on asset intelligence to drive four capabilities:

- Solving multiple objectives simultaneously
- Responding rapidly and without loss of efficiency
- Ultra-low-cost operations
- Full asset life cycle optimization

While the business impact will be transformational, it will take sustained effort over the coming years.

Drivers

- Commodity markets remain volatile, but companies are managing cash flows tightly and are generating profits. The near-term outlook is for a period of healthy cash flow that will support continued investment in oil and gas assets as well as alternative energy assets, such as renewable power and hydrogen. As energy markets continue to change faster than business asset designs, energy companies must employ IIA designs.
- Game-changing digital investment opportunities have come into focus. Virtually all energy companies have formal digital strategies and technology roadmaps. The situation is evolving very rapidly and most CIOs are supporting multiple digital investments at multiple levels.
- Technology markets have matured, enabling cheaper and faster change. Improvements made to connectivity, enterprise data management and edge computing have strengthened the digital foundations upon which new energy assets operate. These advances in digitalization have built organizational confidence in the potential of advanced technology and at the same time, narrowed the time frame to achieve the design and construction of intelligent assets.
- Business confidence in digital innovation is strong. The technology products and services available from vendors have also been rapidly evolving over the last few years. Today's digital environment is shifting toward modular and composable components of hardware, software, cloud/edge, SaaS and PaaS that can be easily integrated and reconfigured. This shift has greatly reduced the commitment needed to design and construct the basic building blocks of IIAs.
- Environmental priorities are reshaping digital ones. Companies can no longer afford to take a wait-and-see approach to the energy transition. Transitioning to net zero requires energy assets capable of balancing their emission implications simultaneously with other business objectives, such as reliability, safety and financial performance.

Obstacles

- Near-term priorities are confusing. Rapid demand volatility, supply chain disruption, inflation, geopolitical crises, and decarbonization mandates are affecting energy markets. Governments and companies are focusing on energy availability and security, driving policy and investment decisions.

- Longer-term priorities are also confusing. Energy companies are entering an era where business models and operating models will be reconstructed. Achieving ubiquitous, affordable, available and acceptable energy provision in these conditions will require advances and innovation across a wide range of energy technologies.

- Digital foundations are weak. The digital environment at most energy companies is dominated by commercial off-the-shelf (COTS) software that is narrowly scoped, hard to integrate and expensive to sustain. Although new digital solutions have shifted toward modular and composable components, these architectures represent too small a fraction of energy company digital foundations.

User Recommendations

- Start now to lead the transition to IIA designs and make progress while market conditions remain favorable. Conceptualize, sponsor and fund a minimum viable product program for developing intelligent asset designs and roadmaps.

- Consider hosting competitions to build engagement and creativity. Empower self-actualized teams to develop innovative and practical advances toward intelligent assets and motivate engagement with social recognition.

- Assign department leaders to work with like-minded colleagues to develop goals, strategies and early solutions for intelligent assets and operations, and to ensure orchestrated action across the company. Identify the key challenges blocking progress, then develop workaround solutions.

Gartner Recommended Reading

Quick Answer: What Are Intelligent Assets and Why Are They Important?

6 Top Practices for Winning the Race Toward Intelligent Assets

2023 Oil & Gas Trend: Preparing for Intelligent Operations

First-Principles AI

Analysis By: Erick Brethenoux, Svetlana Sicular

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

First-principles AI (FPAI) (aka physics-informed AI) incorporates physical and analog principles, governing laws and domain knowledge into AI models. In contrast, 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. FPAI extends AI engineering to complex system engineering and model-based systems (like agent-based systems).

Why This Is Important

As AI expands in engineering and scientific use cases, it needs a stronger ability to model problems and better represent their context. Digital-only AI solutions cannot generalize well enough beyond training, limiting their adaptability. FPAI instills a more reliable representation of the context and the physical reality, yielding more adaptive systems. A better ability to abstract leads to reduced training time, improved data efficiency, better generalization and greater physical consistency.

Business Impact

Physically consistent and scientifically sound AI models can significantly improve applicability, especially in engineering use cases (using IoT data). FPAI helps train models with fewer data points and accelerates the training process, helping models converge faster to optimal solutions. It improves the generalizability of models to make reliable predictions for unseen scenarios, including applicability to nonstationary systems, as well as enhances transparency and interpretability to make models more trustworthy.

Drivers

- **FPAI approaches instill a more flexible representation of the context and conditions in which systems operate, allowing software developers to build more adaptive systems.** Traditional business modeling approaches have been brittle. This is because the digital building blocks making up solutions cannot generalize well enough beyond their initial training data, therefore limiting the adaptability of those solutions.

- **FPAI approaches provide additional physical knowledge representations, such as partial differential equations to guide or bound AI models.** Traditional AI techniques, particularly in the machine learning family, have been confronted with severe limitations — especially for causality and dependency analysis, admissible values, context flexibility and memory retention mechanisms. Asset-centric industries have already started leveraging FPAI in physical prototyping, predictive maintenance or composite materials analysis, in conjunction with augmented reality implementations.

- **Complex systems like climate models, large-scale digital twins and complex health science problems are particularly challenging to model.** Composite AI approaches provide more concrete answers and manageable solutions to these problems, but their engineering remains a significant challenge. FPAI provides more immediate answers to these problems.

- **First principles knowledge simplify and enrich AI approaches** by defining problem and solution boundaries, reducing the scope of traditionally brute force approach employed by ML; for example, known trajectories of physical objects simplify AI-enabled sky monitoring. First-principles-based semantics reveal deepfakes.

- **The need for more robust and adaptable business simulation systems will also promote the adoption of FPAI approaches.** With a better range of context modelization and more accurate knowledge representation 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 FPAI capabilities.
- Computationally, the scaling of the training, testing and deployment of complex FPAI models on large datasets in an efficient manner will also be an issue.
- Resourcewise, collaboration across many diverse communities (physicists, mathematicians, computer scientists, statisticians, AI experts and domain scientists) will also be a challenge.
- Brute force approach is prevalent in AI, and is easy to implement for data scientists, while first principles require additional fundamental knowledge of a subject, calling for a multidisciplinary team.

User Recommendations

- **Set realistic development objectives** by identifying errors that cannot be reduced and discrepancies that cannot be addressed, including data quality.
- **Encourage reproducible and verifiable models** starting with small-scoped problems; complex systems (in the scientific sense of the term) are generally good candidates for this approach.
- **Enforce standards for testing accuracy and physical consistency** for physics and first-principles-based models of the relevant domain, while characterizing sources of uncertainty.
- **Promote model-consistent training** for FPAI 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 and boundary conditions and scenarios.
- **Ensure relevant roles and education** in a multidisciplinary AI team (with domain expertise), so the team can develop the most effective and verifiable solution.

Sample Vendors

Abzu; IntelliSense.io; MathWorks; NNAISENSE; NVIDIA

Gartner Recommended Reading

Innovation Insight: AI Simulation

Innovation Insight for Composite AI

Go Beyond Machine Learning and Leverage Other AI Approaches

Innovation Insight: Causal AI

Predicts 2023: Simulation Combined With Advanced AI Techniques Will Drive Future AI Investments

Gas Emission Management Solutions

Analysis By: Rich McAvey

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Gas emission management solutions (GEMS) consolidate, integrate and coordinate management of Scope 1 and 2 greenhouse gas and other regulated emissions across the business footprint. GEMS augment other functional platforms to provide the unique capabilities required to monitor, account, analyze, plan, optimize, report and commercialize emissions. GEMS integrate with other operating solutions but do not include asset-based hardware, plant control systems or trading platforms.

Why This Is Important

Developing new environmental capabilities is an urgent priority for all energy companies, especially oil and gas operators. Customers, supply chain partners and governments are passionately searching for ways to balance energy-intensive lifestyles (especially for people rising out of poverty) and the environmental impact of greenhouse gas (GHG) emissions. Tensions will remain high as technical, regulatory and behavioral realities are keeping energy markets volatile for at least the next decade.

Business Impact

GEMS provide unique and essential capabilities that enable companies to:

- Accurately quantify operational emission levels.
- Integrate data from all sources into a standard dataset.
- Attribute emissions to operations, products and services.
- Optimize energy consumption and reduce wastage.
- Set emission targets and track progress toward ESG goals.
- Comply with all reporting requirements.
- Communicate emission data to customers and supply chains.
- Respond to changing ESG rules and regulations with agility.

Drivers

- Energy companies are broadening their portfolios to include new forms of energy, new environmental services and new energy management services. These require trustworthy reporting and management of Scope 1, 2 and 3 GHG emissions.
- Significant legal, regulatory and reputational significance is inherently attached to emissions reporting and management. To provide auditability, solutions must clearly document the validity of the data, analysis and decisions it supports.
- Data must be integrated and verified. Emissions data comes from all parts of an organization and can come in all forms of formats from spreadsheets, scanned documents, emails and databases.
- Organizations must be able to use the right emissions factor, based on activity, emitted gas, geographic locations and date. These factors enhance data collection and enable accurate emissions calculations throughout the organization. However, they will be phased out and replaced by measurements over time.
- Organizations must consolidate GHG emissions data from various sources to one central secure platform, to achieve robust, accurate calculations for various protocols and geographies for Scope 1 and 2 (and possibly Scope 3) emissions. The solution must be able to calculate and report to multiple standards and frameworks from a common data pool.

- Modeling is essential for evaluating optimal operating scenarios, developing a comprehensive sustainability strategy and creating tactical rules for consistent carbon footprint measurements and mitigation.
- Flexible reporting is required. The GEMS market evolution is defined by increasing pressure for sustainable environmental practices from governments, international bodies, regulatory agencies, environmental advocacy organizations, and energy company customers and investors. The time frame is shrinking as global energy transition investments are accelerating.
- Advanced analytics and visualization techniques will be used to monitor performance, develop insights and enable evidence-based decision making for GHG management. Application of business intelligence tools will enable dissection of GHG data and extraction of key findings to enable understanding of the underlying causes for positive or negative performance.
- GEMS must address cyber risks, both upfront and throughout the deployment, to effectively identify, manage and navigate cyberattack risks.

Obstacles

- Legacy emission management solutions in virtually all energy companies are overly specialized or too narrow and disjointed (e.g., custom-made, spreadsheet-based solutions).
- Emissions data is scattered throughout organizations in diverse formats with no common standards. Integrating this data is cumbersome, leaving insufficient time for analysis and decision making.
- Anticipating increased spending, a broad range of technology vendors are shifting their marketing campaigns and are announcing new products and services. New offerings range from highly beneficial tools to vaporware.
- The overall market for GEMS is currently immature, and vendors provide only partial solutions. For the next several years, energy companies must develop their own composite GEMS platforms.
- The energy industry is under intense and increasing pressure from governments, regulatory agencies, customers and investors to rapidly create functionality despite the weak vendor ecosystem.

User Recommendations

- Foster a mindset among all enterprise leaders that their gas emissions data, analysis and decisions will be closely scrutinized by external sources. Emissions data must be as accurate, trustworthy and timely as financial data to avoid exposure to potentially catastrophic risks.
- Establish specific objectives for emission management to be achieved in the next three to five years. Work through coalitions to communicate the goals and collaboratively work to achieve them.
- Focus immediate attention on establishing a minimum viable solution for the enterprise that meets the most urgent business and regulatory requirements. Keep costs low by leveraging existing operating, maintenance, engineering and business digital investments.
- Enable success by designing an enterprise data management strategy and architecture that is vendor-neutral, standard-agnostic, flexible and robust enough to provide reliable emissions visibility despite differing regulatory and business reporting standards.

Sample Vendors

Amazon Web Services (AWS); IBM; Microsoft; Salesforce; SAP; Sphera

Gartner Recommended Reading

2023 Oil & Gas Trend: Achieving Environmental Goals

Market Guide for Gas Emissions Management Solutions

Sustainability Opportunities for Oil and Gas Vendors: A Gartner Trend Insight Report

Renewable Energy Management Systems

Analysis By: Nicole Foust

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Renewable energy management systems (REMS) are emerging technologies designed to orchestrate and optimize renewable energy (RE) production and operations. Key functionalities include complex data collection, monitoring, managing and controlling asset operations by orchestrating RE sources, and optimizing their performance. REMS can dynamically reconfigure operational states across discrete assets, from unit to fleet level, across geographies and markets.

Why This Is Important

Renewable resources must dominate power producers' asset portfolios by providing 70% of world energy supply in 2050. However, RE owners/operators find it difficult to operate current fleets with legacy siloed information technology/operational technology (IT/OT) systems. Energy companies that own and/or operate large-scale renewable energy assets can use REMS to better orchestrate and optimize RE production and operations.

Business Impact

RE asset owners/operators will need to prepare for dynamic real-time event-driven business operations and maintenance, by establishing business capabilities and performance levels of RE assets. This will improve operational decisions and production coordination. Energy companies have opportunities to unlock new capabilities through IT/OT alignment and integration to support business operations of large-scale renewable energy by coherent funding of REMS functionality on the RE strategic roadmap.

Drivers

- The International Energy Agency's (IEA's) Net Zero by 2050 scenario calls for the scaling up of solar and wind energy generation rapidly during this decade. The goal is a 500% increase in renewable energy resource capacity from almost 12%penetration in 2021 (see World Energy Outlook 2022, IEA).
- Renewable energy sources are expected to be cheaper to deploy and operate than coal and gas in most regions before 2030.
- Energy companies are now facing scalability changes, challenges and opportunities. Among these are climate change and the energy transition, which are interrelated and are driving industry adaptation pain, but also creating opportunities for untapped economic return.
- Organizations need to maximize energy production to bring down the cost of energy to remain relevant and competitive. Traditional energy capabilities will need to accelerate the scope and scale of the rollout and integration of large-scale renewable energy within their portfolios, across both asset and commodity life cycle.
- As the energy transition progresses and accelerates, REMS is an important tool to scale and optimize the mix of renewable sources in the grid, and to enable available, affordable, acceptable energy.
- Disruption at the grid edge and renewable energy assets are driving the need for grid modernization.

Obstacles

- A major challenge of power system operation and control is deployment of appropriate analytical tools to integrate and holistically manage the new technologies. This will account for system restructuring, while using existing resources optimally.
- RE owners/operators need a larger toolbox to enable asset management automation, including big data and predictive analytics, cloud computing, composable architecture, intelligent solutions, and system security.
- REMS require robust capabilities and data, which are supported by complementary and third-party tools. This often leads to integration complexity and business capability gaps.

User Recommendations

- Use strategic roadmaps to maximum effect and benefit to articulate current-state capabilities, gaps, and the future state, that will enable the organization to reach improved performance and outcomes.
- Optimize the value of a REMS by improving the digital footprint to gather, organize, integrate, store and analyze information across the enterprise.
- Industrialize business capabilities regardless of whether your organization is an existing or new RE generator. This will create the foundation to work across an ecosystem of partners to deliver the volume of renewable energy assets required to support the energy transition.
- Modernize the grid to mitigate potential disruptions at the grid edge and from renewable energy assets. Investments for electricity network resilience must be made via modeling simulation and directed operations. Therefore, modernizing energy data process capabilities in new IT/OT products with specific capabilities is essential.

Sample Vendors

BaxEnergy; CGI; Envision Digital; General Electric; Mahindra Teqo; Power Factors; SparkCognition

Gartner Recommended Reading

Quick Answer: What Functional Capabilities Can Extend the Value of a Renewable Energy Management System Platform?

Quick Answer: What Are the Corporate Renewable Energy Procurement Options in the Pathway to Net Zero?

The Impacts of Exponential Renewable Generation Growth Across the Energy Ecosystem

Energy Companies Must Transform Asset Life Cycle Capabilities to Drive New Business Value From Renewable Energy

Market Guide for Renewable Energy Management Solutions

Energy Management and Optimization Systems

Analysis By: Lauren Wheatley

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Energy management and optimization systems (EMOS) are modular platforms that allow commercial and industrial (C&I) customers to better manage their energy use. An EMOS combines a holistic view of the main energy consumption sources with advanced optimization capabilities to interact with automation systems and production goals. It consumes data from meters and sensors and communicates with an energy supplier, grid operator or market to orchestrate operational use cases.

Why This Is Important

Volatility in energy cost and supply is hurting business and driving inflation. Commercial and industrial (C&I) companies need to proactively mitigate immediate energy price and security concerns while still making meaningful progress toward emissions reduction goals, such as net zero. Managing energy costs will require C&I consumers to increase investment in energy management and optimization technologies.

Business Impact

C&I enterprises are prioritizing cost and environmental impact in their energy-related decision making and are looking to proactively control energy sourcing and consumption. This has resulted in growing markets for energy services by subscription. The move toward service-based models requires the rapid adoption of digitalized products by E&U companies such as offering EMOS capabilities to help customers conserve energy, save money, manage GHG emissions and comply with regulatory mandates.

Drivers

- C&I and community-entity energy customers are increasingly seeking greater control of their energy supply chains to control costs and build energy resiliency.
- There are growing markets for energy technology, energy services and energy-as-a-subscription services.
- Industrial digitalization is instrumenting the asset base, enabling EMOS platforms to proactively optimize energy loads.
- EMOSs require an ecosystem of partners, data, hardware and software that may be provided by multiple vendors. This gives energy company CIOs the opportunity to work with vendors to deploy a composable EMOS platform that aligns most closely with their energy and sustainability strategy.
- Increasing investments in smart grids and smart energy meters allows connection and coordination of all of an enterprise's equipment and devices, enabling continued advancement of EMOSs. By using IoT data and applying tools such as AI and predictive maintenance, EMOS products can provide intelligent operations capabilities, a strategy where physical systems are represented, configured and controlled by intelligent software.
- Volatility and rising energy prices mean that technologies, such as digital twins and AI to enable bidirectional coordination and automation that weren't financially feasible and lacked technical maturity just a few years ago, are now viable.
- The drive toward digital business is about rethinking what is possible, and for E&U companies, how their customers can engage with distributed energy resources in the future. This is particularly important where exponential innovation beyond the meter has delivered consumer energy technology and consequent grid parity, challenging existing energy supply assumptions creating new business models and new opportunities.

Obstacles

- C&I companies seek low-risk solutions that can be easily scaled with a limited management overhead and capital investment, allowing them to focus on critical business activities. However, EMOS system implementation and integration can require energy management expertise and a sophisticated understanding of the financial and risk implications of various purchasing options.
- When creating new business models and opportunities, be aware of the internal challenges faced by customers and align with C&I enterprises' priorities such that they can execute at a lower cost point and unlock additional opportunities.
- C&I business leaders do not trust the data they have to support ROI calculations, agree on priorities or support the digital solutions.
- While there is a myriad of vendors entering the market, many have limited capabilities focused predominantly on dashboarding and reporting rather than insights and energy optimization.

User Recommendations

- Prepare to support an energy services business by factoring EMOS functionality and solutions into deployment roadmaps.
- Invest early to enable commercial success by establishing energy consumption data and information management strategies that will support an energy services business that delivers cost reduction programs and environmental management goals to C&I enterprises. Establish a roadmap to consolidate enterprise real-time data by integrating IoT infrastructure from edge to cloud.
- Align business and digital strategies with changing C&I enterprise drivers. For years, E&U customer engagement focus has been on customer service while managing a narrow scope of commodity transactions, but during this era of transition, customer experience will define the breakout enterprise. CIOs must design customer experience/total experience (CX/TX) that is fit for purpose across the energy transition.

Sample Vendors

C3 AI; Dametis; Energy21; EnergyCAP; GE; Honeywell; IMS Evolve; METRON; Schneider Electric; Siemens

Gartner Recommended Reading

Market Guide for Energy Management and Optimization Systems

Quick Answer: How Electric Utility CIOs Can Respond to Changing Customer Expectations

2022 Sustainability Survey: Energy CIOs Can Help to Retain C&I Enterprises as Customers

Carbon Accounting

Analysis By: Rich McAvey

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

Carbon accounting is the process of reliably and transparently quantifying greenhouse gas (GHG) emissions to assess climate impact, set goals and implement mitigation strategies. It is framed around three scopes. Scope 1 emissions are from operations such as fuel combustion in facilities and vehicles. Scope 2 emissions are associated with purchased electricity, steam, heating and cooling. Scope 3 emissions are associated with upstream and downstream enterprise activities and products in use.

Why This Is Important

Carbon accounting provides the data needed for environmental goals, strategies and reporting. It enables trustworthy answers to the following questions:

- What is the total amount of GHG being emitted?
- What part of the business or value chain is responsible for these emissions?
- Where are the most significant GHG reduction opportunities?
- Is internal and external reporting in compliance with mandatory GHG standards?
- What investments will produce the largest impact?

Business Impact

Credible carbon accounting is essential for multiple strategic business priorities, including:

- Risk mitigation — Organizations accurately report progress and avoid penalties.
- Cost-saving — Lower emissions are correlated with lower energy consumption and lower costs.
- Talent recruitment and retention — Attract key worker groups, such as digital talent and millennials.
- Business resilience and growth — Decarbonization presents energy companies with both existential risks and global growth potential.

Drivers

- Energy companies require a single repository for aggregating emission data in a consistent, verifiable and auditable format.
- Governments, investors and businesses are seeking to demonstrate their commitment to decarbonization. Over 50% of the global economy has made a commitment to reaching net zero by 2050.
- Legacy solutions for tracking, managing and reporting carbon emissions are insufficient. Current carbon accounting practices rely on heroic efforts and are error-prone.
- Energy executives understand the implications of false emissions reporting, even if it occurs unintentionally. They require confidence in the data and auditability at every step in the process.
- Gas emission management solutions depend upon carbon accounting solutions for trustworthy information (see Market Guide for Gas Emissions Management Solutions).
- Environmental strategies require orchestrated action across multiple business units. Reliable metrics are essential to keeping multidepartmental programs aligned and focused on target outcomes.
- Self-reporting of carbon emission data will not suffice. Carbon accounting capabilities are critical withstanding intense external audits.
- Enterprises are under substantial pressure to increase transparency around climate-related performance and are using independent rating agencies to meet stakeholder expectations.

Obstacles

Like financial accounting, carbon accounting is complex. Many challenges must be overcome to successfully establish an enterprisewide solution:

- Inconsistent data — GHG data typically resides in multiple business units or in the value chain, each with different (or incomplete) standards. Gathering this data manually is cumbersome and error-prone.

- Complicated regulatory frameworks — Multiple sustainability reporting standards are independently established and viewed holistically and appear confusing and conflicting. Compounding the challenge are varying metrics, definitions and priorities.

- Weak vendor solutions — For energy companies, no market leaders are offering carbon accounting solutions that cover most carbon accounting requirements.

- Inaccurate reporting and analysis — Large, multinational energy companies often do not have established policies, standards or processes for accurately gathering, integrating and reporting emission data.

User Recommendations

- Enable success by leading the design of an enterprise carbon data model that is flexible and robust enough to provide reliable emissions visibility, despite differing regulatory and business reporting standards.

- Establish a mindset among all enterprise leaders that their gas emissions data, analysis and decisions will be closely scrutinized by external sources. Emissions data must be as accurate, trustworthy and timely as financial data to avoid exposure to potentially catastrophic risks.

- Establish a minimum viable carbon accounting solution for the enterprise that meets the most urgent business and regulatory requirements. Keep costs low by leveraging the existing operating, maintenance, engineering and business digital investments.

- Accelerate progress by partnering with carbon accounting vendors but require all participants to use composable IT architecture. Given the fluidity of this market, it is essential to maintain flexibility for future adaptations.

Sample Vendors

Amazon Web Services (AWS); IBM; Microsoft; Persefoni; Salesforce; SAP

Gartner Recommended Reading

2023 Oil & Gas Trend: Achieving Environmental Goals

Market Guide for Gas Emissions Management Solutions

Sustainability Opportunities for Oil and Gas Vendors: A Gartner Trend Insight Report

Software-Defined Assets

Analysis By: Lloyd Jones

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

A software-defined asset (SDA) encapsulates and virtualizes its hardware capabilities to manage its unique local constraints, by optimizing and modifying its capabilities, behaviors and/or states across control, automation, function and topology to meet global optimization goals. SDAs may orchestrate with other assets and/or systems to meet their assigned goals within a delegated decision envelope.

Why This Is Important

SDAs operationalize reactive and predictive analytics to control and operate cyber-physical systems (CPS). SDAs enable adaptive and orchestrated operations. SDAs dynamically change their control and automation patterns to achieve physical process goals with global optimizations such as lower production costs, and reduced defects or operator errors. SDAs are the building block that will open up machine-to-machine ecosystems across business boundaries.

Business Impact

CPSs need global and local optimizations. SDAs deliver the capabilities to meet a wide range of scheduling outcomes by coordinating CPS outcomes across asset classes and ecosystem participants. Intelligent operational practices across business boundaries will become common as SDAs optimize and orchestrate operations (and production), across operational and contractual envelopes. Orchestrated SDAs may optimize physical flow by changing topology and/or control and automation configurations.

Drivers

- Digital twin capabilities are maturing and have expanded beyond siloed use cases and are becoming truly composite, able to support a wide range of use cases across operations, asset management and performance optimizations.
- R&D developments are positioning distributed digital twins as edge capabilities.
- Intelligent operational practices are evolving away from setpoint optimization of a fixed process toward a dynamic reoptimization and even reconfiguration of an asset control loop.
- Distributed digital twins hosted on the edge with compute capabilities either at gateway and/or asset level, will become a critical lever — able to optimize exposed automation and control variables through software as operational contexts shift.
- Organizations are moving toward adopting intelligent operational practices by exploring AI and machine learning, to systematically orchestrate production (or operations) resources. Examples include distributed energy resources such as electric vehicles (EVs) and rooftop solar systems, and oil well control and coordination.

Representative industry applications:

- The energy transition is pushing utilities to become orchestrators of distributed resources (which are SDAs) owned by multiple participants. Utilities are stabilizing the grid by asking SDAs to orchestrate their operational envelopes to meet multiple and/or conflicting objectives. Use cases include smart chargers, smart thermostats, and solar PV.
- Oil and gas companies need to optimize vast collector networks assembled from discrete assets in remote locations that are hard to reach. These assets can become SDAs able to parallel and serialize their topologies to protect physical flows while enduring disruption, through local coordination and reconfiguration, to return to a preferred operating state, or seamlessly coordinate to align product delivery to market opportunity.

Obstacles

- Legal concerns around decision responsibility have so far constrained AI and edge AI deployment, leaving a person in the loop.
- The standards that will bring together the capabilities of industrial control systems, Industrial Internet of Things (IIoT) and digital twins to enable autonomous intelligent operations by the SDA are still in development.
- Examples of constraints that need to be resolved before operationalizing SDAs and their AI include authorizations, control, bounding, defining, testing, deploying, retiring, retesting and retraining.
- SDAs may not be delivered on a unified platform. In fact, we can expect that the design, deployment and even operation of SDAs will be composable, particularly for industry-specific use cases.
- Horizontal scale-out in some industry applications come with cyber-physical system security concerns.
- SDAs could be perceived as replacing field technicians, requiring human change management to resolve job displacement fears.

User Recommendations

- Invest in advanced analytics and digital twin competencies to help enable this transition.
- Accept that SDA capabilities will not be rolled out across all assets, but will be an essential precursor to intelligent assets. Over time SDAs will evolve into intelligent assets with no central supervision.
- Transition incrementally by investing in discrete digital twins for individual equipment classes one by one and invest in composite digital twins for individual operations one by one. Over time, this will expand your portfolio of capabilities to increasingly build out more resilient grid capabilities.
- Raise your demands of OEM suppliers by specifying digital services that encapsulate asset capabilities in a structured manner to support SDAs.
- Leverage the lessons learned in your own and other asset-intensive industries.

Gartner Recommended Reading

Research Roundup: Top 10 Trends Shaping the Utility Sector in 2023

Quick Answer: What Are Intelligent Assets and Why Are They Important?

Quick Answer: What Are the Digital Checkpoints to Achieve Intelligent Operations?

Composite AI

Analysis By: Erick Brethenoux, Pieter den Hamer

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

Composite AI refers to the combined application (or fusion) of different AI techniques to improve the efficiency of learning to broaden the level of knowledge representations. Composite AI broadens AI abstraction mechanisms and, ultimately, provides a platform to solve a wider range of business problems in a more effective manner.

Why This Is Important

Composite AI recognizes that no single AI technique is a silver bullet. Composite AI currently aims to combine “connectionist” AI approaches, like machine learning (ML) , with “symbolic” and other AI approaches, like rule-based reasoning, graph analysis or optimization techniques. The goal is to enable AI solutions that require less data and energy to learn, embodying more abstraction mechanisms. Composite AI is at the center of the generative AI and decision intelligence market emergence.

Business Impact

Composite AI offers two main benefits. First, it brings the power of AI to a broader group of organizations that do not have access to large amounts of historical or labeled data but possess significant human expertise. Second, it helps to expand the scope and quality of AI applications (that is, more types of reasoning challenges can be embedded) . Other benefits, depending on the techniques applied, include better interpretability and resilience and the support of augmented intelligence.

Drivers

- **ML-based AI techniques lead to insights that inform actions.** Additionally, the most appropriate actions can be further determined by combinations of rule-based and optimization models — a combination often referred to as prescriptive analytics.

- **Small datasets, or the limited availability of data, have pushed organizations to combine multiple AI techniques.** Where raw historical data has been more scarce, enterprises have started to complement it using additional AI techniques, such as knowledge graphs and generative adversarial networks (GANs), to generate synthetic data.

- **Combining AI techniques is much more effective than relying only on heuristics or a fully data-driven approach.** A heuristic or rule approach can be combined with a deep learning model (for example, predictive maintenance). Rules coming from human experts, or the application of physical/engineering model analysis, may specify that certain sensor readings indicate inefficient asset operations. This can be used as a feature to train a neural network to assess and predict the asset's health, also integrating causal AI capabilities.

- **Proliferation of computer vision and NLP solutions.** In computer vision, (deep) neural networks are used to identify or categorize people or objects in an image. This output can be used to enrich or generate a graph, representing the image entities and their relationships.

- **Agent-based modeling is the next wave of composite AI.** A composite AI solution can be composed of multiple agents, each representing an actor in the ecosystem. Combining these agents into a "swarm" enables the creation of common situation awareness, more global planning optimization, responsive scheduling and process resilience.

- **The acceleration of generative AI.** The advent of generative AI is accelerating the research and adoption of composite AI models (through artifacts, process and collaboration generations), which are the foundation of decision intelligence (DI) platforms.

Obstacles

- **Lack of awareness and skills in leveraging multiple AI methods.** This could prevent organizations from considering the techniques particularly suited to solving specific problem types.
- **Deploying ModelOps.** The ModelOps domain (i.e., the operationalization of multiple AI models, such as optimization models, rule models and graph models) remains an art much more than a science. A robust ModelOps approach will be necessary to efficiently govern composite AI environments and harmonize it with other disciplines, such as DevOps and DataOps.
- **Trust and risk barriers.** The AI engineering discipline is also starting to take shape, but only mature organizations have started to apply its benefits in operationalizing AI techniques. Security, ethical model behaviors, observability, model autonomy and change management practices will have to be addressed across the combined AI techniques.

User Recommendations

- **Identify projects in which a fully data-driven, ML-only approach is inefficient or ill-fitted.** For example, in cases when enough data is not available or when the pattern cannot be represented through current ML models.
- **Capture domain knowledge and human expertise** to provide context for data-driven insights by applying decision management with business rules and knowledge graphs, in conjunction with ML and/or causal models.
- **Combine the power of ML, image recognition or natural language processing with graph analytics** to add higher-level, symbolic and relational intelligence.
- **Extend the skills of ML experts, or recruit/upskill additional AI experts,** to also cover graph analytics, optimization or other techniques for composite AI. For rules and heuristics, consider knowledge engineering skills, as well as emerging skills such as prompt engineering.
- **Accelerate the development of DI projects** by encouraging experimentation with generative AI, which will in turn accelerate the deployment of composite AI solutions.

Sample Vendors

ACTICO; Aera Technology; FICO; Frontline Systems; IBM; Indico Data; Peak; SAS

Gartner Recommended Reading

How to Use Machine Learning, Business Rules and Optimization in Decision Management

Top Strategic Technology Trends for 2022: AI Engineering

Innovation Insight for Decision Intelligence

Innovation Insight for Decision Intelligence Platforms

How to Choose Your Best-Fit Decision Management Suite Vendor

At the Peak

Autonomous Underwater Vehicles in Oil and Gas

Analysis By: Simon Cushing

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Definition:

Autonomous underwater vehicles (AUVs) or "underwater drones" are the next generation of programmable and self-guiding remotely operated vehicles (ROVs). The oil and gas industry uses the term ROV to describe remote-controlled underwater vehicles for subsea facilities' construction, inspection and other tasks. 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. AUVs use advances in communication technologies and robotics to give greater autonomy, allowing systems to operate without tethering to surface vessels, remain on station longer, and perform more complex tasks including equipment operation and maintenance. AUVs can be monitored, programmed and controlled from onshore control rooms. They promise safer, more comprehensive and more cost-effective subsea operations.

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 can provide otherwise unachievable levels of awareness of subsea asset conditions 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

- AUVs' usage is predicted to increase in the next five years. One market analysis forecasts a compound annual growth rate (CAGR) of nearly 21% to 2029 (see AUV for Offshore Oil and Gas IRM Market Size, Fortune Business Insights).
- Subsea asset integrity is critical to production maintenance, environmental performance and major cost avoidance for upstream companies. AUVs can increasingly provide continuous, comprehensive surveillance, and basic maintenance, cost-effectively and with minimal intervention.
- To reduce capital and operating costs, many offshore facilities use subsea completion designs that allow wellheads to be tied back to host platforms many miles away. Underwater vehicles are critical in inspecting and maintaining these facilities.
- AUVs' use is not confined to offshore oil and gas installations. Any offshore construction can make use of them, and growing investment in offshore renewable generation by oil and gas companies will add momentum for use and development. The same is true of rising decommissioning requirements in aging offshore oil and gas provinces.
- Providers continue to advance AUV capabilities, reduce deployment costs and improve navigation. These advances also enable ROV piloting from remote control centers, as well as AUV subsea residency. Subsea resident drones conduct missions from subsea recharging stations or "garages."
- Pilot deployments of fully autonomous AUVs have grown and some larger oil and gas companies are investing significantly in R&D with provider partners. Fully commercial operational deployments are anticipated during 2023.
- AUVs are likely to become a key tool in the future technology platforms for operational control and optimization of offshore assets.

Obstacles

- Commercial AUVs have come to market; however, the technical challenges of environments where AUVs offer the most benefits (for example, deep water or long-term immersion) require continued R&D investment and extensive system development to enable widespread adoption.

- Security concerns may moderate AUV adoption. AUVs will patrol close to, and may work on, physical assets that are inaccessible to human operators. Some use novel communication methods. Users will need confidence that AUVs are protected from the risk of accident or malicious action endangering physical assets.
- AUV development will be incremental along a scale of increasing autonomy. The complexity, and initial marginal expense, of providing fully autonomous capability along with the need to manage risk in inaccessible subsea environments will moderate the pace of use.

User Recommendations

- Anticipate the 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.
- Track the development of AUV communications and data transfer technologies and standards, and ensure that platform development roadmaps include the ability to integrate AUV data, when required.

Sample Vendors

Boeing (Liquid Robotics); Lockheed Martin; Nauticus Robotics; Oceaneering International; Saipem; Teledyne Marine

Cloud-Out to Edge

Analysis By: Ed Anderson, Bob Gill

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Cloud-out to edge describes an architectural construct where a centrally managed cloud environment, typically a hyperscale cloud, provides cloud service capabilities that are extended to edge environments. In a cloud-out to edge architecture, the cloud control plane, including security, identity and access management, governance, operations, programming models and interfaces, and other control elements, originate in the cloud and are then instantiated at the edge.

Why This Is Important

The move to public cloud drives centralization of operating processes, including the controls used to govern the environments. Cloud-out to edge is an architectural construct that supports the extension of public cloud control models to edge environments. Cloud-out to edge complements edge-in to cloud models. Cloud-out to edge is popular when organizations standardize IT operational control through centralized, public cloud environments.

Business Impact

IT environments are growing in complexity due to the expanding cloud use cases creating complexity, operational risks, and increased costs. Cloud-out to edge models extend cloud capabilities, including the cloud control plane, to other environments, including systems operating at the edge. Extending public cloud capabilities to edge environments can be a means to address the complexities of distributed, hybrid environments by unifying IT operations under a common operational framework.

Drivers

- Adoption of hyperscale public cloud services continues to increase. Gartner predicts continued growth in public cloud adoption with IT spending rates on public cloud services expected to grow almost 20% through 2027.
- Cloud operations have become critical for most organizations, driving increased investment in tools and skills in cloud management practices.
- Centralized, hyperscale cloud services are not well-suited for all application scenarios, particularly those better-suited to run at the edge. This creates an architectural divide between cloud and edge, which impacts operations, programming interfaces, security, identity and access, and application compatibility.
- Enterprise digitalization trends increasingly involve use cases and processes that operate in a distributed manner, driving the need for services deployed at edge locations.
- Distributed architectures, including edge computing and distributed cloud, can benefit from the distribution of cloud services from centralized environments to edge. Cloud-out to edge models can extend the cloud control plane to provide management, governance and oversight to edge environments.
- Standardizing technologies around cloud technologies and unifying operations using the cloud control plane can reduce complexity and help manage costs.

Obstacles

- Cloud-out to edge assumes a centralized cloud system, which may not exist in organizations that are still maturing their cloud strategy.
- Cloud-out to edge assumes the standardization of architecture, technologies and operational control using a centralized cloud service. This approach can increase dependence on a single cloud provider.
- Cloud-out to edge implementations may intersect with existing edge services, including operational technology, which may be managed outside the IT domain and funded by non-IT budgets.
- Multicloud strategies, which are common with most organizations, may conflict with the cloud-out to edge approach. Cloud-out to edge typically drives unification of technology, architecture and control to a single cloud environment, which may conflict with an organization's desired multicloud approach.
- Cloud provider offerings purported to support cloud-out to edge implementations are still maturing, and often don't deliver the full benefits of distributed cloud approaches.

User Recommendations

- Focus on the needs of use cases operating at the edge to determine whether an edge-in to cloud or a cloud-out to edge approach will work best.
- Establish a comprehensive cloud and edge strategy to guide cloud-out to edge and edge-in to cloud implementations. Let business value and operational benefits lead cloud and edge decisions.
- Build strong, centralized cloud operating capabilities before pursuing cloud-out to edge strategies. Cloud competencies will be critical to achieving success in cloud-out to edge implementations.
- Assess the risks and benefits of a cloud-out to edge approach, particularly if you have a stated multicloud strategy.
- Seek expert help from system integrators and managed service providers with expertise in both cloud and edge environments.

Sample Vendors

Alibaba Cloud; Amazon Web Services; Google; IBM; Microsoft; Oracle; VMware

Gartner Recommended Reading

I&O Platforms Primer for 2023

Market Guide for Edge Computing

Quick Answer: How to Make the Right Choice Between Hyperconverged, Traditional and Distributed Cloud Infrastructure

Distributed Cloud: Does the Hype Live Up to Reality?

Emerging Tech: Hyperscale Edge Enables Integrated Edge Infrastructure and Platform Services

Computer Vision in Oil and Gas

Analysis By: Simon Cushing

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Computer vision (CV) is the process and technologies involved in capturing, processing, and analyzing real-world images and videos to allow machines to extract meaningful, contextual information from the physical world. CV in oil and gas is differentiated by use cases such as operations optimization, site surveillance, remote monitoring, and safety and security.

Why This Is Important

Oil and gas asset sites can be remote and unstaffed. Staffed assets are hazardous, and have a finite set of measuring devices that acquire operating data. Computer vision incorporating AI/machine learning (ML) automates identification of important conditions from image data, providing expanded and continuous coverage of asset and people's status, without the need for human interpretation or site visits. It can also provide a low-cost way to digitalize basic legacy assets by reading analog instruments.

Business Impact

CV can continuously monitor sites or targets and automatically alert operators to events or conditions of interest. In advanced applications, it can also interpret conditions and recommend actions. Cost, safety and the need to better leverage expertise drive oil and gas companies to reduce staffing in the field and on the asset. CV enhances and expands situational awareness, providing improved safety, asset integrity, operational performance and site security, with relatively low complexity and cost.

Drivers

- Reduced or eliminated human presence at oil and gas facilities is a long-standing oil and gas company goal, for reasons of cost and safety. Similarly, operational optimization, asset reliability, access to expertise and cost reduction imperatives drive adoption of remote operations solutions and automation.
- Image data is widely acquired in oil and gas operations today. Remote monitoring of surface and subsurface locations and facilities with CCTV is well-established. Drones, autonomous underwater vehicles (AUVs) and robots routinely carry cameras for inspection and surveillance.
- CV can also be applied using low-cost, IoT-enabled cameras to augment data from existing sensors, and avoid the need for wired cameras or CCTV installations. Existing asset control and monitoring systems do not need to be modified or disturbed.
- Advances in machine learning methods and applicable hardware, and a growing range of provider options, are enhancing CV capability. CV hardware and systems' costs are decreasing. CV that supports operations automation is likely to be a feature of future oil and gas intelligent assets.
- The range of use cases in the industry is expanding. This includes site surveillance and interference detection; workforce safety and productivity monitoring; personal protective equipment compliance; driver safety monitoring; corrosion monitoring; leak, emissions and flare detection; drill bit wear evaluation; rig floor state analysis; artificial lift optimization; and others.
- CV is not confined to oil and gas assets. Users are exploiting the value of CV-based automated image feature identification in geological, geophysical and remote-sensing workflows, as well as engineering documentation classification and other non-asset-centric use cases.
- The trend toward expansion of edge computing deployment may boost the value of on-site CV, even removing the need for a permanent connection to enterprise networks.

Obstacles

- The CV market lacks standardization or open interfaces, making integration with other data pipelines difficult and impeding ability to scale beyond point solutions.
- Variability in real-world conditions means CV algorithms need careful development, appropriate training data and thorough testing to be robust outside the lab. Mission- or safety-critical use cases may need independent verification or carry unacceptable risk.
- Monitoring employees or on-site personnel may infringe workplace or privacy regulation or legislation.
- CV value in many cases depends on backhauling data to where the AI models can consume it, and where human operators can take action when needed. Lack of bandwidth (or power) at remote sites and/or transmission latency would raise the requirement for improved comms or energy infrastructure, and undermine the value for some locations.
- For many applications, ruggedized and intrinsically safe on-site hardware is needed, ruling out some use cases. High-end systems can be expensive to maintain, increasing the cost significantly and undermining ROI.

User Recommendations

- Exploit third-party CV systems, platforms and services to ease data preparation and integration, and reduce costs. Prioritize data and system integration criteria in partner selection.
- Develop computer-vision-specific expertise and competencies in data science and analytics teams. Leverage existing image and video data assets to experiment, test skills, and identify innovation opportunities. CV competency will enable informed procurement choice of third-party tooling.
- Investigate the legal, regulatory, operational and reputational risks associated with any CV project, before and during significant development effort.
- Ensure systems are thoroughly tested under real-world conditions before releasing for full operational use.

Sample Vendors

Agora; CleanConnect; CoVar; Osperity; Roboflow

Gartner Recommended Reading

Improve Computer Vision Use Cases With Standardized Implementation Patterns

Cool Vendors in AI for Computer Vision

Cyber-Physical Systems

Analysis By: Katell Thielemann

Benefit Rating: Transformational

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Cyber-physical systems (CPS) are engineered systems that orchestrate sensing, computation, control, networking and analytics to interact with the physical world (including humans) . They control production and mission-critical assets, and underpin all critical infrastructure-related industries.

Why This Is Important

Whether deployed in smart grids, smart buildings or autonomous vehicles, CPS are core to manufacturing, industrial control systems (ICS) /supervisory control and data acquisition (SCADA) , operational technology (OT) , Internet of Things (IoT) , and industrial IoT deployments. They represent the confluence of physical and digital systems to connect people, products, data and processes. Deployments can use sensors, robotics, cloud services, analytics, machine learning and high-speed networks, to orchestrate data and physical processes in real time.

Business Impact

CPS orchestrate data flows and physical processes between previously disconnected systems, automate unstructured processes, shorten cycle times, and improve product and service quality. In industrial environments, CPS replace stand-alone production process control and automation, materials handling systems, and transactional workflow systems to process real-time information. They improve productivity, reduce costs, and enable value creation for all asset-intensive industries.

Drivers

- Customer or citizen demand for faster, cheaper, better and more products/services.
- New digital business models.
- Productivity and maintenance improvements.
- Labor cost reduction made possible by automation provided by robotic CPS.
- CPS-enabled operational excellence and enhanced operational data gathering.
- Improved situational awareness in operations or mission-critical environments.
- The need to keep up with the competitive landscape by automating as many processes as possible.

Obstacles

- Concerns over physical perimeter breaches, jamming, hacking, spoofing, tampering, or command intrusion must be addressed above and beyond cybersecurity considerations.
- Deployment-related obstacles include scale (potentially billions of devices are in scope), complex architectural requirements and design approaches from many disciplines involved, sense and control loops that must be designed to evolve with business needs, the need for significant computational resources, and a variety of sensory input/output devices.
- Many organizations increasingly have a mix of legacy and new systems with proprietary protocols, which creates interoperability challenges. While end users have been seeking better interoperability, common standards are still under development in many industries.
- Many devices lack storage and compute power to facilitate security mechanisms.
- Because CPS are usually highly automated, new skills are needed for operations, security and maintenance.

User Recommendations

- Determine the business value of CPS deployment by weighing benefits against cost, complexity and security.
- Promote the use of standards and interoperability recommendations to manage complexity, enable scalability and extensibility, and ensure focus on security and safety imperatives.
- Make sure that any deployment is negotiated with CPS OEMs to ensure upgrades can be easily incorporated. Emerging technologies, such as cloud computing and 5G, will greatly impact these systems.

Sample Vendors

Honeywell International; Johnson Controls; Medtronic; Siemens; Yokogawa

Gartner Recommended Reading

Predicts 2023: Cyber-Physical Systems Security — Beyond Asset Discovery

CPS Security Governance — Best Practices From the Front Lines

Innovation Insight for Cyber-Physical Systems Protection Platforms

Advanced Algorithmic Trading

Analysis By: Sruthi Nair

Benefit Rating: Low

Market Penetration: 1% to 5% of target audience

Maturity: Obsolete

Definition:

Advanced algorithmic trading tools assist energy companies in creating and executing trades using 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 clear rules set by traders. Energy trading has evolved and requires such capabilities to manage intraday trading (such as algorithmic and automated trading) .

Why This Is Important

Reduced fossil fuel dependency and the growth of renewables constantly shift demand and supply, 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 is ideal for human traders. Algorithmic trading platforms enable rapid testing, deployment and refinement of automated strategies, but come with new risks.

Business Impact

Advanced algorithmic trading primarily impacts the trading teams — front, middle and back office; risk; and supply chain teams. Existing energy trade and risk management platforms need to be significantly enhanced to allow algorithmic or automated trading. Alternatively, companies would need to invest in new platforms exclusively for this purpose.

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.
- Identifying spot changes and trends in various markets is increasingly necessary, concurrently combined with the requirements of unparalleled forecasting, trade information management, and balancing and settlement tools for intraday trading markets.
- Volatilities caused by oil and gas pricing and renewables require access to real-time market feeds to monitor product portfolios and 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.
- Deploying a stand-alone algorithmic trading platform will compound hindrances around cost and other implementation dependencies and, most importantly, adoption and acceptance by traders who are used to legacy trading platforms.
- While some energy companies still purchase stand-alone advanced algorithmic trading solutions, to manage volatility in power, Gartner marks advanced algorithmic trading as obsolete before plateau because most buyers are purchasing this functionality within energy trading and risk management systems, which are used by power utilities, instead of oil and gas companies.

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 to enhance 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 proofs of concept. 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

NODE Energy Services; Volue

Gartner Recommended Reading

Market Guide for Energy Trading and Risk Management Systems

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

Drivers

- Production efficiency, cost optimization, safety and environmental performance are key drivers for today's oil and gas companies. Operators pursue improved asset uptime and safely extended asset life at a lower, incremental cost.

- Fully implemented, unmanned operations may significantly reduce operating expenses and environmental impact 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 or pilot deployments of autonomous robots patrolling production facilities, and for specific use cases such as firefighting and inaccessible area inspection in explosive risk environments.

- Academic and commercial robotics research continues to advance, and the scope of use cases and available commercial solutions is expanding. For example, recent advances in legged robot performance show high potential for oil and gas use, and are being trialed.

- Collaboration between operators and academia (for example, in industry robotics initiatives, such as TotalEnergies' 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 and advances will be slow to scale. 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 considering 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.
- 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, factoring upgrade and investment into future budgets where necessary. Operational robots in oil and gas are being designed to use the cloud for noncritical processing and software updates can be done remotely.
- Check 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; Nexxis; Sonomatic; Taurob

Generative AI

Analysis By: Svetlana Sicular, Brian Burke

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Definition:

Generative AI technologies can generate new derived versions of content, strategies, designs and methods by learning from large repositories of original source content. Generative AI has profound business impacts, including on content discovery, creation, authenticity and regulations; automation of human work; and customer and employee experiences.

Why This Is Important

Generative AI exploration is accelerating, thanks to the popularity of Stable Diffusion, Midjourney, ChatGPT and large language models. End-user organizations in most industries aggressively experiment with generative AI. Technology vendors form generative AI groups to prioritize delivery of generative-AI-enabled applications and tools. Numerous startups have emerged in 2023 to innovate with generative AI, and we expect this to grow. Some governments are evaluating the impacts of generative AI and preparing to introduce regulations.

Business Impact

Most technology products and services will incorporate generative AI capabilities in the next 12 months, introducing conversational ways of creating and communicating with technologies, leading to their democratization. Generative AI will progress rapidly in industry verticals, scientific discovery and technology commercialization. Sadly, it will also become a security and societal threat when used for nefarious purposes. Responsible AI, trust and security will be necessary for safe exploitation of generative AI.

Drivers

- The hype around generative AI is accelerating. Currently, ChatGPT is the most hyped technology. It relies on generative foundation models, also called “transformers.”
- New foundation models and their new versions, sizes and capabilities are rapidly coming to market. Transformers keep making an impact on language, images, molecular design and computer code generation. They can combine concepts, attributes and styles, creating original images, video and art from a text description or translating audio to different voices and languages.
- Generative adversarial networks, variational autoencoders, autoregressive models and zero-/one-/few-shot learning have been rapidly improving generative modeling while reducing the need for training data.
- Machine learning (ML) and natural language processing platforms are adding generative AI capabilities for reusability of generative models, making them accessible to AI teams.
- Industry applications of generative AI are growing. In healthcare, generative AI creates medical images that depict disease development. In consumer goods, it generates catalogs. In e-commerce, it helps customers “try on” makeup and outfits. In manufacturing, quality inspection uses synthetic data. In semiconductors, generative AI accelerates chip design. Life sciences companies apply generative AI to speed up drug development. Generative AI helps innovate product development through digital twins. It helps create new materials targeting specific properties to optimize catalysts, agrochemicals, fragrances and flavors.
- Generative AI reaches creative work in marketing, design, music, architecture and content. Content creation and improvement in text, images, video and sound enable personalized copywriting, noise cancellation and visual effects in videoconferencing.
- Synthetic data draws enterprises’ attention by helping to augment scarce data, mitigate bias or preserve data privacy. It boosts the accuracy of brain tumor surgery.
- Generative AI will disrupt software coding. Combined with development automation techniques, it can automate up to 30% of the programmers’ work.

Obstacles

- Democratization of generative AI uncovers new ethical and societal concerns. Government regulations may hinder generative AI research. Governments are currently soliciting input on AI safety measures.
- Hallucinations, factual errors, bias, a black-box nature and inexperience with a full AI life cycle preclude the use of generative AI for critical use cases.
- Reproducing generative AI results and finding references for information produced by general-purpose LLMs will be challenging in the near term.
- Low awareness of generative AI among security professionals causes incidents that could undermine generative AI adoption.
- Some vendors will use generative AI terminology to sell subpar “generative AI” solutions.
- Generative AI can be used for many nefarious purposes. Full and accurate detection of generated content, such as deepfakes, will remain challenging or impossible.
- The compute resources for training large, general-purpose foundation models are heavy and not affordable to most enterprises.
- Sustainability concerns about high energy consumption for training generative models are rising.

User Recommendations

- Identify initial use cases where you can improve your solutions with generative AI by relying on purchased capabilities or partnering with specialists. Consult vendor roadmaps to avoid developing similar solutions in-house.
- Pilot ML-powered coding assistants, with an eye toward fast rollouts, to maximize developer productivity.
- Use synthetic data to accelerate the development cycle and lessen regulatory concerns.
- Quantify the advantages and limitations of generative AI. Supply generative AI guidelines, as it requires skills, funds and caution. Weigh technical capabilities with ethical factors. Beware of subpar offerings that exploit the current hype.
- Mitigate generative AI risks by working with legal, security and fraud experts. Technical, institutional and political interventions will be necessary to fight AI's adversarial impacts. Start with data security guidelines.
- Optimize the cost and efficiency of AI solutions by employing composite AI approaches to combine generative AI with other AI techniques.

Sample Vendors

Adobe; Amazon; Anthropic; Google; Grammarly; Hugging Face; Huma.AI; Microsoft; OpenAI; Schrödinger

Gartner Recommended Reading

Innovation Insight for Generative AI

Emerging Tech Roundup: ChatGPT Hype Fuels Urgency for Advancing Conversational AI and Generative AI

Emerging Tech: Venture Capital Growth Insights for Generative AI

Emerging Tech: Generative AI Needs Focus on Accuracy and Veracity to Ensure Widespread B2B Adoption

ChatGPT Research Highlights

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 is the coordination of information technology (IT), operational technology (OT), and engineering technology (ET) through shared standards and governance. Each plays a complementary role to the other two technologies. While IT records transactions and business processes, OT operates and monitors industrial assets, and ET is used to define, design, simulate, analyze, visualize and validate those assets (e.g., GIS, computer-aided design and manufacturing [CAD]/CAM]).

Why This Is Important

For asset-intensive industries, system interoperability is improved when OT, ET and IT systems and processes share infrastructure and planning. This also enhances the agility to change configurations to adapt to market demands, improve product quality and optimize productivity. As a result, organizations seek common architecture plans and standards for the technology acquired, and increasingly look for vendors that support this direction. Most companies are at least beginning this exercise.

Business Impact

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

- More efficient use of technology and support resources across IT, OT and ET investments.
- Easier sharing of data from design documents (ET) to operational systems (OT) and business administration, supporting digital threads and digital twins.
- Easier sharing of performance data from OT into the ET process for design and improvement.
- Consistent security and risk management across all technology.

Drivers

- Cost reduction by not duplicating licensing, maintenance and support for common software components.
- Cost optimization by consolidating via cloud, virtualization or colocating 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.
- Process and information sharing between domains driving collaboration and cross-pollination of practices and approaches, leading to effective management of digital threads.
- Easier access to ET and OT data for IT analysis such as digital twins, predictive maintenance and production optimization.
- Leveraging OT performance data in product development using ET systems.
- Designing of systems via ET that better cater to OT effectiveness, and future OT system support and data acquisition.

Obstacles

- Coordination between three domains is complex technically and politically. Different cultures and approaches of IT departments, manufacturing/operations and design/engineering need to be reconciled.
- There may be a possible temporary increase in cost on the OT or ET side initially, as technology investments are made to bring software up to the required IT standard/version and to deal with any license compliance gaps.
- The lack of common tools for software asset management (SAM) that caters for IT and OT technology makes centralized control difficult.
- The absence of short-term benefits in terms of cost avoidance make project approval more challenging.
- The entrenched separate positions and practices associated with OT and ET systems, and their criticality, safety and stability, means that realignment takes time.
- Aligning risk appetite and security requirements across three domains with different pedigrees increases the effort needed to identify and manage risk and security.

User Recommendations

- Get agreement on a change imperative, so you have a mandate for change.
- Establish a common governance model across the three domains.
- Evaluate 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 and secured by design.
- Incorporate OT and ET requirements in enterprise risk management by adopting an integrated security strategy across IT, OT, ET, physical security and cyber-physical systems (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 a responsible, accountable, consulted and informed (RACI) analysis to help manage this transition, and to map out organizational responsibilities for different parts of the technology environment.

Sample Vendors

Bentley Systems; Dassault Systèmes; PTC; Siemens

Gartner Recommended Reading

2022 Strategic Roadmap for IT/OT Alignment

What Should I Know About OT Security?

How IT Standards Can Be Applied to OT

Survey Analysis: IT/OT Alignment and Integration

When Does a CIO Need to Be Involved in OT?

OSDU Data Platform

Analysis By: Simon Cushing

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

OSDU Data Platform is an open-source, cloud-native data architecture for energy industry data, developed and released by the Open Group OSDU Forum. The stated mission of the OSDU Forum is to deliver an open-source, standards-based, technology-agnostic data platform for the energy industry that stimulates innovation, industrializes data management and reduces time to market for new solutions.

Why This Is Important

Seamlessly shared data and modeling tool interoperability could transform oil and gas upstream workflows, significantly shortening cycle times and increasing accuracy. Adopting a shared data architecture could significantly increase value from digital technology, and support high degrees of business and operating efficiency for energy businesses. The OSDU Data Platform aims to provide similar benefits to energy businesses, including renewables, carbon capture and storage, and oil and gas upstream operations.

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 are costly to acquire and maintain. An industry standard data architecture would solve these issues and reshape the market for modeling tools. Adopted by energy businesses beyond the subsurface, a shared data architecture would avoid these legacy problems from the outset, and allow greater efficiency and lower costs in business processes.

Drivers

- Upstream operating companies aspire to flexibly deploy their optimum choice of upstream modeling tools, maintain access to the knowledge held in past models and extract maximum value from legacy data, while minimizing data management cost and effort. With impetus from operating companies, periodic attempts have been made to establish industry standard data models with these aims.
- The OSDU Forum is an initiative aimed at achieving these capabilities with modern data architectures by using a provider-agnostic, cloud-native platform. Cloud adoption, and consequently public cloud, have risen widely in the industry.
- Since 2018, more than 200 active operator and provider organizations have collaborated under the umbrella of the Open Group OSDU Forum to develop an open-source standardized data architecture. The first production release, Mercury, was made available in early 2021. A number of major upstream modeling suite (UMS) vendors have contributed core architecture and data access code to the project.
- Leading UMS vendors have increased the openness of their solutions, offering open-source, API and application marketplaces. They have released products with OSDU compatibility. Smaller vendors are delivering native applications and data management tools to interact with the OSDU data platform. These developments point to acceptance of, and adjustment to, the principles and approaches with which OSDU is aligned in the provider ecosystem.
- OSDU is in operational use with some operators, though typical with a restricted scope. Some operators are including OSDU compatibility requirements in their data-related service requests to providers. AWS and Microsoft have launched OSDU-based industry targeted offerings.
- The current OSDU Data Platform release covers exploration and development data. Production and facilities data are slated for a release. Subsequent releases are designed to cover energy data.

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 small number of vendors, operating companies have not totally succeeded in reshaping vendor offerings around data sharing and interoperability requirements.
- OSDU development relies on coordination between, and resources from, varied participating organizations. As the scope, complexity, and maintenance requirements grow, development will become more challenging. This may moderate the pace of achievement of future ambition.
- Previous data standards efforts have been impeded by users' customization demands and real-world implementation complexity. To become widespread, the OSDU Data Platform will need to be robust, reliable, easily configurable and maintainable, and meet the varying requirements of individual companies, without undermining its function as a standard.

User Recommendations

Upstream operating companies and companies should:

- Engage with the initiative by joining the OSDU Forum, actively participate in its activities and contribute development or coordination resources.
- Conduct proof of concept and, if successful, pilot evaluation of the current release. Make 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 the initiative by joining the OSDU Forum and actively participate in its activities.

- Demonstrate a clear position to clients with respect to the OSDU Data Platform and for all other stances, rather 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.

Sliding into the Trough

Data Literacy

Analysis By: Alan D. Duncan, Donna Medeiros, Sally Parker

Benefit Rating: Transformational

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

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. Data-literate individuals have the ability to identify, understand, interpret and act upon data within business context and influence the resulting business value or outcomes.

Why This Is Important

Data and analytics (D&A) are pervasive in all aspects of businesses, communities and our personal lives. Thus, data literacy is foundational to the digital economy and society. It helps stakeholders:

- Draw a directlink between D&A and desired outcomes
- Unlock knowledge workers' business acumen
- Explain how to identify, access, integrate and manage datasets
- Draw insights relevant to specific use cases
- Describe advanced analytics techniques and enable AI
- Reduce risk through improved decision making

Business Impact

To become data-driven and equipped to use data and analytics to their competitive advantage, enterprises require explicit and lasting organizational change. Chief data and analytics officers (CDAOs) need to promote and orchestrate "leadership moments" where they act as role models, exemplifying new cultural traits at critical points. To be successful, they will need to guide the workforce by addressing both data literacy and data-driven culture.

Drivers

- The continued growth in digital transformation is amplifying a focus on D&A best practices. Employee data literacy is becoming increasingly recognized as an important factor in an organization's overall digital dexterity.
- The role of the D&A function has evolved. It is now at the core of an organization's business model and digital platforms, and with everyone being an information worker, the footprint of business use of data and analytics is broader than ever before.
- Effective D&A strategies require an increased focus on change management. Higher-performing CDAOs prioritize their emphasis, energy and effort on change management requirements, including data literacy.
- Defining what data-driven behaviors are expected — using a "from/to/because" approach — is central to employee development plans. It ensures that creators, consumers and intermediaries have the necessary D&A skills, knowledge and competencies.
- Data literacy is not a one-off project. CDAOs need to take immediate action to create and sustain data literacy through assessment of maturity, awareness, and education. Quick wins build momentum, but lasting and meaningful change takes time because it requires people to learn new skills and behave in new ways. (For example, there is a hunger for this type of skills development within Gen Z, especially in order to future-proof their careers.)

Obstacles

- Lack of common data literacy models/frameworks/standards and terminology.
- Varying interpretations of the term "data literacy" in terms of training, curriculum and understanding, ranging from enhanced data visualization skills to fostering business curiosity about data.
- Failure to measure contribution of data to business outcomes.

- A sporadic and inconsistent approach to training and certification.
- Not recognizing that data use is a behavioral change or change management initiative.
- Lack of talent and poor data literacy within the current workforce.
- Lack of initiatives to address cultural and data literacy challenges within strategies and programs.
- Overall adoption will still take years, due to the complexity of upskilling entire workforces.
- Data literacy is treated as a checkbox activity, especially when delegated to more junior (and unempowered) resources.
- Lack of a designated leader accountable for the development and execution of the program, roadmap and communication plan.

User Recommendations

- Make the business case for data literacy by identifying stakeholder outcomes and linking these to underlying learning needs.
- Designate a leader who will be accountable for developing and executing the roadmap.
- Foster data literacy during D&A requirements gathering by bringing data and business experts together around the problem to be solved.
- Call out examples of “good” and “bad” data literacy to promote desired behaviors.
- Nurture data literacy by rewarding stakeholders who recognize this as a factor for success and sharing their stories.
- Partner with HR and business leaders to incorporate data literacy learning outcomes into job descriptions, career paths and employee value proposition.
- Use data literacy assessments to evaluate current skill levels and desire to participate.
- Go beyond vendor product training to focus on people’s role- and industry-related D&A skills. Improve learning effectiveness by using a mix of training delivery methods (classroom, online, community, on the job).

Sample Vendors

Avado; The Center of Applied Data Science (CADS) ; Coursera; The Data Lodge; Data To The People; Pluralsight; Skillsoft; Udacity; Udemy

Gartner Recommended Reading

How CDAOs Must Lead Data Literacy and Data-Driven Culture

Address Both 'Skill' and 'Will' to Deliver Data-Driven Business Change

Drive Business Outcomes by Measuring the Value of Data Literacy

Tackle Data Literacy Head-On to Avoid Data and Analytics Program Failure

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

Digital Twins in Oil and Gas

Analysis By: Simon Cushing

Benefit Rating: Transformational

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Digital twins are virtual proxies that represent a real-world entity such as an object, person or process. They are created in software through design patterns that facilitate management and optimization of the entity 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 entity, data aggregation and continuity through the life of the entity.

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. More than 80% of oil and gas companies will have deployed digital twins within three years. These will be integral to the development of intelligent oil and gas assets.

Business Impact

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.
- **Visual integration:** 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.

Drivers

- 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.
- Digital twin enabling software is becoming more capable and the range of use cases is expanding. Operators can acquire a greater range of digital twin capability from commercially available platforms with established integration pathways.
- More complex and composite digital twins are emerging as a core component of the technology architectures for highly digitalized oil and gas assets. These types of digital twins provide integration of information and decision support to enable highly automated and remote operation of assets, while ensuring high efficiency, safety and environment performance.

Obstacles

- Oil and gas digital twin adoption has slowed. The 2023 Gartner CIO Survey reports that 37% of companies have deployed digital twins, or plan to do so within 12 months. This is up by only 3% from the previous year.
- Digital twin definitions and architectures are widely varied in the industry. Stakeholder conversation can bog down in different conceptions and slow progress.
- The digital twin design patterns and software for different use cases can differ considerably, making standardization and scaling difficult.
- Complex digital twins require significant investment and effort, and not all such implementations have achieved the expected value. Not every company is willing to accept the risk or prioritize this effort over other technology initiatives.
- 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.
- Manage risk by reducing 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

Ansys; AVEVA; Cognite; Dassault Systèmes; Emerson Electric; General Electric; Kongsberg Maritime; Microsoft; Siemens

Gartner Recommended Reading

2023 Oil & Gas Trend: Digital Twins Expansion

2023 CIO and Technology Executive Agenda: An Oil and Gas Perspective

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 network participants. 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. High interest applications include 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

While significant blockchain (or blockchain-inspired) solutions have been in operation for several years, the potential anticipated from distributed ledgers has yet to be realized. Blockchain offers industry leaders the opportunity to imagine new kinds of operating models and business strategies. Once created, these solutions offer participants immutable shared records where no organization can make unilateral changes. This immutable audit trail will ensure trust among participants.

Drivers

- Organizations want to pursue higher levels of automation through platforms that leverage blockchain capabilities for straight-through transaction processing. One example is the Blockchain for Energy consortium that is developing solutions collaborative across multiple companies (future chain members) and vendors (ongoing solution developers) .
- Provision of data provenance 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.
- Industry forums such as the Blockchain in Oil and Gas Conference are refining opportunities to create industry solution frameworks and guidelines, leveraging blockchain technology to reduce costs, improve timelines and eliminate disputes. In addition, the forums are building momentum among operators, service companies, engineering/procurement companies (EPCs) and industry stakeholders invested in transforming the future of oil and gas through blockchain technology.
- Multiple companies are developing smart contracts through prestigious industry organizations. Since smart contracts require no paperwork to process, waste no time reconciling errors and are fully transparent, they are seen as a promising tool for improving speed, efficiency and accuracy.

Obstacles

- While significant improvements have been made, establishing a minimum viable technical solution, establishing sensible commercial functionality and building sufficient community participation are complex endeavors that will take many for years to resolve.
- To be successful, most blockchain solutions must be adopted by a community of users in multiple organizations. When this involves a large number of small vendors, such as hauling services, the effort to gain their commitment to use the solution can be challenging.
- While awareness of blockchain is growing among business leaders, most oil and gas business executives don't understand it. 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.
- While blockchain data is cryptographically secured, it does not mean that the data is legitimate. Bad actors still have ways to compromise the security of blockchain applications and data without cracking the cryptography.

User Recommendations

- Begin the journey to create a multicompany 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, and 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

Amazon Web Services (AWS) ; AVEVA; BlockApps; Blockchain for Energy; Data Gumbo; GuildOne; Microsoft; Xpansiv

Gartner Recommended Reading

Emerging Tech Impact Radar: Blockchain and Web3

Guidance for Blockchain Assessments

Guidance for Blockchain Solution Adoption

Edge-In to Cloud

Analysis By: Bob Gill

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Edge-in to cloud describes an architecture where edge applications, servers and gateways make use of cloud-derived technologies and connect as needed to public cloud services — but they are deployed and can operate independently from the public cloud. Rather than using the programming models, or the IAM capability of a hyperscale cloud platform ("cloud out") , the application is centered around its role at the edge first, and its need for hyperscale cloud application services second.

Why This Is Important

Many edge solutions are designed to operate mostly independently of the cloud while maintaining connections as needed with one or more hyperscale cloud providers. These "edge-in to cloud" architectures leverage some cloud services, but use edge-specific functionality to support edge requirements, rather than pushing public cloud architecture to the edge as a complete platform. This is critical where cloud independence, multicloud core or predominantly "brownfield" infrastructures are present.

Business Impact

Making the decision whether to adopt a "cloud-out" or an "edge-in" model is fundamental to the set of services available, and the extensibility of the platform providing edge computing in the enterprise. This decision affects:

- Cloud independence
- Application and platform availability
- Technology stack availability
- Evaluations of whether an edge-centric approach may better align with a brownfield modernization effort

Drivers

- While the hyperscale cloud providers continue to grow their portfolio of cloud-to-edge solutions, enterprises report that such offerings are still functionally incomplete, not optimized for specific solutions, and poorly supported. Enterprise architects we speak to indicate that they want to avoid single-cloud vendor solutions and must reduce the chance for lock-in.
- Edge-centric approaches can provide solutions that are more tuned to edge requirements.
- They provide cloud independence for enterprises that are planning to be multicloud.
- They provide greater flexibility when dealing with legacy brownfield environments.
- They come with a greater likelihood of compatibility with existing vertically focused devices, application software and systems integrators.

Obstacles

- Edge-in architectures require implementation expertise beyond a normal IT skill set, leading to cost overruns and mistakes in implementation.
- The lack of “off the shelf” edge-in solutions is more likely to create a long-term dependence on a systems integrator or value-added reseller (VAR).
- Some edge-in platforms are generic and do not offer an application ecosystem, while others may be too focused on a specific vertical subset and the investment cannot be recouped across a range of use cases.
- Many edge-in platform vendors are early stage startups, providing increased risk due to inability to support projects at a very large scale. These vendors may lack the staying power to survive in a rapidly changing marketplace.
- Absence of common standards or frameworks for implementation will result in highly customized solutions that will be harder to extend or replace over time.

User Recommendations

- Use overall requirements to determine whether an application is ideally an edge extension of a cloud-based application, or an edge application that may use some cloud resources on the back end.
- Determine whether the edge and Internet of Things (IoT) portfolio will be used in conjunction with a single hyperscale cloud provider, or be multicloud.
- When adopting a newer edge-in platform, consider your need for long-term support and have a backup plan in place if your platform vendor does not thrive or is purchased by another vendor.
- Ensure architectural compatibility with your systems integrator (SI) or independent software vendor (ISV), as these solution- or vertical-specific providers deliver the actual business value of the effort.
- Ensure alignment with any edge-in or cloud-out preference they have.

Sample Vendors

LF Edge; Mirantis; Platform9; Rancher

Gartner Recommended Reading

Market Guide for Edge Computing

Hype Cycle for Edge Computing, 2022

Cool Vendors in Edge Computing

Infographic: Understanding Edge Computing

Real-Time Remote Operations

Analysis By: Simon Cushing

Benefit Rating: Transformational

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Real-time remote operations (RTRO) provide remote experts with oversight of on-site operations. 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) . ROCs are often purpose-built facilities in company offices, or consumed as a service from specialist multiclient providers.

Why This Is Important

Intermittent remote oversight and decision support of drilling and production operations in upstream oil and gas are mature and have been in use by some for decades. However, use of continuous real-time oversight is varied. Some companies have used it for many years, while others not at all. Most oil and gas companies are renewing efforts to reduce the size of field workforces to lower costs and improve efficiency, environmental performance and safety. RTRO offers these benefits along with improved operational transparency.

Business Impact

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

Drivers

- Advances in communications and technology, the advent of IoT, AI, ML, digital twins, wearable technologies, computer vision 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 an increasing range of operationalized solutions for field remote control and automation.
- The concepts, approaches and technologies of RTRO are being applied for a wider range of specific use cases (for example real-time drilling, real-time well reporting and real-time remote inspection).
- 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. Uptake of oilfield service company remote operations services is increasing.
- Newer, advanced remote control for offshore platforms are in planning and at the design stage and implemented on greenfield projects.

Obstacles

- The uniqueness of most oil and gas assets and their legacy systems environments means RTRO architectures are highly tailored.
- Consequently, RTRO systems need to replace legacy or integrate with operational technology (OT) systems. Vendors' solutions are increasingly open but broad adoption will be limited due to a lack of APIs and standards built into legacy technology.
- The cost and complexity of replacing or upgrading legacy infrastructures will also curtail the pace of development and mitigate against universal adoption. Many older facilities are unlikely to deploy RTRO even as it becomes routine elsewhere.
- Constrained investment in new facilities as oil and gas companies face geopolitical uncertainty and the energy transition may undermine the RTRO business case for companies who have not yet invested significantly.
- RTRO success is dependent on work practice and cultural change. For new adopters, failure to provide the necessary change management can undermine both the perceived and actual value of RTRO.

User Recommendations

IT's involvement becomes essential as the scope, complexity and level of integration of remote operations systems grow. 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 stakeholders, and vendor partners 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; Baker Hughes; Emerson Electric; Honeywell International; Rockwell Automation; Schneider Electric; Siemens

Hyperautomation

Analysis By: Frances Karamouzis, Keith Guttridge, Laurie Shotton, Saikat Ray

Benefit Rating: Transformational

Market Penetration: More than 50% of target audience

Maturity: Mature mainstream

Definition:

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

Why This Is Important

The primary reason that hyperautomation is critical is the unrelenting demand for accelerated growth through business model innovation or disruption, coupled with the underlying foundation of operational excellence across processes and functions. This is important as organizations continue to focus on business outcomes such as higher quality, more resilient processes, and higher usage due to employee- and customer-centric experiences, among others.

Business Impact

The most important business impacts are aligned to business outcomes such as cost optimization, growth, business agility or innovation. Hyperautomation initiatives are fluid enough to align to one or all of these outcomes. Examples of results may be better (higher quality, more resilient) business or IT processes, speed (time to market, cycle time reduction and quicker adoption) or intelligent (data-driven) decision making at scale.

Drivers

- The biggest driver of hyperautomation is funding from business units (as opposed to the IT budget). These business units continue to hire and fund initiatives driven by fusion teams and business technologists.
- The continued unabated spending on hyperautomation initiatives is forecast to exceed $1 trillion in 2023. This includes spending on products (software, platforms and tools) coupled with services spending on consulting, system integration and managed services.
- Additionally, there have been five successive years of capital investment of $1 billion or more in vendors that can be attributed to the various technology categories that enable hyperautomation initiatives.
- The increased investment has fueled the growth of offerings with expanded breadth and depth within the vast vendor landscape (both organic growth and through acquisitions).

Obstacles

- **Lack of measurement of quantifiable value:** Only a few organizations (estimated at less than 20%) have mastered the measurement of hyperautomation initiatives.
- **Lack of planning for total cost of ownership (TCO) or governance:** The explosion of funded hyperautomation initiatives, coupled with the need for speed, often leaves unaddressed the all-important planning for post-production-managed operations and governance structures.
- **“Siloed” approach:** The ubiquity of hyperautomation has led to an incredible volume and velocity of adoption across functions. Unfortunately, the concurrent nature across business functions has been executed via “siloed” or diffuse purchases of technology tools, solutions and platforms.
- **Technology confusion and overspend:** There is no single vendor or technology that will enable hyperautomation initiatives. Highly fragmented and overlapping technology markets have resulted in complex architectures, overspending and lack of enterprise orchestration.

User Recommendations

- Define shared ownership and metrics. Focus on regular intervals for measurement and updates. The leading organizations in the world ensure this involves finance to facilitate public reporting of success.
- Maximize the likelihood of successful hyperautomation initiatives by architecting and planning multiple concurrent initiatives. Demand holistic mapping of collective initiatives, rather than siloes within specific functions.
- Recognize that the technology is not trivial as there is no single vendor or technology that will enable hyperautomation initiative. Focus on modularity and discoverability in the design. Take an API-first approach.
- Ensure appropriate investment in vendor management and risk competencies due to the volume of services and technologies involved.
- Establish and curate an adaptive governance structure with the goal of managing risk, and driving operational resiliency and agility while optimizing TCO.

Sample Vendors

Automation Anywhere; Boomi; Celonis; Microsoft; OutSystems; SnapLogic

Gartner Recommended Reading

The Gartner 2023 Predictions: Hyperautomation (Inclusive of AI, RPA & Low Code)

The Executive Guide to Maximizing Hyperautomation

Future of Work Trends: Hyperautomation Growth Initiatives Delivered by High-Performance Fusion Teams

Geospatial Platform

Analysis By: Nicole Foust, Lloyd Jones

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Geospatial platforms are platform as a service (PaaS) and data as a service (DaaS) 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 are important items 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 expanding capabilities to manage and optimize spatial location data, which is essential for the optimization of an enterprise.

Business Impact

A geospatial platform will help asset-intensive organizations with a pace-layered strategy toward intelligent operations, deploying innovative applications that leverage time- and event-stamped locational transactions. Geographic information system (GIS) developers in IT organizations and “citizen developers” in business units can easily develop web and mobile applications that access geospatial services. Maps can be easily put to business use in an agile delivery model to improve transactional data quality and timing.

Drivers

- Organizations seek to capture the value of location to understand and engage customers, improve sustainability capabilities and initiatives (such as climate risk modeling), optimize supply chains and asset usage, develop and interact with a broader ecosystem, and improve operational efficiencies.
- Investments in the Internet of Things (IoT), cloud, analytics, edge capabilities and more, are driving greater adoption, broader utilization, and new use cases and services. In these investments, ecosystem partners are building capabilities to augment platform products and expand opportunities further.
- Geospatial platforms are foundationally a spatial information system of record. Core geospatial functions are expressed as web services, and interfaces are expressed as restful APIs and HTML5-based applications 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 expanding the geospatial platform footprint to 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

- Accessing data in legacy GIS can be difficult without the help of GIS analysts, and the cost of application development and maintenance can be substantial. The quality, storage and management of spatial data can be a challenge for many organizations. However, modern applications leverage geoprocessing workflow capabilities with low-cost, commercial data layers, satellite imagery, aerial photogrammetry and mobile GPS.
- Business and software silos are 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.
- Asset, network and field mobile applications, when integrated with geospatial and enterprise systems, can further improve operational capability, data quality and business performance.
- Supplementing a GIS with improved land-based data, aerial photography, location-based services and customer engagement applications can make GIS useful 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 mapped to specific business goals.
- 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.
- 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

Bentley Systems; CARTO; Esri; General Electric; Hexagon; QGIS; Supergeo Technologies; SuperMap Software; TatukGIS; Trimble

Gartner Recommended Reading

Market Guide for Geospatial Information Systems for Energy and Utilities

How Utility CIOs Can Unlock the Business Value of Geospatial Information Systems

Digital-Outcome-Driven Metrics for Utilities

Market Guide for Enterprise Asset Management Software

Research Roundup: Top 10 Trends Shaping the Utility Sector in 2023

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 and edge technology to communicate and sense/interact internally and/or with the external environment. IoT comprises an ecosystem of assets and products, communication protocols, applications, and data and analytics. In oil and gas (O&G) , IoT enables intelligent operations and is used to optimize cost, operations and assets, expand ecosystem participation, increase engagement and conserve resources.

Why This Is Important

IoT is essential to digital business transformation, intelligent operations and composable business initiatives as O&G companies navigate market volatility, geopolitical forces and the energy transition. O&G organization investments in IoT favor a business-operations-centric approach. IoT is transforming the entire value chain, affecting seismic data capture, modeling/analytics, workflow automation, renewables, services and retail/wholesale marketing and trading.

Business Impact

With more things connected, the information that IoT provides is transforming 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
- New service and capability opportunities: renewables, emissions management and carbon

Drivers

- Due to the broad scope of IoT applications in O&G and emerging developments in intelligent assets and operations the time to plateau remains at five to 10 years.
- IoT in O&G continues 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.
- IoT enables digital business and is a core building block of digital platforms.
- According to the O&G respondents to Gartner's 2023 Gartner CIO and Technology Executive Survey, IoT is one of the top 10 investment technologies, with 26% of respondents planning to spend more on it.
- Most if not all 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 due to 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 operational technology (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 COVID-19 pandemic, climate change concerns and the energy transition, contributes to IoT adoption.
- IoT enables the proliferation of digital twins and intelligent operations, and we expect this to continue driving the technology further along the Hype Cycle.

Obstacles

O&G CIOs and business leads should ensure due diligence in planning for initiatives in common challenge areas such as:

- 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 supervisory control and data acquisition.
- Proprietary technologies, deployed in custom-engineered solutions with limited interoperability, are expensive and difficult to secure.
- Some enterprises approach IoT projects as technology projects, not as 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 that 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 IoT's potential.
- 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; C3 AI; Detechtion Technologies; GE Digital; Itron; Microsoft; SAP; Siemens

Gartner Recommended Reading

Research Roundup: Top Digital Trends Shaping the Oil and Gas Industry in 2023

2022 Sustainability Survey: Energy CIOs Can Help to Retain C&I Enterprises as Customers

Digital-Outcome-Driven Metrics for Oil and Gas

Magic Quadrant for Global Industrial IoT Platforms

2022 Strategic Roadmap for Asset Management

Predicts 2023: Oil and Gas — Navigating Constant Turbulence

6 Top Practices for Winning the Race Toward Intelligent Assets

OT Security

Analysis By: Katell Thielemann

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Mature mainstream

Definition:

Operational technology (OT) includes hardware and software that detect or cause a change, through the direct monitoring and/or control of industrial equipment, assets, processes, and events. OT security focuses on protecting them. As threats and security solutions multiply, a generic category of OT security that was once dominated by network-centric tools is now evolving into multiple categories.

Why This Is Important

Once disconnected from IT networks, the increased connectivity of OT and IT systems has created new security risks. As operational systems are the centers of value creation, OT security has major relevance to organizations in national critical infrastructure, and to any other industrial verticals with operations and asset-centric environments. Network-centric security, with a focus on segmentation and firewalls, traditionally anchored OT security approaches, but new categories have emerged.

Business Impact

Whether it be nation-states targeting critical infrastructure and intellectual property (manufacturing is often targeted for cyber espionage) , or financially motivated hackers deploying ransomware, the number of attacks on systems in production or mission-critical environments has increased over the past five years. The impact of operational disruption can range from mere annoyance to hundreds of millions of dollars, along with reliability, life and safety impacts.

Drivers

- Digital transformation initiatives are multiplying in asset-intensive organizations, in turn creating new risks that security teams may have no visibility into.
- Due to a rapidly changing threat landscape, asset-centric organizations are increasingly focusing their attention on the security risks they face outside of enterprise IT. They realize they are surrounded by cyber-physical systems (CPS) that underpin all their production, distribution and value creation efforts.
- International standards, such as IEC 62443, NIS2 and NIST 800 series, are emerging to provide guidance. In some industry verticals, security mandates, such as NERC CIP or TSA directives, 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 on the rise, adding to the growing list of existing national legislations.
- One of the initial focus areas was network-based security, which has underpinned most OT security efforts for the last decade. But, many specific categories have emerged to deal with the fast-evolving threat landscape and introduce innovation in security operations. As a result, a singular OT security market is evolving.
- Some of the emerging new categories for CPS include protection platforms, cyber risk quantification platforms, secure remote access solutions, security services, network-centric solutions, or onboard diagnostics solutions.

Obstacles

- Organizations face cultural, governance and security controls challenges that prevent a one-size-fits-all approach to security. For instance, production assets often run 24/7 and cannot be stopped at will.
- Manufacturers often connect remotely to production assets to maintain and update them. If not done securely with consistent policies, this creates additional risks. They also often control deployment of updates on the basis of contracts and warranties, which can hamper security efforts.
- Shortages of OT security skills remain acute and growing.
- The age of systems and devices (up to 20 years) means no security updates are available anymore.
- OT security is evolving into CPS asset-centric security, enabled by platforms that support not only OT, but also IoT, industrial IoT, or smart building assets. This is changing OT security from focusing on segmentation and firewalls to placing the assets at the center of security, and layering defense-in-depth approaches around them.

User Recommendations

- Initiate risk discussions between IT security and production/engineering teams, and determine the current extent of OT security efforts.
- Deploy CPS asset discovery, inventory and network mapping security platforms.
- Determine immediate gaps, such as flat networks and missing or misconfigured firewalls.
- 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 that OEMs of OT systems ensure that systems are secure by design.
- Prepare for the new reality of CPS security as a centralizing discipline for securing the ever-growing list of IT, OT, IoT and industrial IoT systems, and for bringing together an asset-centric cybersecurity discipline.

Sample Vendors

Blue Ridge Networks; Booz Allen Hamilton; Optiv Security; Waterfall Security Solutions

Gartner Recommended Reading

3 Initial Steps to Address Unsecure Cyber-Physical Systems

Predicts 2023: Cyber-Physical Systems Security — Beyond Asset Discovery

CPS Security Governance — Best Practices From the Front Lines

Innovation Insight for Cyber-Physical Systems Protection Platforms

Climbing the Slope

Hybrid Cloud Computing

Analysis By: David Smith, Milind Govekar

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Hybrid cloud computing comprises two or more public and private cloud services that operate as separate entities but 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 — cost optimization, agility, flexibility, scalability and elasticity benefits of public cloud, in conjunction with control, compliance, security and reliability of private cloud (assuming their on-premises environments are truly cloud). As a result, virtually all enterprises have the desire to augment internal IT systems with external cloud services. Note that many organizations start with hybrid IT, which lessens the requirement of a true private cloud.

Business Impact

Hybrid cloud computing enables an enterprise to leverage both its data centers as well as the capabilities of the public cloud. 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 and sets the stage for new ways for enterprises to work with suppliers, partners (B2B) and customers (B2C).

Drivers

- The desire to evolve data centers to become more cloudlike and, therefore, have a private cloud having cost and other characteristics 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” (a flavor of distributed cloud) means that you have a vendor-provided private cloud offering that is packaged and connected to a public cloud in a tethered way. Azure Stack HCI 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 the hybrid cloud provides include service integration, availability/disaster recovery, cross-service security, policy-based workload placement and runtime optimization, as well as cloud service composition and dynamic execution (for example, cloud bursting).

Obstacles

- Hybrid cloud computing is different from multicloud computing, which is the use of cloud services from cloud providers for the same general class of IT service.

- Hybrid cloud computing complements multicloud computing. Although most organizations are integrating applications and services across service boundaries, few large enterprises implemented hybrid cloud computing for a few services.

- Hybrid cloud is different from hybrid IT, 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 Tata Consultancy Services (TCS), and other service providers and systems integrators.

User Recommendations

- Note that internally run, virtualized environments are often recast as “private clouds,” 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.

- Establish security, management, and governance guidelines and standards when using hybrid cloud computing services to coordinate the use of these services with public and private services.

- Approach sophisticated cloud bursting 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.

Gartner Recommended Reading

Top Strategic Technology Trends for 2021: Distributed Cloud

'Distributed Cloud' Fixes What 'Hybrid Cloud' Breaks

Predicts 2023: The Continuous Rising Tide of Cloud Lifts All Boats

Leverage Platform Engineering to Scale DevOps Platforms Into Hybrid Cloud

Industrial IoT

Analysis By: Simon Jacobson, Scot Kim

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

The industrial Internet of Things (IIoT) is a subsegment of the greater market of IoT. In manufacturing, it is used to improve asset management decision making and operational visibility, as well as control for plant infrastructure and equipment within asset-intensive industries and environments.

Why This Is Important

IIoT is a core building block for smart manufacturing, improving its reliability and accessibility by extending, augmenting or replacing operational technology (OT). IIoT improves how data sources (historic and real-time across operations and systems) are accessed, analyzed, contextualized, and leveraged. Overlay IIoT platforms and solutions pave the way for how to leverage cloud, edge computing/devices, sensors, and AI/machine learning (ML) to optimize performance through enabled applications and a digital thread across operations.

Business Impact

IIoT provides access to a wider range and deeper set of data sources with the power of extracting insights and improving data-based decision making (and therefore operational performance), influences trade-offs across the network, and identifies future opportunities for automation and cost-efficiencies. The impact that IIoT delivers is bringing insights into industrial data that legacy OT systems have failed to provide.

Drivers

- Smart manufacturing, Industrie 4.0, proliferating industry consortia and nationally driven industrialization initiatives placing IIoT at the center of their initiatives. This highlights the importance of interoperable platforms as a nucleus to an organization's strategy, and not simply a nice-to-have technology.
- Better cost-efficiency in industrial operations by extending the functional life of capital assets.
- Improved productivity and operational excellence through improved quality and optimized asset performance.
- Improved data-driven decision making by frontline workers.
- Ambitious automation designs and the exploration of how certain processes can be managed remotely.
- Establishment of distributed manufacturing networks and servitization/"as a service" models.

Obstacles

- Organizational complexity, cultural impediments and process (re)engineering are required for success.
- IT and OT heterogeneity catalyze architectural debates and turf wars, impeding progress.
- Components for successful IIoT implementation are complex and of diverse maturity levels.
- Security concerns go beyond data confidentiality, integrity and availability to encompass the safety and reliability of physical operations.
- IIoT projects rely on interoperability which inherently introduces new integration challenges, making firms navigate a sea of standards, reference models and proprietary protocols.
- Resource requirements (skills, cost and integration) are often underestimated.
- Provider options continue to expand and create complications for manufacturing systems' strategies.
- Even with robust ROI, the funding models for scalability are elusive.
- The knowledge to build, partner or acquire IIoT expertise and technologies is lacking.
- IoT-enabling technologies without any business value or business buy-in are still preferred.

User Recommendations

- Develop a plan to map data, processes and use cases with site capabilities. Then segment use-case pursuits into those that will enhance the core of operations and those that will foster future innovation and process capabilities.
- Use a maturity-based continuum to develop the roadmap by aligning current and future use with both site and supply chain business objectives. Leverage a maturity-based continuum to holistically plan architecture, deployment models, standard work and interoperability.
- Ensure alignment between IT, OT, engineering technologies (ET), frontline workers and line-of-business stakeholders, so they can accurately budget resources, identify the role of standards and clarify expected benefits.
- Examine the trade-offs around buy/build/acquire/partner diligently based on in-house capabilities, time, budget and deployment environment.
- Determine the prerequisites prior to embarking on an IIoT journey by identifying the vision, architecture and associated data sources to ensure successful transformational implementations.

Sample Vendors

Amazon Web Services; Augury; Automation Intellect; Braincube; Litmus Automation; Microsoft; PTC; Software AG

Gartner Recommended Reading

Magic Quadrant for Global Industrial IoT Platforms

Innovation Insight for Smart Factory

Quick Answer: How to Communicate the Value of Industrial IoT Platforms to SCADA Solutions

Emerging Technologies and Trends Impact Radar: Internet of Things for Industrial Manufacturing

Machine Learning

Analysis By: Shubhangi Vashisth, Peter Krensky

Benefit Rating: Transformational

Market Penetration: 20% to 50% of target audience

Maturity: Mature mainstream

Definition:

Machine learning (ML) is an AI discipline that solves business problems by utilizing statistical models to extract knowledge and patterns from data. The three major approaches that relate to the types of observation provided 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

Over the last few years, ML has gained a lot of traction and is entering mainstream adoption 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 are often inaccurate and unreliable, by generalizing knowledge from data.

Business Impact

ML drives improvements and new solutions to business problems across a vast array of business, consumer and social scenarios, such as:

- Credit approval automation
- Price optimization
- Customer engagement
- Supply chain optimization
- Predictive maintenance
- Fraud detection

ML impacts can be explicit or implicit. Explicit impacts result from ML initiatives. Implicit impacts result from products and solutions that you use without realizing they incorporate ML.

Drivers

- Augmentation and automation (of parts) of the ML development process has improved productivity of data scientists and enabled citizen data scientists to make ML pervasive across the enterprise.
- Availability of quality, labeled data is driving ML adoption at enterprises.
- Pretrained ML models are increasingly available through cloud service APIs, often focused on specific domains or industries.
- ML education is becoming a standard at many academic institutions, fueling the supply of talent in this space.
- Active research in the area of ML in different industries and domains is driving applicability far and wide.
- Newer learning techniques — such as zero- or few-shot learning — are emerging, reducing the need to have high volumes of quality training data for ML initiatives, thus lowering the barrier to entry.
- New frontiers are being explored, including federated/collaborative, generative adversarial, transfer, adaptive and self-supervised learning — all aiming to broaden ML adoption.

Obstacles

- Conventional engineering approaches are unable to handle the growing volumes of data, advancements in compute infrastructure and associated complexities.
- ML is not the only popular AI initiative to emerge in the last few years. Organizations also rely on other AI techniques, such as rule-based engines, optimization techniques and physical models, to achieve decision augmentation or automation.
- Organizations still struggle to take their ML models into production. MLOps continues to be a hot trend and organizations look to specialized vendors and service providers for support in their journeys of better operationalizing ML models.
- Application of ML is often oversimplified as just model development. Several dependencies that are overlooked — such as data quality, security, legal compliance, ethical and fair use of data, and serving infrastructure — have to be considered in ML initiatives.

User Recommendations

- Assemble a (virtual) team that prioritizes ML use cases, and establish a governance process to progress the most valuable use cases through to production.
- Utilize packaged applications that fit your use-case requirements to derive superb cost-time-risk trade-offs and significantly lower the skills barrier.
- Explicitly manage MLOps and ModelOps for deploying, integrating, monitoring and scaling 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; ClearML; Databricks; Dataiku; Domino Data Lab; Google; H2O.ai; KNIME; Microsoft; MindsDB

Gartner Recommended Reading

Market Guide for Multipersona Data Science and Machine Learning Platforms

Market Guide for DSML Engineering Platforms

How to Improve the Performance of AI Projects

Infographic: Common Layers of Data Science and Machine Learning Activity

Use Gartner's MLOps Framework to Operationalize Machine Learning Projects

Mobility in Oil and Gas

Analysis By: Rich McAvey

Benefit Rating: High

Market Penetration: More than 50% of target audience

Maturity: Early mainstream

Definition:

Mobility is an integrated application of software, hardware and connectivity to improve the productivity of workers by presenting relevant information, offering decision support, enabling remote workflows and facilitating real-time collaboration irrespective of location. Mobility is beginning to include virtual reality (VR), augmented reality (AR) technologies and mixed reality (MR).

Why This Is Important

Oil and gas investment in mobile solutions is high and continues to grow. 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) interoperate with mobile solutions to 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 user experience (UX) designs that are created 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 operational technology computing is providing access to a vast amount of relevant information on current operating conditions, engineering designs and historical maintenance actions.
- 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, checklists for training and maintenance, or 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

- 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 workers' 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.
- Form factors for helmet and head-mounted equipment have not yet resolved tactical operating issues such as comfort, distraction, and accuracy.

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.
- Refresh your vision as VR and AR markets are fragmenting and evolving, and oil and gas applications are still emerging.
- Test solution capabilities frequently as vendors are promising solutions beyond current capabilities, which can lead to poor or unsuccessful implementations.
- Ensure compatibility by working with oil and gas 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.

Sample Vendors

Amazon Web Services (AWS) ; Microsoft; Mobideo; ServiceMax; ServiceNow; Siemens; Voovio

Gartner Recommended Reading

Magic Quadrant for Field Service Management

Market Guide for Mobile Workforce Management Software for Utilities

Quick Answer: What Is a Metaverse?

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

As oil and gas markets are more volatile, operators need to more frequently and actively manage portfolios. Portfolio management solutions have been slowly integrated into more comprehensive planning solutions and are being delivered as components of software-as-a-service (SaaS) service from cloud locations. The new formats offer better overall capabilities, but can be challenging to buy as effort is required to load legacy data into them and the migration pathway into a SaaS platform can be tricky.

Business Impact

Volatile markets make rapid optimization of large portfolios of existing and potential capital projects into a critical business capability. In addition, the 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

- Stand-alone solutions do not require extensive data migrations, but remain more narrowly scoped than the typical 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.
- SaaS offerings offer better functionality and much better cross-functional integration, but working out a transition program that does not require excessive data manipulation can be tricky.
- As some oil and gas business strategies expand to include alternative energy markets, the challenge of a single solution for all capital portfolios may be growing.

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 SaaS-based integrated optimization solutions for old and new classes of energy investments, limited by practicality.
- Develop more comprehensive, flexible and fast portfolio management capabilities to provide an effective strategy to combat decarbonization realities in oil and gas.
- Focus efforts in the short term on reducing the cost and cycle time of portfolio planning by consolidating the tools and methods used across the business assets and project teams.

Sample Vendors

Aspen Technology (AspenTech); Halliburton Landmark; Oracle; Quorum Software; SAP; SLB

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) tools support decision making and produce 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 incorporating this analysis into reliability forecasting and budgeting.

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

- Maintain reliability
- Optimize investments
- Balance budgets
- Give regulators a long-range investment requirement to maintain reliability
- Rate impact and risk tolerance
- Align asset investments with strategic corporate objectives

Business Impact

Implementing AIP systems helps optimize investments of mission-critical assets in asset-intensive industries by:

- **Informing** better asset investment decisions based on asset condition data, maintenance costs, criticality, budgets and risks
- **Analyzing** the data to produce capital investment plans over extended time horizons as opposed to rules of thumb or past experience

- **Providing** 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 leading to the wrong answer) and can potentially introduce more risk.
- AIP 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. AIP is also 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 takeup of AIP has increased in recent years, in part, spurred by complementary technologies advancing, such as asset performance management (APM) and enterprise asset management (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, criticality, impacts of time, and other factors to create alternative investment scenarios. In many regions, regulators favor performance-based or outcome-based systems, forcing organizations to rethink the way they manage their asset bases.

Obstacles

- **Access to sufficient data and required quality** — Quality data is critical to define when deciding whether to go with a commercial off-the-shelf (COTS) or custom implementation solution.
- **Availability of degradation models** — Some organizations create these in-house; others outsource them or buy COTS software.
- **Change management** — Organizations must assess the value of their data input and other nontechnical aspects of implementing AIP solutions.
- **Vendor selection (asset-centric versus project-centric)** — Many vendors focus primarily on asset management, while others concentrate on project and portfolio management (PPM), which can include asset planning.
- **Poorly implemented EAM systems** — High-quality asset data is foundational for all effective AIP deployments. Ideally, the EAM system is populated with accurate historical data; however, if it is not, data cleansing 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 clarify what decision should be made, then informs 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 evaluating current offerings and vendors in light of your specific organizational requirements.

Sample Vendors

Arcadis Gen; CGI; Copperleaf Technologies; Cosmo Tech; DIREXYONTechnologies; Ovarro; PowerPlan

Gartner Recommended Reading

2022 Strategic Roadmap for Asset Management

Market Guide for Asset Investment Planning Solutions for Energy and Utilities

Market Guide for Enterprise Asset Management Software

Market Guide for Asset Performance Management Software

2023 CIO and Technology Executive Agenda: A Utility Industry Perspective

Data Lake

Analysis By: Roxane Edjlali, Michele Launi

Benefit Rating: Moderate

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

A data lake is a collection of data storage instances combined with one or more processing capabilities. Most data assets are copied from diverse enterprise sources and are stored in their diverse formats, so they can be refined and repurposed repeatedly for multiple use cases. Ideally, a data lake will store and process data of any structure, latency or container (files, documents, result sets, tables, formats, BLOBs, messages, etc.) .

Why This Is Important

Data lakes enable advanced analytics and complement traditional data warehouses. For example, the massive repository of source data in a data lake supports broad, flexible and unbiased data exploration, which is required for data mining, statistics, ML and other analytics techniques. A data lake can also provide scalable and high-performance data acquisition, preparation and processing, either to be refined and loaded into a data warehouse, or for processing within the data lake.

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, as well as the structure-agnostic storage and processing options, that advanced analytics require.
- Data exploration and data engineering 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. A data lake, when designed properly, can provision data for the diverse exploration requirements of multiple user types and use cases.
- Data lakes can expand the data warehouse and address additional use cases, such as data exploration on data. In these cases, the warehouse and lake are integrated by shared refined datasets, platform infrastructure (DBMS brands and storage, whether on-premises or cloud) and architecture components (data landing/staging).

Obstacles

- Data lake best practices are still evolving. There is still much confusion about how to design and govern a data lake, plus how to optimize a lake's data without losing its purpose as a repository for data science and advanced analytics. An emerging practice clears this obstacle by designing the internals of a data lake as a series of 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).

- The first data lakes, built on Hadoop, were for data science only, and they lacked metadata, relational functionality and governance. Today's data lake is on cloud, it has different data storage types, and it supports multiple analytics techniques (not just data science). Data governance is crucial and cannot be neglected; it includes data quality, data catalog, data security and data life cycle management.

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, data engineers 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 or customer 360.

- 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 the whole data architecture to extend the data lake. Consider logical data warehouse and lakehouse concepts.

- 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) ; ChaosSearch; Cloudera; Databricks; Dremio; Google Cloud Platform (GCP) ; 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

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

Market Guide for Analytics Query Accelerators

Adaptive Portfolio Governance

Analysis By: Sarah Davies

Benefit Rating: Transformational

Market Penetration: 20% to 50% of target audience

Maturity: Mature mainstream

Definition:

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

Why This Is Important

The majority of strategic portfolio leaders are managing a changing variety of portfolio activities to deliver enterprise outcomes. Strategic portfolio management is transformational because organizations effectively managing their strategic portfolios are twice as likely to achieve their outcomes. Portfolio governance must be frequent and diverse as roles evolve with the maturity of digital and organizations, and manage increasing change and uncertainty.

Business Impact

The ability to respond to disruptions has challenged existing governance practices in organizations. Many are deploying a variety of governance styles and mechanisms to balance risk and cost to deliver value. Each style must allow for specialization, localization and enterprise guardrails. As different styles emerge, organizations will struggle to balance the adoption of changes and existing management frameworks. Repetition of success will elevate emergent practices to best practices.

Drivers

- Adaptive portfolio governance is necessary to manage the impact of disruptions on well-made portfolio plans and continue progress toward strategic objectives.
- 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 reached high levels of adoption among strategic portfolio leaders, and other organizational roles plan to adopt this approach within the next two years.

Obstacles

- In order to adopt adaptive portfolio management, the systems and processes used for portfolio management 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 supporting the portfolio, will provide cultural and political challenges. The perceived lack of “enough” control by those formally engaged in traditional portfolio governance, if unanswered, will provide a barrier to a full adoption in the long run.

User Recommendations

- Evolve your organization's portfolio governance by assessing the differences between traditional and adaptive governance. Update your governance by adopting adaptive decision styles or capabilities that enable planning to keep pace with enterprise objectives.
- Refine 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 change. Scaling this discipline may take time.
- Apply continuous improvement at various checkpoints within the portfolio practices. As the business shifts from project to product portfolios and automated data analytics, opportunities to change decision making emerge.

Gartner Recommended Reading

Use Adaptive Governance Styles for Portfolio Management

Define Principles for Adaptive Governance to Quickly Respond to Change

Adaptive Governance Principles: How to Orchestrate and Boost the Success of Fusion Teams

5 Key Changes to Achieve Just-Enough I&T Governance

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 systems are business applications for optimizing reliability and availability of operational assets (such as plant 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 is an important technology for asset-intensive organizations to enable business outcomes with strategic asset maintenance decision support. 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 leverage APM to improve overall business operations.

Business Impact

APM is an important investment area for asset-intensive industries and can deliver measurable benefits:

- Asset availability (reducing maintenance and inventory carrying costs)
- Improved uptime and cost savings can be substantial (benefits measured in millions of dollars per year)
- Improved scheduling of maintenance and planned outages
- Reliable data quality
- Effective alarm management
- Reduced manual data entry hours per month
- Optimized resources to monitor spatially distributed assets

Drivers

- With the increased focus on the overall availability of their assets in asset-intensive industries (not just breakdowns and repair costs), organizations need better solutions to deliver enhanced asset insights. 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, yielding 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 that 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, consistent and the right asset data to support a more advanced maintenance capability.
- Limited adoption of asset management standardization (such as ISO 55000) as well as digital business immaturity constrains organizational ability to support advanced asset maintenance capabilities.
- 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.
- Integration to your EAM to be able to execute APM recommendations, which may be complicated if they are from two different vendors.

User Recommendations

- Assess the maturity of your EAM system and have an integration plan with your APM before investing in APM, as CIOs should not expect to get all APM capabilities from the EAM vendors themselves.
- Identify the combination of asset maintenance capabilities to support your asset types and situations across the business. 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 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

ARMS Reliability (a Baker Hughes company) ; AVEVA; Bentley Systems; Cognite; Detechtion Technologies; GE Digital; Hitachi Energy; IBM; SAP; SAS

Gartner Recommended Reading

2022 Strategic Roadmap for Asset Management

Market Guide for Enterprise Asset Management Software

Market Guide for Asset Performance Management Software

Use a Step Program to Orchestrate Maintenance and Reliability Technology

Design Thinking

Analysis By: Brian Prentice

Benefit Rating: High

Market Penetration: More than 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 is generally delivered through a workshop format. It promotes investment in empathetic learning about the organization's customers/stakeholders as the key step to ensure the right problems are defined before innovative actions are taken to deliver solutions. It 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. It helps business innovators explore multiple solutions and 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 add 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. It helps organizations see how they fit within the broader context of their customers' goals or see the organization's operations through the eyes of people at the front line.

- Integration with design practices — Design thinking isn't contingent on making a new product or service. However, when it is used for that, there is seamless integration into a broader design process.
- Most design thinking occurs through workshops run by design team members 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.
- Often, workshops proceed without any research and quickly devolve into empathy sessions, resulting personas and journey maps are more likely to echo existing biases than 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 to build internal design capability or to retain design agencies. The end result is 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 precedes 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.

Upstream Modeling Suites

Analysis By: Simon Cushing

Benefit Rating: High

Market Penetration: More than 50% of target audience

Maturity: Mature mainstream

Definition:

Upstream modeling is the development of a virtual model of the physical characteristics and future performance of subsurface hydrocarbon reservoirs to predict their economic value. Upstream modeling suites (UMS) are 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

Reservoir modeling is key to the successful economic exploitation of oil and gas resources. UMS are the latest generation of upstream modeling tools providing integration, enhanced workflows, modern analysis techniques such as AI/machine learning (ML) and, in some cases, cloud-compatible architectures. They offer enhanced ease of use, modeling cycle times, better uncertainty handling and the potential for greater cost-effective accuracy than previous generations of upstream modeling applications.

Business Impact

Seismic data acquisition represents one of exploration and production (E&P) companies' most significant costs. Better upstream modeling supports improved field development and operation, enables higher return, and creates competitive advantage. 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

- UMS are the mainstream approach to reservoir modeling, characterization and simulation in the industry. Modern UMS are characterized by integrated solutions where data sharing and workflows are streamlined. Major UMS vendors' suites are now more or less integrated, thereby reducing the need for data transfer, and facilitating established business- and user-defined workflows.

- These platforms are more modular and open, and can increase productivity and collaboration through seamless integration across subsurface workflows. Vendors are extending these capabilities to include or integrate surface operations (capital projects, production surveillance and process simulation) with the UMS.

- Oil and gas companies seek to optimize return on investment in UMS, 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.

- Major vendors now offer comprehensive UMS platforms, incorporating high-performance computing advanced analytics and AI/ML. Major vendors have also established the first generation of cloud-based or cloud-native UMS, and advances are addressing performance and data access concerns.

- The Open Group OSDU Forum's OSDU Data Platform for subsurface data is now released and gaining traction. Compatibility requirements may significantly reshape the UMS software market in coming years.

Obstacles

- Oil and gas companies' upstream modeling portfolios typically include best-of-breed solutions alongside integrated UMS. 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.

- Oil and gas companies have embraced the cloud for enterprise applications. Meanwhile, UMS cloud solutions are newer. Data residency, platform availability, latency and other performance considerations, combined with the cost and effort of legacy data migration, will moderate the pace of their adoption.

User Recommendations

- Create a roadmap for UMS migration to the cloud. Gain the latest information from vendor partners and run feasibility studies or test deployments in line with the normal cycle of upstream application portfolio upgrade.
- 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 ML features), adopting these where the business case is sound.
- 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

Aspen Technology; Baker Hughes; Cegal; CGG; Computer Modelling Group; Emerson Electric; Halliburton; LMKR; S&P Global (IHS Markit); SLB

Entering the Plateau

API Management PaaS

Analysis By: Mark O'Neill

Benefit Rating: Moderate

Market Penetration: 20% to 50% of target audience

Maturity: Mature mainstream

Definition:

API management PaaS (APIM PaaS) takes an on-demand approach to the delivery of API management by providing an alternative to the installation and management of API management software. APIM PaaS manages API access via provider-hosted API gateway services, and it may also include an API developer portal. In some cases, an on-premises API gateway option will be provided. APIM PaaS may be optimized to be used with PaaS services from the same vendor, such as function PaaS (fPaaS).

Why This Is Important

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 to offer 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 grows. 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.
- An increasing number of available APIs and a growing volume of API interactions drive organizations to APIM PaaS for its high-scale quality of service, including throughput, high availability, and global access.

- SaaS adoption is also a driver, as organizations wish to use API management without needing to operate and maintain an API management software.
- Serverless computing, including fPaaS (also known as function as a service or FaaS), 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.
- Since many organizations build APIs in the cloud, APIM PaaS is also increasingly used in hybrid and multicloud scenarios.
- Automation is also a driver for APIM PaaS. This is because APIM PaaS itself includes documented APIs in the API management platform. These APIs are used for tasks such as registering APIs. APIM PaaS typically can automatically register APIs built on the same platform.

Obstacles

- APIM PaaS tends to focus on runtime (API gateway) capabilities, with limited support for an API developer portal or other aspects of API management beyond API gateways.
- Network latency concerns impact the uptake of APIM PaaS for managing on-premises APIs. Even in a hybrid scenario, any requirement for the remote gateway to connect to the core platform introduces latency concerns.
- Data residency concerns, such as a 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 costs as API traffic grows.
- APIM PaaS solutions from cloud hyperscalers are generally tied to their larger PaaS platforms, and are not portable for their use on other PaaS platforms.

User Recommendations

- Investigate the use of APIM PaaS to provide a cost-effective means of providing API management. If some or all of your APIs are on-premises, then investigate a hybrid option.
- For organizations migrating to the cloud, investigate hybrid APIM PaaS options.

- Compare the pricing of APIM PaaS vendors, since not all provide consumption-based pricing.
- Include API PaaS as part of your API strategy, since it can accelerate the time to market of your mission-critical digital initiatives.

Sample Vendors

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

Gartner Recommended Reading

Magic Quadrant for Full Life Cycle API Management

Reference Model for API Management Solutions

Infographic: Decision Point for API and Service Implementation Architecture

Drones in Oil and Gas

Analysis By: Simon Cushing

Benefit Rating: High

Market Penetration: More than 50% of target audience

Maturity: Mature 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 type, they can hold a stationary position, follow predefined routes or patrol freely within geographic boundaries. The degree of autonomy varies from minimal to fully autonomous.

Why This Is Important

Drones can perform inspection and similar 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 payloads and integration with other services are expanding capabilities. Drone services are maturing and becoming commoditized. Use is now routine and widespread. However, exploiting the full value still needs 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 manual site visit frequency.
- Planning efficiency from site surveys.
- Regulatory compliance and sustainability by reducing emissions.
- Situational awareness and response in emergencies.
- Continuous or regular site surveillance.

Drivers

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

- Drone service provider offerings are maturing and growing in sophistication. Some now offer a level of integration with enterprise IT systems, such as ERP. Others have developed commoditized services, or integrate drones into other digital-enabled operations services. Autonomous drones can be programmed to conduct regular surveys of defined areas.
- Tethered or resident drones can provide continuous observation.

- Drones are increasingly being harnessed to track methane and other emissions in combination with satellite communications and AI. Examples such as the U.S. Inflation Reduction Act (IRA) requiring methane emissions tracking point to an increasing need for robust and reliable emissions detection by oil and gas companies.
- More time on station, longer flight time, wider ranges of sensors and greater autonomy will continue to enhance capabilities, especially as regulation becomes more mature and 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 continue to increase their ability to fly in complex environments.
- Some countries are developing the airspace and regulatory frameworks needed for safe commercial drone deliveries. Progress here will drive drone use cases and technology, likely feeding into enhanced capability in oil and gas operations.

Obstacles

- Drone use is typically tightly regulated. Civilian drone size, range and payloads are restricted, limiting operational capability. Generally, flight permits (and pilot qualifications) must be obtained, adding effort and cost to missions. These factors are, however, routine in many operational environments.
- Drones can be used maliciously to damage assets or disrupt operations. Drone malfunctions/failures also have the potential to harm people and assets, and these risks must be mitigated.
- Autonomous, resident and integrated drone systems are relatively new and require more complex technologies, increasing risks and costs.
- For some oil and gas use cases covering very remote sites or large areas, such as fugitive methane emissions monitoring, drones face increasing competition from recent advances in satellite imaging.
- Drones deliver most value from automated data processing and the use of analytics on acquired data. Provider cloud hosting allows access to data without interaction with enterprise IT systems. Accordingly, business users 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.
- Seek drone services or 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.
- Deliver superior value from drones by implementing automated data processing and the application of analytics to acquired data.

Sample Vendors

Baker Hughes; Cyberhawk; Motorola Solutions (CAPE Aerial Telepresence) ; PrecisionHawk; Sky-Futures

Appendixes

See the previous Hype Cycle: Hype Cycle for Oil and Gas, 2022

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 2023)

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 2023)

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 2023)

Evidence

[1] Gartner's 2023 CIO and Technology Executive Survey for Oil and Gas was conducted to help CIOs and technology executives overcome digital execution gaps by empowering and enabling an ecosystem of internal and external digital technology producers. It was conducted online from 2 May 2022 through 25 June 2022 among Gartner Executive Programs members and other CIOs. Qualified respondents are each the most senior IT leader (for example, the CIO) for their overall organization or some part of their organization (for example, a business unit or region). The total sample is 2,203 respondents, with representation from all geographies and industry sectors (public and private), including 35 from oil and gas.

Disclaimer: Results of this survey do not represent global findings or the market as a whole, but reflect the sentiments of the respondents and companies surveyed.

Document Revision History

Hype Cycle for Oil and Gas, 2022 - 19 July 2022

Hype Cycle for Oil and Gas, 2021 - 22 July 2021

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

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

Understanding Gartner's Hype Cycles

Tool: Create Your Own Hype Cycle With Gartner's Hype Cycle Builder

Research Roundup: Top Digital Trends Shaping the Oil and Gas Industry in 2023

2023 CIO and Technology Executive Agenda: An Oil and Gas Perspective

Quick Answer: What Are Intelligent Assets and Why Are They Important?

To Enable Intelligent Industrial Assets, Strengthen These Digital Capabilities

Table 1: Priority Matrix for Oil and Gas, 2023

Benefit	*Years to Mainstream Adoption*			
↓	***Less Than 2 Years*** ↓	***2 - 5 Years*** ↓	***5 - 10 Years*** ↓	***More Than 10 Years*** ↓
Transformational	Adaptive Portfolio Governance Hyperautomation	Composite AI Cyber-Physical Systems Data Literacy Digital Twins in Oil and Gas First-Principles AI Generative AI Machine Learning OSDU Data Platform	Intelligent Industrial Assets IoT in Oil and Gas Real-Time Remote Operations Renewable Energy Management Systems	
High	Design Thinking Drones in Oil and Gas OT Security Upstream Modeling Suites	Asset Performance Management Cloud-Out to Edge Computer Vision in Oil and Gas Edge-In to Cloud Geospatial Platform Hybrid Cloud Computing Mobility in Oil and Gas	Autonomous Underwater Vehicles in Oil and Gas Carbon Accounting Energy Management and Optimization Systems Gas Emission Management Solutions Industrial IoT IT/OT/ET Alignment Software-Defined Assets	Autonomous Contact Robots in Oil and Gas Blockchain in Oil and Gas

Benefit	*Years to Mainstream Adoption*			
↓	***Less Than 2 Years*** ↓	***2 - 5 Years*** ↓	***5 - 10 Years*** ↓	***More Than 10 Years*** ↓
Moderate	API Management PaaS	Data Lake Portfolio Management Solutions	Asset Investment Planning	
Low	Advanced Algorithmic Trading			

Source: Gartner (July 2023)

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