About Jacobs

Jacobs leads the global professional services sector delivering solutions for a more connected, sustainable world. With $15 billion in fiscal 2018 revenue and a talent force of more than 80,000, Jacobs provides a full spectrum of services including scientific, technical, professional and construction- and program-management for business, industrial, commercial, government and infrastructure sectors. For more information, visit www.jacobs.com, and connect with Jacobs on LinkedIn, Twitter, Facebook and Instagram.

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Connected, Sustainable Enterprise Solutions

Connect, Protect, and Analyze Your Business
The Connected, Sustainable Enterprise

How will digital transformation affect the growth trajectory of your business? Jacobs delivers innovative, digital solutions, from early concept through operations and maintenance phases, ensuring your assets generate the greatest possible lifecycle returns on capital and operating expenses.

**Industry 4.0 Advising and Consulting**
Our consulting services specific to Industry 4.0 and our industry combines our understanding of the technology market in conjunction with our commercial and business drivers, domain expertise in: engineering, supply chain, construction, operations & maintenance, and experience deploying technology solutions in other industries.

We offer these services in a fully customizable approach to address your specific needs.
- Digital roadmap workshop & development
- Information dashboards and connectivity
- Digitizing work processes
- Business case development to drive value
- Data management and architecture

**Digital Engineering, Procurement, and Construction**
Digital EPC is the integration of all engineering, design, supply chain, construction, and project services information into a common data-centric platform that provides a single source of truth for holistic and full asset life usage.

We build this platform with a focus on digitizing construction through new technologies that improve safety, efficiency, quality, and on-time completion.
- Digital solutions foundation
- Data-centric project deliverables
- Automated construction solutions
- Resource optimization
- Personnel/equipment/material tracking

**Intelligent Asset Management**
Optimizing assets is crucial to increasing market competitiveness by increasing up-time, minimizing safety & environmental risks, and decreasing operating costs. Our asset management process considers operability, cost, warranties, reliability, and historical and real time data.
- Digitally integrated asset lifecycle management
- Asset performance improvement
- Care plan & reliability optimization
- Bad actor elimination
- Warranty value services

**Performance Analytics**
Performance Analytics is the connection of data, domain subject matter experts, and proven data analytic tools and methodologies to solve problems and provide unrealized value.
- Operational data analytics
- Remote performance monitoring
- Commercial performance support
- Machine learning / artificial intelligence
- Energy efficiency management

**Industrial Cyber Security & Safety**
Industrial cyber security integrates the Information Technology (IT) and Operational Technology (OT) systems with a focus on protecting, monitoring, and evolving with technology as it becomes more prevalent in our industry.

In order to provide a holistic approach, we connect all of the following functions and capabilities.
- Industrial cyber security (ICS) inventory and audit
- ICS design testing and commissioning
- ICS intrusion, maintenance, and health monitoring
- ICS plan for control of critical assets and systems during construction so assets are installed and configured in a secure manner
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Workshop/Roadmap Development

**Challenge**

The need to invest in digital technology to remain competitive and cope with the dramatic disruptions being seen across industries is clear; the most effective way to do so for an individual company often is not as straightforward. Where traditional consulting firms focus on universal organizational issues to advise on change management, Jacobs delivers industry-specific SMEs in conjunction with technology experts to deliver technology roadmaps for process facilities and sophisticated industries, to address areas including:

- Integration of EPC project tools suites
- Enterprise systems, analytics and data lakes in the cloud
- Supply chain and logistics optimization
- Advanced analytics and asset management
- Virtual and Augmented reality for maintenance, operations and training
- Personnel and materials tracking for safety and productivity
- Cyber and physical security

**Solution**

Our technology experts work with you to:

- Organize and prioritize digital solutions that align with your business objectives
- Build understanding and consensus around digital technology solutions
- Generate insights and outcomes for business interfaces and problematic areas through collaborative Subject Matter Expert brainstorming and individual work

Jacobs Roadmap
1. **Kick-off meeting:**
The kick-off meeting uses “blue sky” thinking together with our combined specialist knowledge to gather a detailed understanding of where current and future capabilities are needed to fulfill your vision, strategic goals and objectives. The meeting is an interactive one-day session focused on your objectives, priorities, challenges, and aspirations. The meeting identifies business and technical alignment opportunities within your company to create disruptive new competitive advantages, business models, and transformation results.

2. **Opportunity prioritization and workshop planning:**
Post kick-off planning consolidates the information gathered during the kick-off meeting allowing for the planning, setup, and preparation of the agenda and appropriate activities for the top technology priorities to be addressed in the “deep dive” workshop.

3. **Deep dive workshop:**
This two-day workshop focuses and dives down into the targeted technology priorities, identified during the kick-off meeting. This dive will focus on both Horizons 1 and 2, as shown in the Horizon Diagram, of your emerging digital strategy and provides a timeline for reaching Horizon 3. Fundamental to the workshop is:

- SME-facilitated breakout workshops on each of the identified technologies
- Technology prioritization and constraints (internal & external SWOT analysis) and ROI
- Development of a digital technology roadmap outline
- Agreement to proceed and task assignments
- Time plan and next steps

4. **Output Preparation**

**Outcomes**
The ultimate deliverable to you is a living digital roadmap based on ideas and insights gathered in collaborative workshops that clearly define key steps, stakeholders, owners of each action, and a timetable for completion of the next proposed step in the larger roadmap journey.

Our objective is to provide a starting point for the digital centric transformation. We will use the information and thought threads derived from these workshops to inform the next proposed step in the overall roadmap journey. The roadmap will give context and direction to the journey, with increasing detail being added in each subsequent step.
Performance Dashboards

Challenge
With all the recent advancements in process technologies, data processing, and information systems, industry is starting to actively use data to become more commercially competitive. Unfortunately, many organizations continue to build up large volumes of operating data without taking full advantage of the information it contains. To compound on this, with the number of sensors being installed in modern equipment and advances in digital plant designs, the volume of data being collected is only ramping up. Being able to convert this data into useful information is necessary in today’s business environment. Unfortunately, many operating facilities lack the necessary skills, experience and resources to convert this large amount of data into useful business information.

Solution
To maximize the use of stored and streaming process data, we offer services to help clients develop advanced digital dashboard systems specifically designed to address real business issues. We work with our clients on all components of a system from connecting to the data sources through graphical representation of information.

We start our process by reviewing the information needed by the system, the quality of the data available and a detailed understanding of the associated work processes that will be using the information. We then help develop data content, structure and functionality that is integrated with the site’s work process model. We work collaboratively with our clients all through the development process and we can use several software systems and data platforms to help you select the tools that best match your infrastructure.

Our industry experts help develop dashboards with performance metrics designed specifically for our industry including technical content, trends, graphs and data roll-ups as necessary to maximize functionality, clarity and work process integration. In addition, by combining our industry experts with our expertise in data systems, we can help you enhance the normal process monitoring with more advanced data processing algorithms techniques including:
- Advanced Data analytics for predictive performance
- Machine learning applications
- Industry Benchmarking
- Key performance indicators
- Unit to unit comparisons & evaluations

Each system is custom designed in collaboration with the client to help make sure it fully meets your needs. Furthermore, our dashboards can also be linked with other digital systems including standardized business forms, alert systems, and automated report generation to further enhance functionality.

Outcomes
Our recent dashboards include:
- Energy dashboards that monitor energy use across an entire refinery
- Process technology dashboards to help client extend plant turn-around cycles
- Project management dashboards to help clients track Ready-to-Operate status
- Dashboards that monitor heating and cooling equipment across a multi-building facility
- Operational info consolidated across multiple sites to understand holistic operational status
**Challenge**
The rise of digital, artificial intelligence and automation technologies create opportunities to change business models and improve facility operation processes. The challenge is the documentation and related information resides in unintelligent and disconnected software silos, or is paper-based. Working in this environment is inefficient, expensive, time intensive, and is more likely to introduce mistakes. Lack of data and document integrity means the information doesn’t accurately reflect the actual facility. The desire for many existing facilities is to creatively exploit digital technology and transform work processes. Real-time data scenarios presented by the Internet of Things (IoT) sensors, analytics, operational technology and information ecosystems cannot operate without a digital data foundation.

**Solution**
The digitalization transformation journey with Jacobs begins with understanding your strategic objectives to ensure the ultimate solution serves your business needs. Our digitalization process then applies our domain expertise, extensive experience with integrated plant design suites, and conversion & capture capabilities. Machine learning solutions speed up the document conversion process while maintaining data integrity. All 2D drawings (P&IDs, Loop Diagrams, etc.), datasheets and other documents can be converted to digital formats. Additional services include re-symbolization to common formats and adjusting P&ID layout to clean up congested drawings.
- 3D models are created or enhanced through photogrammetry, laser scans, and drone capture.
- On site activities confirm that the physical facility is matched in the now-digital environment.
- Integration services connect the 2D drawings, other documents and the 3D model into a cohesive digital platform.

As smart digital assets are introduced to your organization, Jacobs offers additional services to analyze work methods to enhance informed decision making, and to efficiently maintain the 3D models, P&ID’s, other documents and databases. We do this analysis collaboratively, as in our broad experience, the best solutions are never created in isolation, but with broad engagement to recognize the desired outcomes with an aligned purpose.

**Outcomes**
Jacobs digitalization services will deliver a comprehensive digital portfolio of your asset to support optimizing facility operation processes without compromising health, safety or the environment. Integrating legacy data into a single digital platform has the potential for significant productivity improvements.

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**Employees spend**
1.8 hours every day on average searching and gathering information

7.6% to 10% of all company documents are lost or so misfiled – therefore they might as well be lost

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**20%**
Productivity improvement in internal work processes

**Artificial Intelligence**
Digitized Data Analytics

Lay the foundations for further digitalization improvements
Intelligent Operating Network (ION)

Challenge
In an increasingly digitized world, industrial systems that were once analog, manual, and isolated are now digital, smart, and connected. Cars, factories, ports, refineries, roads, office buildings, and even entire cities are already communicating together in ways that fundamentally change how people and systems interact. This evolution continues to rapidly impact our world.

Today, businesses across a broad range of industries and geographies have an opportunity to leverage the power of digitalization to revolutionize their operations and realize a vision of a connected enterprise.

Improving efficiencies requires more than just selecting the right set of digital tools from the many on the market today - it requires integrating disparate tools to deliver their expected value.

Many of the out of the box solutions offered today require a rip and replace process with a new vendor specific system or force you to manage multiple interfaces to realize value from each application. In the future, these independent systems can limit your ease of expansions or upgrade as technology advancements in our industry improves.

Solution
Our Intelligent Operations Network (ION) platform, a vendor-agnostic, centralized management system that seamlessly connects siloed systems and devices. ION contains a modular suite of applications that address safety, security, accountability, compliance, and performance within industrial sites and facilities. Because we own ION, we are able to scale and build in any customization to suit your specific needs.

ION integrates hardware, IIOT devices, and applications with a robust engine for rules, events, and notifications into a single tailorable platform. It uses active monitoring to enhance security and reliability, and automates personnel safety and accountability with location tracking, mustering, and emergency notification. Condition based monitoring and asset material tracking improves uptime and availability.

A mature open architecture platform, ION has been successfully delivering advanced digital solutions in industrial facilities since 2009. It is built to use a variety of off-the-shelf hardware components to monitor and collect data.

Outcomes
ION enables you to leverage existing investments, source the right digital tool, and seamlessly connect with other applications to achieve your specific business objectives.

Integrated  Scalable/Future-Proof  Customizable
The ION Platform

ION integrates hardware, IIOT devices, and applications with a robust engine for rules, events, and notifications into a single tailorabale platform. It uses active monitoring to enhance security and reliability, and automates personnel safety and accountability with location tracking, mustering, and emergency notification. Condition based monitoring and asset material tracking improves uptime and availability.
Connected Construction Solutions

Challenge
Construction projects are complex and have many moving parts. Even a small slippage in productivity over time can have a drastic impact on cost and schedule.

Personnel, equipment, and material interdependencies create complexity in construction environments that result in uncertainty in cost and risk estimation and management.

For example, a foreman faced with increasing amounts of paperwork and administrative tasks have limited time at the workface leading the craftsman, resulting in decreased productivity and an increase in safety incidences.

Productivity in manufacturing has increased 1.7X over construction in the past 2 decades

Solution
We provide comprehensive Connected Construction Solutions that improves productivity, reduces risk, and improves predictability. These integrated modules streamline the flow of information during project execution.

Our solutions and services include:

- Wireless infrastructure design, installation and / or integration for data connectivity. This foundational layer enables or accelerates value creation for other solutions
- Personnel Location using Wi-Fi / LTE / GPS to improve safety and productivity of the workforce. This streamlines the accountability of personnel in emergency situations and offers tools to help debottleneck onsite activities
- Material Location using active and passive location devices to efficiently manage the supply chain
- Equipment location and utilization using LTE / Bluetooth to maximize usage and reduce costs
- Worker Mobility using tablets / cellphones to provide information at the workface where it is needed. This 3D model, schedule, progress, work package documents, and RFIs are available in the field, maximizing construction leadership time with craft to improve productivity and reduce safety incidences
- Digital Workflow using mobile forms for electronic entry, approval routing, and 3rd party system integration to reduce costs, errors, and the time it takes to report and act on site activities. Progress can be seen and acted upon daily vs. the 1+ week that are norms for the industry and manual data entry is reduced and even eliminated by connecting disparate systems

Our integrated solutions provide information when and where it is needed in order to make better decisions and produce better business outcomes.
Outcomes

The return on investment (ROI) for our connected construction solutions are realized across multiple key areas: productivity, cost, schedule, and safety. Near real-time reports and performance indicators increase productivity and provide better visibility into cost, schedule, performance, and identification of desirable work strategies and viable alternatives.

Recent results from USCG Petrochemical Project ($500 MM TIC with 1,000 Peak Craft personnel)

- Engineering drawing and 3D model updates were immediately available to construction via tablets, allowing supervisors to spend 15% more time in the field rather than the office.

- Real time monitoring of supply chain simplified complex logistics and allowed seven (7) laydown yards to be managed as one, resulting in a 285% ROI on the technology cost.

- Over 2,000 safety observations per day were automatically processed, improving the Safety response to observations and trends.
Intelligence Asset Management

Challenge
Optimizing maintenance and care plans for industrial facilities requires a balance of operability, cost, warranties, and reliability. Most facilities utilize time based care plans for assets. The most common time based care is preventive maintenance but also includes cleaning, inspection, predictive data collection, lubrication, overhaul, component replacement, and adjustments. This method provides certainty at the cost of over spending and redundant activities that produce little to no extra value.

The frequency of time based care is set based on industry norms, manufacturer recommendations, user experience, and other factors. Additionally, care routes are set based on experience; and once set, time based care is rarely reviewed in terms of cost versus effectiveness.

This approach does not allow for any optimization or efficiency gains beyond what was originally set in the care plan.

1st quartile performance companies, spend
60% or more
of total maintenance on labor hours
that are preventive and predictive
time based care

The top 50% of companies have
maintenance cost per year equal to
1.5 - 2.5% of
the total asset replacement value

Solution
A Care Optimization system and associated services can provide the added value of reducing time based care costs while mitigating the risk of equipment failure. Combining our industry design, engineering, equipment, and operations & maintenance experience with powerful analytics tools we can develop a system specific to any facility that continually evaluates and provides data for the needed adjustments for care plans.

We connect into the data that resides in Computerized Maintenance Management Systems (CMMS) such as SAP, Oracle, and Maximo, and historical data bases. We automatically extract the data and leverage our proprietary care and maintenance database for storing data and assisting with the analysis by our asset management SMEs. We integrate a real time analytical process that compares hours and costs for time based care versus the rate of failure and cost to repair for specific assets to optimize the costs and downtime.

By accessing and analyzing selected data remotely, our SMEs can optimize the frequency of the time based care.

Our system provides continual adjustments and updates as needed in order optimize the care plan on an ongoing basis and does not allow the care plan to fall back into a set time based plan that results in inefficiencies.
Asset Connect – System Integration

Facility Data
Availability
Maintenance Downtime
Cost Of Downtime In Production
Frequency Of Planned Care By Type
Labor Hours For Planned Care By Type
Materials Cost Of Planned Care By Type
Breakdown Repair Labor Hours
Breakdown Repair Materials Cost
Maintenance History
Repair Hours Resulting From Planned Care
Failure Codes
Labor Costs
Parts Consumption

SME
Map And Validate Input Data
Validate Analysis
Provides Recommendations

Analytics Expert
Build Dashboards
Analyzes Code

Outcomes
We have achieved savings of 30% of the associated maintenance labor costs tied directly to historic time based care plans, which is 20% or more of the total maintenance labor costs.

Asset Replacement Value
Annual Maintenance Budget
Annual Budget Tied Directly to Preventative Maintenance
Our Solution has a Possible Annual Savings of

$500MM $10MM $6MM $1.8MM
Challenge

Most facilities in every industry have problem assets that cost them disproportionately more downtime and maintenance cost than the rest of the assets combined. These problem assets are often called “bad actors”. Beyond the cost of downtime and maintenance, bad actors distract leadership and drive maintenance toward reactive responses.

Elimination of bad actors requires identification, prioritization, an improvement plan, and monitoring. Plans must identify and mitigate all sources of defects – design, process, operations, maintenance, materials and storage.

Studies have shown the cost of unplanned and emergency work increases

3-9X
more than the cost of planned work

Jacobs experience is

80% of the maintenance risk and cost lies within

5% or less of the critical assets

A Jacobs specialty chemical customer was living with avoidable Bad Actor costs of

$9MM per year

Solution

A Bad Actor elimination system and associated services can reduce downtime and maintenance costs. Combining our industry design, engineering, equipment, and operations & maintenance experience with powerful analytics tools we have developed a defect elimination platform for any facility that continually assesses data to identify and rank Bad Actors. Our platform enables defect identification leading to defect elimination.

We connect into the data that already resides in common operations and maintenance databases.

We automatically extract the data and leverage our proprietary failure and maintenance platform for storing data and assisting with the analysis by an SME. We integrate a real time analytical process that compares downtime frequency, duration, maintenance labor hours, materials, and other costs to locate the worst Bad Actors for elimination.

Suites of sensors can be added to the Bad Actor assets as appropriate to enhance the data sets for ongoing analysis supported by predictive analytics and machine learning applications. By accessing and analyzing selected data remotely, our SMEs can identify the sources of defects so they can be eliminated. The suite of added sensors can be removed once the defects have been eliminated or left in place for ongoing monitoring to assure sustained value.

Our system provides continual updates in order to refresh the bad actor list and help leadership make decisions on where to spend their efforts to minimize lost production and cost.
Outcomes

Applying a Bad Actor program based on real time data provides leadership with better decision making tools that reduce downtime and costs.

For a plant with a $500MM replacement asset value (RAV) a reactive culture drives the maintenance budget to 4% or more of RAV. This represents a maintenance budget of $20MM annually with 30% or more spent reacting to break downs. If Bad Actors represent 80% of effort, then the cost of Bad Actors is $16MM per year. That is without factoring in lost production.

NASA Langley from 2006 to 2010 found that 80% of their total maintenance labor hours were expended on only 8% of their assets and 80% of the reactive hours were spent on only 2% of the assets. 80% of reactive maintenance material costs were for only 0.7% of the assets.
Mechanical Integrity - Digital Inspection

**Challenge**

The containment integrity of mechanical assets (piping, tanks, pressure vessels, valves, pumps, compressors, etc.) decreases over time due to internal and external corrosion and erosion.

Companies follow standards (API) and regulations (OSHA) ensuring the integrity of their assets to prevent the unintended release of gases and liquids to the environment. The mechanical integrity of these assets is managed through a Process Safety Management (PSM) program. Many PSM programs incorporate a Risk Based Inspection (RBI) process that measures asset condition and evaluates the risk of loss of containment due to corrosion and erosion. A key part of RBI is measurement of wall thickness and inspection of exterior corrosion, especially under insulation (CUI).

Critical assets are inspected visually and with instruments to detect changes in surface condition and/or wall thickness. The thickness changes are compared to the original wall thickness of the asset and calculations are performed to evaluate the integrity of the asset. When the thickness is close to or at the minimum, repair procedures are devised.

The regular inspections and measurements can be used to predict the life the asset so changes to the corrosion/erosion mechanism can be implemented or the asset can be repaired before the minimum allowance is reached. The corrosion/erosion mechanism can accelerate between inspections putting the asset at risk.

Conversely, if inspections are too frequent while there is little change, the cost of the inspections exceeds their value. The management of the PSM program makes changes to inspection frequencies to optimize cost/risk.

Many companies/sites do not have dedicated resources to frequently inspect assets.

These measurements and inspections are labor intensive. Measurements are subject to error based on the skill and experience of the practitioner. Visual inspections are subject to interpretation by the inspector.

Physical access to the location for inspection often requires building scaffold, removing insulation, cleaning the pipe/tank surface, taking the measurement, replacing the insulation and removing the scaffold. Substituting a man-lift for the scaffold requires the costs of the equipment and operator. Taking a single thickness measurement could cost one thousand dollars ($1,000) in labor. Multiply this by dozens or hundreds or even thousands of points quarterly, the costs could be $200,000 to over $1,000,000 per year just to collect the data.

The volume of data requiring review and analyses can be overwhelming leading to poor decisions, missed opportunities to reduce costs, and in the worst case, loss of the asset integrity requiring replacement or expensive repairs.
Solution
Jacobs can supplement or implement an existing RBI program with sensors to reduce the cost of data collection. The sensors can be wired, wireless, or networked through telephone connectivity.

Jacobs solutions are agnostic regarding hardware and software and can accommodate disparate vendor sensors. Sensors are selected based on the best application to the asset and data acquisition system.

The collected data can be hosted on site or in the cloud. The data can be real time or historical data transmitted at regular intervals.

Jacobs supports the risk decision making process by creating trends and dashboards to collect and analyze the data. Jacobs Subject Matter Experts (SME) advise on the calculated results and recommend repair plans when required. Predictive analytics and machine learning provides the way to analyze large volumes of data. This supports decision tools for determining when an asset needs to be taken out of service or if the interval to next turnaround can be extended.

Analytics also provides information that can be used to remove or move sensors to optimize the number and cost of data.

Installed sensors provide a higher level of accuracy than hand held readings and do not require removal of insulation. They also do not require people being exposed to hazardous environments.

Real time data and analytics provide results without delay thereby reducing risk.

Jacobs can manage all of the records and the program or support the customer PSM/RBI program.

Outcomes
Customers will get better more timely information to make decisions on critical asset risks at a lower cost per point without exposing people to a hazardous environment.

Predictive analytics based on real time streaming data will allow better decision making on extending outages.

Cost savings in labor of $200,000 to over $1,000,000 per year directly tied to mechanical integrity inspection.
Spare Parts Optimization

**Challenge**
Spare parts are considered the key element of Maintenance, Repair, and Operations (MRO) management. Spare parts constitute 40% to 60% of annual maintenance costs. Shortages of critical spare drive down asset availability. Overages of spares drive inventory costs up. The holding cost of spares can be as much as 30% of the purchase price considering storage, management, depreciation, loss, and preservation costs.

For a best in class plant valued at $500,000,000 TIC, the replacement asset value (RAV) would typically be $200,000,000. That same company would have 1% of RAV in inventoried parts or $2,000,000 that would cost approximately $600,000 each year to hold in stock.

The facility would have yearly maintenance costs of about 2% RAV or $4,000,000 per year. About half of that cost would be attributed to spare parts and asset associated materials. That’s $2,000,000 in parts and materials each year.

Best in class companies represent about 25% of all companies. Therefore, 75% of all companies are spending more than $2,600,000 per year on MRO for maintenance and are sustaining an inventory of critical MRO valued at $2,000,000.

Unfortunately, in long existing warehouses there are also items heal in inventory that are no longer needed to support the current assets. They are items that experience no turnover but there is cost associated with storing them.

Decisions on what is held in stock should be based on facts not suppositions or inventory cost mandates.

Operations should not overstock critical spares as insurance when the usage is not supported by asset history or production rates.

Maintenance should return unused spares or spares held near the work face should be visible in the inventory.

The challenge is striking a balance between asset availability and inventory costs.

**Solution**
The balance of asset availability and inventory costs can be done, if there is accurate information for decisions.

Jacobs will assess the inventory to assure that the spares for critical assets, assets that are run to failure, rotatable spares, and those spares held by suppliers are optimized to balance the cost of downtime risk to inventory.

A spare parts interchangeability analysis will assure that interchangeable parts are identified for an accurate count.

A digital parts tracking system will be implemented.

This would be through use of scanned labels, passive and active RFID tags as appropriate. High value parts are tracked with active RFID. All items that require preservation should be identified with RFID and be in the preventive maintenance program. Parts and tool kits would be tracked as a kit from the warehouse to the workface with RFID. Planners and craft would know that the kit was at the job site before traveling there.

By collecting data on actual parts usage, predictive analytics and machine learning for asset can provide decision support tools for changing parts quantities and reorder points.

By identifying all inventories. The system will allow the user to manage multiple warehouses as one virtual warehouse. Interchangeable materials across multiple warehouses can be managed as a single combined inventory to sustain the overall need.
A best in class company would have 1% of RAV in inventoried parts or $5,000,000 that would cost approximately $1,500,000 to hold in stock.

**Outcomes**

Customers who are not best in class can achieve best in class. Moving from second or third quartile to first quartile could lower inventory costs $1,500,000 per year for a facility valued at $500,000,000.

A similar first quartile facility could achieve a best in class savings of $500,000 or more each year in inventory costs.

These savings exclude the added savings that can come from reducing warehouse labor and by right sizing the warehouse or consolidating warehouses.

The 30% cost of holding inventory can be reduced as the tracking system will reduce lost parts, theft, and parts that are not fit for service due to deterioration.

Additional savings can be obtained by including tools and other tool room stocked equipment in the program.

For an existing facility valued at $500,000,000 TIC savings per year of $1,000,000 or more are possible in less than two years by optimizing inventory and reducing holding costs.

For a greenfield facility, a spares optimization program implemented during detail design will reduce the size of warehouses and reduce initial inventory by $500,000, more if availability analyses drive asset reliability and reduce the need for spare assets.
Warranty Management

Challenge
Asset warranties represent a significant cost on new assets. 1.5% of the cost of an asset can be warranty cost. While that might not seem like much, that is $7,500,000 for new chemical plant or $22,500,000 for a new refinery. Warranty costs in the USA alone average over $25B per year.

Warranties often receive little attention by operations and maintenance because they were paid for in a project budget. This leads to complacency resulting in:

- Many warranties expire before the asset is installed.
- Often costs of repairs are paid out of pocket when warranties are in place.
- Warranties can expire or be extended without a decision based on facts.
- Warranty claims are often denied by the OEM because the owner can’t prove that operations and maintenance were performed to requirements.
- OEM care costs for service to sustain a warranty can be unreasonable but sometimes are tolerated to minimize risk.

Solution
The potential solution and resulting savings depend on the scope of supply and control given to Jacobs.

For new facilities, if given the design, procurement, installation/commissioning, and maintenance scope, Jacobs warrants the assets at cost considerably below standard OEM and constructor’s costs. Since Jacobs designs for reliability and health monitoring, selects assets with known reliability, assures correct installation, and performs the optimum necessary care, the risk is lower and therefore Jacobs can self-warrant the assets at a lower cost to the owner.

For existing operating assets, we assess the current asset condition and the warranties in place. Jacobs will implement a Warranty Management program that assesses recommended OEM care against common best practices, negotiate terms with OEM’s, integrate the warranty care plans and term into the CMMS, monitor scheduled care frequency and costs, represent the owner in repair/warranty claims, optimize the care and warranty costs, recommend changes to care and warranty extensions, perform predictive analytics and machine learning to evaluate cost/risk. We would expect you to recover the cost of program and fully benefit within six months.

Outcomes
Customers have Jacobs as an advocate who places focus and effort on getting the most value out of warranties, reduces the cost, and manages claims. We reduce the cost of failures and increase warranty recovery.
Challenge
Lubrication is a foundational element that makes it possible for assets with rotating or sliding parts to deliver on their value proposition.

Over or under lubrication, the wrong lubricant, contamination, leakage, and other causes can cause or accelerate asset failure.

Sampling lubricating fluids is common practice in industry. Most sampling is done by manually collecting samples for analysis by specialized outside laboratories.

Manual sampling is expensive ($25 per point based on current labor rates), subjects the samples to potential contamination, and sample bottles can be mislabeled or lost.

Laboratory analysis can be as simple or complex as required to assess lubrication condition and life. Common analyses are: clarity, viscosity, moisture, wear particles, acidity, base, spectrometry, infrared spectroscopy, ferrography, foaming, rust prevention, and oxidation stability. The cost of basic analysis is approximately $30 per sample.

Asset condition and life associated with lubricant condition are closely tied with clarity, viscosity, moisture, wear particles, and ferrography. These key factors can be used to determine overall asset condition. The other tests can be used to identify lubricant issues.

Greases are usually only sampled when there are asset condition problems. Once the proper grease is selected for the application, grease is added as required to maintain lubrication. Over greasing is as damaging as under greasing. New tools such as acoustic sensors in grease guns can assure the right greasing levels. Greasing is done by manually by operators or technicians and the labor per point is approximately $15 per point.

A typical refinery may spend 50,000 manhours on lubrication each year at an estimated labor cost of $2.5M per year plus another $50K to $150K for laboratory results. Analysis of results, and management of a lubrication program, requires a full time trained subject matter expert who adds another $100,000 or more to the cost each year.

Solution
Jacobs will implement an online oil analyses program for critical assets minimizing the need to take manual samples. We determine the best sampling points and install continuous sensors connected to a database that can be on your site or hosted by Jacobs.

The results and analyses by our SME’s will be available online including dashboards, displays of trends, reports, and actions requiring decisions. Detection of problems with oil condition will be alerted for immediate verification and resolution. Predictive analytics and machine learning will be used to estimate lubricant and asset life.

Jacobs will implement the program and execute the work. The customer will get machine health data and failure risk information as needed to make decisions.

If coupled with a Jacobs partnering lubrication provider, Jacobs will provide all lubricants and hydraulic fluids, dispose of used fluids, and warrant the assets for any repair costs for unpredicted failures.

Outcomes
Customers will save labor and laboratory costs on lubricant sampling and avoid field exposure for lubrication technicians. Test results will be available real time with access from computers and mobile devices. Alerts for potential problems will be sent to users in text and email messages. Predictive analytics and machine learning will provide improved estimates of lubricant and asset life.

The cost of the lubrication program will decrease over time and unexpected failures due to lubrication will be eliminated. The cost of implementation is typically paid back the first year.
Digital Leak Detection & Repair (LDAR)

**Challenge**

EPA has found significant widespread noncompliance with Leak Detection and Repair (LDAR) regulations. EPA estimated that as a result of this noncompliance, an additional 40,000 tons of VOCs are emitted annually from valves at petroleum refineries alone.

Leaks pollute the atmosphere, are a safety hazard, and cause loss of product.Leaks can result in fines and loss of reputation. EPA has estimated that product losses average $1,370 per ton and eliminating leaks could save $700,000 per year per facility.

Leak sources include pumps, compressors, valves, flanges, connectors, sampling points, pressure relief valves, tank seals, etc. In a typical plant there are more than 20,000 potential sources of leaks.

The typical LDAR program includes identifying potential leak sources, defining leaks, monitoring the sources, repairing components, and keeping records.

The detection of leaks is more complex than the repair aspects. Detection is also labor intensive. Inspecting for leaks at height often requires scaffolding or man lifts.

Detection of leaks is highly dependent on the instruments used, placement, and instrument calibration. Sensors employed include portable and remote gas detection, infrared cameras, and ultrasonic.

Management of the inspection and repair data is time consuming and difficult to manage. There can be lost savings opportunities when data is not regularly analyzed, and inspection and repair data is not correlated.

**Solution**

Jacobs can implement an LDAR program that integrates disparate data into a database that enables dashboards of key performance indicators, and most importantly, performs analytics on the inspection and repair data.

Data analytics and machine learning provides actionable information to identify ways to eliminate leaks, optimize inspection schedules, and track the cost and effectiveness of inspections and repairs.

**Outcomes**

Customers will reduce leaks and thereby save production losses and fines. The LDAR program will be optimized to decrease inspection costs. Analytics will provide information that will identify the most cost-effective repairs. The entire LDAR program will be documented in a format that is up-to-date and compliant.

EPA has estimated that product losses average $1,370 per ton and eliminating leaks could save $700,000 per year per facility.
Machine Learning for Analytics, Optimization and Control

Challenge
Industry has historically found difficulty in transforming the large amount of data they have stored related to the operations of their facilities into useful information. Supervised and unsupervised Machine Learning (ML) techniques can assist Process Optimization Engineers and Plant Managers where historical methods have been limited by the experience, time and bandwidth of individuals. ML can be applied whether a site is looking for deeper insight on plant performance, developing the ability to predict future parameters, or optimization of existing control strategies. Unfortunately, few sites have the ability to assess the data, data structures, and conditioning needed to apply these techniques effectively for tangible results.

Solution
Jacobs helps clients build and deploy ML platforms to optimize their operations and capabilities. Jacobs draws upon the extensive domain knowledge of our Analytics and Process SMEs, Big Data Analytics resources of our Technology group to guide clients in:

Connecting devices – Jacobs assists with the appropriate level of industrial Internet of Things (IoT) device buildout based on gaps in existing data availability, strategic requirements, constraints on data throughput, distance-based connectivity issues and data sensitivity.

Collecting data – Jacobs evaluates the various architectures/technologies that are available to collect, process and store the data depending on considerations such as overall system size, on-premises versus cloud services.

Learning from data – Jacobs delivers a Machine Learning and Analytics platform based on the client business requirements and our knowledge of industry tools to develop the most effective solution on the appropriate platform to fit their needs.

Integrating data and assets – Jacobs solutions include dashboards, alerts and connectivity to other systems tailored to client needs for monitoring. Jacobs also engineers solutions capable of integrating the ML system with the Control System and Advanced Process Manager applications to truly close the loop with the site’s assets.

Outcomes
Machine Learning models are able to process large volumes of available data in real time at a volume and scale never before possible, enabling the discovery of new insights, advanced optimization and accurate prediction of future performance.
Heat Exchanger Monitoring and Analytics

**Challenge**
With rising energy costs and tighter environmental pressures, refineries are placing renewed focus on energy-reduction projects. For many refineries, the crude preheat provides one of the largest potential energy savings focal points. In addition, fouled exchangers contribute to reduction in crude capacity and lower separation efficiency which can result in reprocessing and recycling of crude unit product streams. All of which can have a significant impact on commercial returns.

Knowing which exchangers to clean and when is often difficult to determine in a complex exchanger network. Current methods are typically based on general plant experience and specific employee’s knowledge. Unfortunately, this approach may not be 100% accurate and missing the opportunity to clean the right exchangers within a critical turn around scope or process slow down can have serious process impacts for the entire run, especially those sites looking to maximize throughput or extend run length.

**Solution**
Our exchanger monitoring system creates a custom thermodynamic simulation model of your crude preheat network and connects it to your plant operating data. Connecting the plant data to the model creates a reconciled process model of the entire network that can be used for both on-line tracking of any degradation of efficiency of the system as a whole or an individual exchanger basis, as well as allowing off-line use to perform what-if analysis on proposed exchanger cleanings. In the on-line mode, the system can be used to track individual heat exchanger fouling coefficients, time averaged degradation of coil inlet temperature, and potential fouling caused by specific crude types or different modes of operation.

In the off-line mode, the fouling coefficient of any exchanger can be changed to a clean status and rerun in the network to determine the overall impact of cleaning one or more individual exchangers, thus making sure the optimum exchangers are selected for cleaning. Our system interface also allows the users to add additional functionality process economics such as downtime impacts and cleaning costs.

**Outcomes**
Optimizing the cleaning frequency of crude pre-heat exchangers can help reduce energy consumption by up to 10 percent of the total energy consumed in the unit. For a 250,000-barrel-per-day refinery (~ 12 Million Tons Per Annum), that could mean a savings of as much as $200 K/yr in energy alone. In addition, improved capacity and separation efficiency achieved through an optimized exchanger cleaning program can return benefits well in excess of the energy cost reductions.

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**Quote from a refiner:**
“… Typically 2-3C of FIT is recovered in a year by judicious selection and cleaning of exchangers using this model…”

Our Exchanger monitoring system can also be developed for other heat exchanger networks.

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**Diagram:**

- **PI Historian**
  - Historical Data
  - Request PI Data
  - Screen Data
  - Data to Hysys
  - Review Results
  - Store Results

- **Exchanger Monitoring System**
  - Screened Data
  - Hysys
  - Calculate UAs
  - Calculate Lost Duty
  - What if Scenarios

- **Calculated Results**
Digital Energy Management and Performance Analytics

**Challenge**
An effective energy management program in place is necessary to address the increasing demands to reduce carbon footprints and address the never-ending battle to reduce operating costs. For example, the difference between a typical top tiered and bottom tiered 200 kbpsd refinery can be up to 25MM$/yr. Unfortunately, most sites struggle to build and maintain effective energy efficiency programs. Too often energy programs focus too much on reporting energy and not enough on finding sustainable improvements. Also, even the best programs tend to decay over time as they lose focus due to competition from the continuous barrage of ever rising issues.

**Solution**
We have combined our extensive energy consulting expertise that help clients build their programs and identify energy solutions with a suite of energy monitoring and analytic tools all built on a digital platform. By joining these systems, we offer a highly sustainable system that allow focus on improvements over reporting.

In addition to an accounting based foundation for the energy use, this system is designed to incorporate the site work practices and accountabilities to assure that energy information is provided directly to those responsible for operating the equipment. This process has the advantage of distributing responsibility to those who can make the greatest impact.

Our custom programs also incorporate subject matter expertise through the use of energy workshops, providing industry benchmarks and best practices, and training on methodologies for analyzing energy use. We work closely with site staff to assure the system is properly designed for each client and industry.

Each system is custom designed to meet the client’s needs and resources. Additionally, all programs focus on the principle that energy use is optimized based on trade-offs to yields, capacities and safety.

To keep the system adoptable and evergreen, performance targets and KPI’s are all easily modifiable to a adopt to changing conditions and improved performance. Additional features can also be incorporated including CO2 emissions reporting or steam and fuel gas balance calculations.

Our solution integrates the following performance indicators:
- Comparisons of energy per unit production
- Performance vs both industry standards and best historical performance
- Cost of energy per unit or area
- User configurable energy indicators with estimated cost impacts
- Information on possible trade-off values with capacities or product quality
- Historical energy gap cumulative costs

**Outcomes**
The final delivery is not just a study and a list of improvements, but a fully functioning Energy Management Program that is built for sustainability and ease of use. Metrics are built into the tool that clearly track performance to demonstrate real energy savings.

In a recent study, a multi-site program identified and implemented 15MMS$/yr in documented energy improvements within a year (~3% reduction in energy use) using only no-cost solutions.
Challenge
Industrial Control Systems (ICS) have become highly-integrated open systems. The advantages of open systems allow integration of disparate control systems in an operating environment to more efficiently operate and increase margins in industrial manufacturing. Unfortunately, with the open systems comes added cybersecurity vulnerabilities that must be mitigated to maintain the safety risk profile provide of the client.

Existing communication networks and protocols at the Process Control and even at the instrument level do not have established standards or guidance to defend against cybersecurity threats. The threats at these levels allow intruders to go around existing cybersecurity programs if not mitigated.

The expertise to assess ICS Cybersecurity vulnerabilities maintain ICS Cybersecurity mitigations and deal with ICS Cybersecurity attacks is lagging the demand. The skills to reduce ICS Cybersecurity risk require an understanding of control and safety systems designed today and 10 to 20 years old systems. These skills are difficult to develop in a manufacturing environment where operational demands outweigh ICS Cybersecurity tasks.

Solution
Jacobs has a rich history of cybersecurity experience with multiple governments, oil & gas, and many other industrial industries. This experience combined with our domain expertise provides a unique offering or a complete solution in our industry.

An ICS Cybersecurity Risk Assessment is the first step to reducing the risk of an ICS Cybersecurity attack. Jacobs uses a high-level risk assessment process following industry standards guidance to quickly assess the client’s ICS Cybersecurity risk. Identified gaps are ranked and recommendations are provided to the client for short term mitigation and longer-term ICS Cybersecurity management.

This provides the client with a roadmap to manage ICS Cybersecurity risks within budgetary limits.

Outcomes
- Major component asset inventory and network diagrams
- Risk ranked ICS Cybersecurity Gaps
- Recommended mitigation for high consequence risks for immediate action
- Recommended Policy and Procedure modifications/additions
- Recommended roadmap for maintaining ICS Cybersecurity risk reductions program

54% of Industrials surveyed reported a cybersecurity incident in 2017*

Shipping company Maersk says 2017 June cyberattack could cost it up to** $300MM

*Kaspersky 2017 **CNBC 8/16/2017
ICS - Design, Implement, and Construct

Challenge

Many existing Industrial Control Systems (ICS) networks were not built considering the cybersecurity environment we now live in. To build a new ICS secure network or modify an exist ICS network to be secure, it takes an in-depth knowledge of control and safety systems that may be new or 10 to 20 years old. It also takes an in-depth knowledge of current cybersecurity methods and tools to provide the cybersecurity risk reduction that meets the needs of a client corporate risk structure.

The expertise to design or modify an ICS network has become scarce. These skills are also difficult to maintain in a manufacturing environment where demands to keep systems operational for safety reasons outweigh ICS cybersecurity tasks. Resources to design new or modify existing networks is frequently not available.

Outcomes

- Design plan and implementation services to intrinsically secure and efficiently operate resilient ICS Network to meet business and risk objectives
- ICS Cybersecurity gap closure plan based on industry standards: NIST SP 800, IEC 62443, IEC 61511, ISO 27000, NERC CIP, NEI 08-09, AWWA G430-14 and others
- Tools to test, monitor, manage and maintain the cybersecurity and reliability of the ICS environment
- Documented operating procedures and training to meet cybersecurity objectives

Solution

Jacobs offers design, implement and construction services to provide clients ICS Secure Networks considering the entire lifecycle of ICS networks including cybersecurity, consulting, design, integration and support. Jacobs leverages aerospace and military experience to design and build security into new and existing ICS networks. Jacobs’ deep expertise and holistic approach to plant safety and security provides an integrated approach to cybersecurity. This approach starts with an ICS Cybersecurity assessment for existing networks.

- TRITON – A recent successful Safety Instrumented System cybersecurity attack. (In 2018, US researchers have traced this attack to a nation state entity.)
- IIoT Pivot – Hacktivists pivot into an ICS via a poorly-defended cloud vendor. (ICS-Cert)
- Compromised Vendor Website – Hacktivists use a compromised vendor’s website to insert malware into a software update, malware that targets specific industrial sites. (ICS-Cert)
- Hardware Supply Chain – An intelligence agency grade attack intercepts new computer destined for an ICS site and inserts wireless electronics. (ICS-Cert)

Jacobs has deployed 48 secure ICS Networks and are continuing to manage 18 of these networks for the client.