The Internet of Things:
Understanding the Adventure

sas
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INTRODUCTION

The Internet of Things (IoT): a simply complicated endeavor. Connect some things, analyze the data and act. If only it were so easy.

Despite increasingly proven value of IoT initiatives, broad enterprise adoption remains low. From creating a persuasive business case for investment, to effectively corralling the data, to changing legacy systems and processes to act, challenges abound.

The path to IoT success must be deliberately laid. Whether you are exploring the IoT's potential or actively planning your organization's journey, this guide is here to help.

Where will you begin?

$11 Trillion
in Economic Impact by 2025
- McKinsey

For a glossary to all things IoT:
Nongeek's A-to-Z Guide to the Internet of Things.

HOW TO USE THIS BOOK

This interactive PDF contains links at various points that allow you to customize your reading experience. Navigate the pathways that matter to you or read along page by page. The choice is yours.

Let's get started...

Choose Your Path

REVIEW
IoT Foundations

LEARN
about IoT in Industry

PLAN
Your Journey

IoT Foundations

Choose Your Path:

THE BASICS

At the most basic level there are three steps to putting the IoT into action:

ACQUIRING relevant data.

ANALYZING collected information to generate insight.

ACTING on found insight at the right place and time.

This pattern is no different than other analytics-enabled endeavors. However, the advent of connected things enables organizations to:

- **Capture information** not previously accessible and at a level of detail not previously available. This may include current operating conditions, voice, video and environmental factors.
- **Extend their reach** outside of traditional enterprise boundaries. This may include connections in the air, on the road, at home and in the store.
- **Engage in intuitive, contextual interactions** with employees, partners and customers alike. This may include mobile interactions, virtual/ augmented reality and speech.

The combination of timeliness, location awareness and environmental context empowers a new level of business performance, operational efficiency and highly relevant, differentiated experiences for everyone from internal employees to end customers.

However, the value of the IoT does not come easy. To succeed, organizations must have highly developed data and analytics practices, robust operational technologies and agile IT chops, as well as the ability to navigate change and manage risk.

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WHY NOW?

A major force in digital transformation, the IoT has been enabled by increasingly powerful computing delivered on shrinking containers, pervasive connectivity, and rapid advances in applied analytics and artificial intelligence (AI).

From shipping containers to turbine engines, drones to embedded collection devices for environmental sampling, there is almost no limit to what can be fitted with data collection or interactive capabilities and connected to the internet.

This is the fundamental opportunity and challenge underlying the IoT.

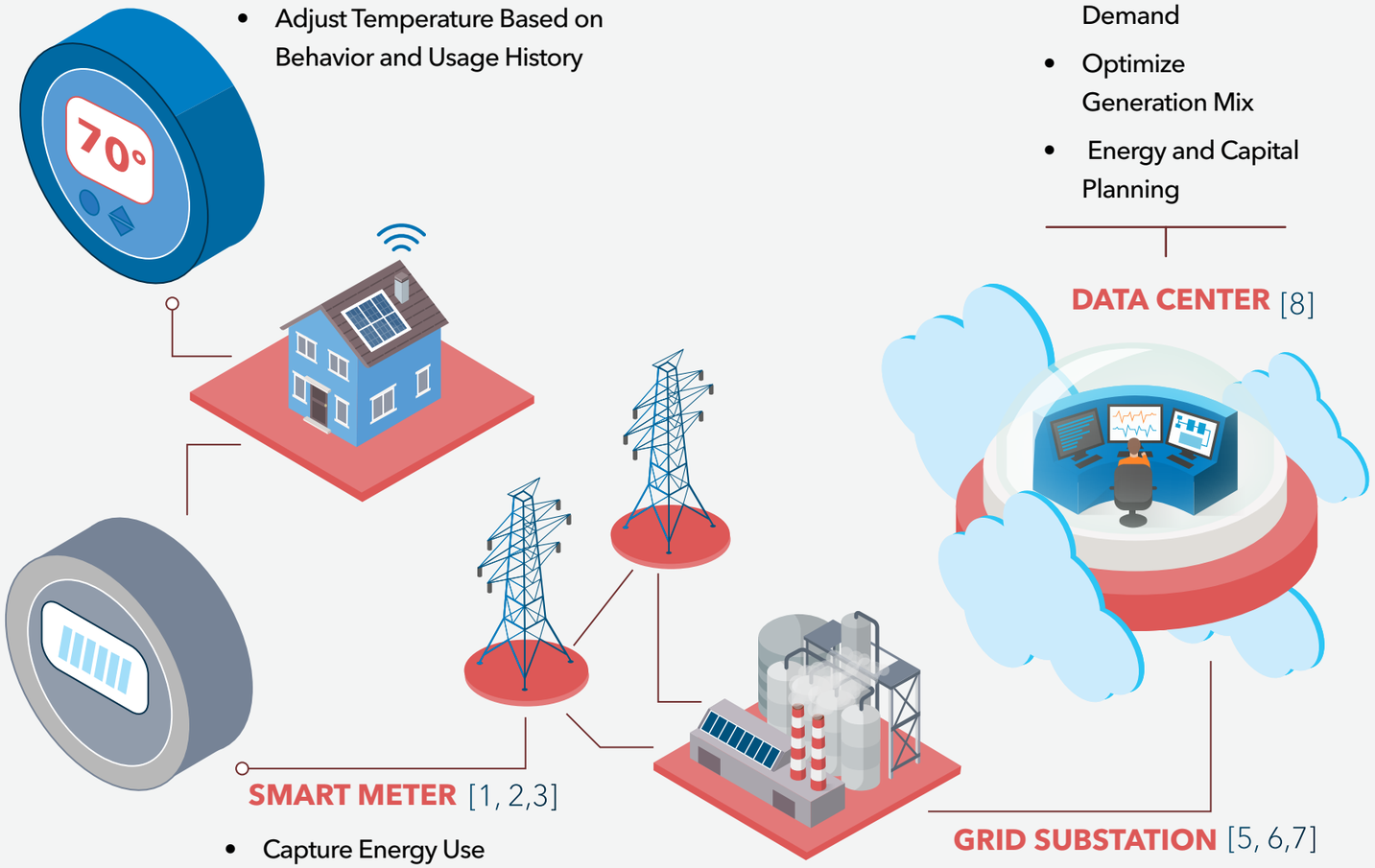
EDGE → **FOG** ⇢ **ENTERPRISE** ← (aka "Core")

SMART THERMOSTAT [1, 2, 3, 4]

- Adjust Temperature Based on Behavior and Usage History

- Forecast Aggregate Demand
- Optimize Generation Mix
- Energy and Capital Planning

DATA CENTER [8]



SMART METER [1, 2,3]

- Capture Energy Use
- Capture Power Quality

GRID SUBSTATION [5, 6,7]

- Analyze Grid and Asset Reliability
- Alert if Spike or Outage Detected

KEY CONCEPTS

1. **Endpoint** – A connected device (aka a thing).
2. **Edge** – On or very near the endpoint. The connection between endpoints and the network.
3. **Edge Computing** - Processing on or near an endpoint. May refer to the enabling infrastructure/environment or specific capabilities.
4. **Edge Analytics** – Analyzing data on an endpoint.
5. **Fog** - The local networks and entities between the edge and the enterprise.
6. **Fog Computing** – Processing/analyzing data in the fog (often within a local network).
7. **Streaming Analytics** - Analyzing data streaming (in motion) between the endpoint and enterprise. ESP can occur on the edge or in the fog.
8. **Enterprise** – Enterprise computing assets on the cloud or on-premise (aka the Core).

NOTE: It is apropos that the boundary of the fog can be foggy. In other words, definitional boundaries can vary. Where the fog begins and ends relative to the edge and the cloud is a matter of debate.

Continue to "Making the Case"
Select Another Topic

MAKING THE CASE

The transformation potential of the IoT is enticing. The path to achieving value is less definitive. It is tempting to start by slapping sensors onto – well, everything – and worrying about what comes next later. However, as early adopters learned the hard way, instrumentation for the sake of instrumentation is fraught.

IoT objectives fall into two broad categories: business efficiency/optimization or creation of new business models. While jumping straight to shiny and new is seductive, managing the change required can be overwhelming. As a result, many IoT projects flounder while others measure return on investment (ROI) not in months but years. This does not need to be the case.

To succeed, organizations must modulate enterprise aspirations against their ability to deliver and desired time to value. Identifying a portfolio of increasingly mature capabilities allows for a steady progression towards a holistically connected enterprise.

Make Money, Save Money, Stay Out of Jail

While the titled options are tongue-in-cheek, understanding the intended outcome is step one. What is the desired business objective: improved business efficiency, revenue growth, customer engagement and/or deployment of new data-driven products and services?

Specificity matters: enterprises are best served not to start with the universe of potential things. Rather, clearly identify how the result will be realized: today we do A, tomorrow we will do B, resulting in C.

The Customer Quid Pro Quo

What's in it for them? A deceptively simple question that can be difficult to answer, particularly in B2B contexts. Customer-centricity is a core tenant of digital transformation. Defining how value will be realized for you, your employees, partners or customers is critical.

Next, have affected parties affirmed your belief? Do they agree with the value proposition and will they participate? Be wary of delivering insight in isolation. Without a clear path to how insight delivers differentiated value, skepticism will obfuscate your ability to monetize the offering.

Critical Inflection Points

Is a critical mass of deployed things required to realize value? The required inflection point may result from the need for collective data to train the system or critical mass to act in a meaningful manner.

To the same end, what level of end user adoption or customer sales must be achieved to meet the established goal? Are there incremental steps to deliver value while ramping up to full-scale deployment or engagement?

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Top Emerging Applications:
Remote Monitoring, Asset Tracking and Predictive Maintenance

Time to Value and ROI

Investment or cost? Organizations that view the IoT as an investment are better able to realistically evaluate time to value and ROI. Especially as early endeavors establish – and therefore fund – core infrastructure and practices later projects leverage.

Stability or speed? IoT technologies such as GPS sensors and edge computing are evolving rapidly. Perceived risks of investing too early can be a barrier if not proactively addressed. This is particularly true in industries such as manufacturing used to making long-term investments at scale.

IoT-enabled products and services tend to be sticky and can confer early-mover advantages. Therefore, the potentially shorter lifespan of new, evolving technology must be deliberately recognized and weighed against the risks of non-adoption and participation. Consideration should be given to both capital investments as well as benefits of developing internal expertise and partnerships in IoT technologies sooner rather than later.

~25% of businesses using the IoT in 2019: up from 13% in 2014. - McKinsey

83% Return on targeted ROI achieved by IoT users with more than 5 years experience. - SAS

30% of IoT projects fail in POC due to implementation expense or unclear bottom-line value. - VentureBeat

Explore "Three Stops on the IoT Journey"
Explore "To Partner or Not to Partner?"
Continue to "Managing Change"
Select Another Topic

MANAGING CHANGE

The propensity with the IoT is to jump directly to reinvent existing processes and services or bypass the current business model altogether. However, most enterprises do not possess the requisite business and technology environments nor the agility required to navigate this level of disruption wholesale.

Too often, enterprise aspirations outreach the ability of the organization to change core business and technical practices while navigating the all-important people factor. A phased IoT strategy that meets the organization where it is at and incrementally builds requisite capabilities is more likely to succeed.

Managing Business Change

How will the proposed solution impact existing business processes and roles? Effective enablement requires clearly identifying how humans will engage with the technology and with each other. Start by identifying whether existing tasks will be automated, existing workflows augmented or both.

In many cases, employees may be asked to cede control over specific decisions to the machine. Or to take on a new role. This may be as simple as allowing a VR goggle to direct their attention towards a potential fault to trusting there is an impending failure at all. Proactively incorporating affected employees into the design process early and often is a prerequisite for success.

Delivering a new product or service to your customers or partners? They too should be incorporated into fast test-and-learn product cycles whenever possible.

Crossing the Digital Divide

Does your enterprise embrace collaboration? Value methodical, deliberate and right-the-first-time mentalities over iterative learning and experimentation? The IoT was born digital. Many businesses were not.

Learning to balance digital-native approaches with traditional industrial sensibilities is the crux of the conflict at the heart of digital transformation. Creating a collaborative, responsive environment that transcends traditional organization silos (business-IT, OT-IT, R&D-customer service, etc.) and embraces rapid and purposefully imperfect design iterations requires a plan. And patience.

Tackling the Technology

Are your IT practices agile? Do you favor cloud-native development practices? From extending your ecosystem beyond traditional operational boundaries to exponential increases in data volumes, adopting continuous integration/deployment (CI/CD) practices and applying DevOps to data and analytics, the IoT challenges traditional IT paradigms.

IT or OT? The IoT requires a level of integration between operational (OT) and information technologies (IT) historically uncommon. Developing effective working relationships requires a deliberate plan to engage and educate all parties; as well as redesign of long-standing standard operating procedures (SOP) and service level agreements (SLA).

Explore “Three Stops on the IoT Journey”
Continue to “Considering the Thing”
Select Another Topic

CONSIDERING THE THING

Things, like people, come in all shapes and sizes. Thankfully, when it comes to understanding a thing's role in the IoT, things get considerably simpler. A thing can collect data and/or act. In some cases, a thing may act alone. In others, action must be taken in concert with other things, business processes or systems.

Understanding where and how a thing – be it a sensor, camera, drone, engine or shipping container – will be deployed is the underpinning of a comprehensive strategy.

Ownership and Control

Who owns and controls the target device? Does the target device already exist in the target environment, or must it be deliberately placed? Is the target stationary or mobile?

Simple questions, yes. But required to determine how both the physical asset and associated digital applications will be accessed and maintained. Connectivity requirements and challenges for a drone are quite different than those of a machine on the shop floor or a mobile phone in the hands of a consumer.

Innate Data Capabilities

Is data of interest collected natively by the target device/hardware? If the target device or environment must be modified, consider whether integrated componentry is commercially available. Alternatively, integration can occur in-house, although cost versus time to market should be considered if this will not be your core business.

If the manufacturer or a third party will modify the device, who owns the data? More specifically, is data access provided as an integral part of the product or as a subscription-style data service?

To Observe or Act

Is the thing a connector, a reporter and/or an actor? Clarity regarding this point underscores the potential architectural complexity of your IoT solution. More specifically, it informs decisions regarding just how edgy your solution may need to be.

If the thing is expected to act: will the thing act independently, trigger another actor (system or human) to act or just report? Make sure to consider whether action will be initiated unilaterally – without input from other systems or humans – or if the thing must work in concert with others (human or machine).

Network Effects

How many other like things must contribute to the collective for gathered information to be valuable or initiate action? In some cases, the answer may be minimal to none. For instance, with consumer products where the primary objective is connectivity: allowing me to control my washing machine from another room. In other cases, such as a smart grid, understanding collective performance – both within a local and global network – is required to accurately assess and optimize the performance of the system.

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Connectivity

How will the thing connect to your enterprise? Is there an existing connector to your IoT gateway? Will data be communicated wirelessly? If yes, is bandwidth limited due to capacity, cost or any other constraints? To support the desired outcome, can the thing go offline? How likely is that to happen (e.g., is device mobile and subject to wireless network vagaries)?

Explore "To Partner or Not to Partner?"
Continue to "Dealing with Data"
Select Another Topic

DEALING WITH DATA

Data is the lynchpin of the IoT. The advent of connected things allows data to be captured and interrogated at a level of detail and depth previously unthinkable. While the volume of data that can be generated is breathtaking, it is the data's diversity which enables many new use cases.

A word to the wise: simply slapping on sensors and collecting the data exhaust from any available thing leads to data overload, not opportunity. Although the advent of the cloud has made data storage cheaper, it is not cheap. The overhead cost and risk incurred with transporting mass amounts of potentially sensitive or low-value data across distributed networks must also be considered.

A deliberate strategy to identify what information is important, how the data will be curated and its ultimate disposition is crucial. If you haven't yet identified how the thing delivers value, start there. Some data requirements (such as composition of data to be collected) can be defined without knowing the intended use. Others, such as integration and storage requirements, are intrinsically informed by the device's intended use.

Data Composition

What is the format of the data to be captured or evaluated? Is the data stream well structured? Are special analytics techniques required to interpret the data? For instance, to analyze images, audio files or written text.

Volume, Velocity and Veracity

How much data will be generated by each thing and by the collective holistically? What is the expected velocity, cadence and frequency of data collection? Consider not just the quantity but also the quality and integrity of the data. How clean and consistent is the target data stream(s)? Are there known quality or integrity issues?

Volatility and Best Used by Date

How volatile is the information being captured? Sensor data, for example, is notoriously noisy. Does the data captured have an expiration date? In other words, is the value of the information only relevant if acted on within a specified time?

Integration

Is the full data set, a subset of attributes and/or found insights required for tracking or future analysis? Is data capture only required if specific events occur?

Does captured information need to be combined with other data sources to derive insight? This may include data from operational systems such as your ERP or CRM systems, non-traditional data sources such as service records, product specifications and design documents, contracts or social media. Just to name a few.

Is the information reusable? Determine whether captured data or generated insights can be applied to support other use cases or analysis distinct from the initial project.

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By 2025, **41.6** billion connected devices will generate **79.4** zettabytes of data daily.

– IDC

Security & Privacy

Is information being collected sensitive or subject to specific regulations? Is permission required from the user to collect and utilize said information? Are there geographical restrictions on where data may be stored, used and with whom it may be shared?

When considering security and privacy make sure to evaluate not only the raw data streams. Often, it is not the individual data streams but the combination of data sources and the insights that result which create privacy, security and ethical conundrums.

Explore "How Edgy is Edgy Enough?"

Explore "Why AI?"

Continue to "Taking Action"

Select Another Topic

TAKING ACTION

There are things, and there are things. The ultimate value of the IoT comes from putting things into action. This, in many respects, is the trickiest aspect of IoT projects.

Make no mistake, the IoT ecosystem required to enable even relatively simple applications can be technically challenging.

Yet, as complicated as the technology can be, it pales in comparison to the consideration required when implementing solutions designed to change how people work and interact. The intent of most solutions is not to eliminate humans wholesale, but to better focus human attention on problems humans are uniquely suited to solve. But it is disingenuous to assume this will be accepted by the affected party if they are not involved in the process, early and often.

The Insight

What do you need to know? Are these things being used to monitor business performance, predict the next best action or outcome, or prescribe action to be taken? The type and complexity of analytics required are directly linked to the intended use. As well as the volume, variety and velocity of the enabling data streams.

With the IoT, the scale of the data and time to action often require the use of machine learning (ML) or deep learning (DL). New data sources including text, audio and video necessitate adoption of techniques such as natural language processing (NLP) or computer vision (CV). In many cases, AI algorithms will be integrated with business rules to initiate appropriate next best action.

The Decision Horizon

Is the information collected time-sensitive? Is action required in real time, near-real time or at specified decision intervals? Make sure to match the cadence of generated insights and alerts with the capability of the organization to act upon them. While faster always seems better, there is a cost and complexity associated with enabling real-time action that may not be offset by the incremental value of changing existing operating practices to react sooner.

The Customer Experience

How does the customer (be it an end consumer or employee) experience change as a result of this solution? How and to whom will insight be delivered? Will insights be made available on operational dashboards? Generate triggered alerts? Be incorporated into existing business and system process flows and therefore unseen?

Putting the IoT into action starts with identifying how and when humans – as well as other systems – will connect with the solution. For example, information may be pushed to the operator on an operational dashboard or trigger an alert in an existing application. Or, information may be provided inline as is the case with VR goggles that overlay schematics and recommendations for next steps in fixing an error to the technician. A customer may receive an alert their energy usage is high through a mobile application or a text message with a coupon for a nearby coffee shop, just in time.

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The Engagement Model

Information, augmentation or automation? One of the trickiest aspects of the IoT is to clearly articulate how work gets done. And by whom: human or machine.

Clearly defining the engagement model between human and machine is key to successful business process design. If automating or augmenting existing tasks or workflows, clearly identify under what circumstances (if any) the "machine" has authority to act. Under what circumstances can and should the human override machine recommendations? In addition, make sure to determine how errors or new requirements will be identified and fed back to improve the process.

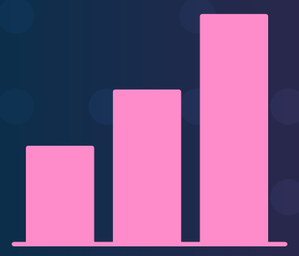
The Future View

Are generated insights applicable to or of interest to other applications and consumers? Do generated insights support future analytics use cases?

Take time up front to consider future use cases and what role the actions taken today may play in future decision making. This may be as simple as ensuring you are capturing the data required to appropriately monitor the efficacy of the solution on an ongoing basis. More importantly, such analysis ensures the appropriate groundwork is established for the next generation of products and services. In this case, requirements for future analytics may inform incremental data or interface requirements that can be accounted for in initial solution designs.

30% of data generated will be consumed in real time by 2025.

- IDC



TOP 3 GLOBAL BENEFITS OF IoT:

- Improved customer satisfaction (70%),
- Operational efficiencies (67%)
- Improved product/service quality (66%)

- Cisco

Explore "How Edgy is Edgy Enough?"
Explore "Why AI?"
Continue to "Securing ... Everything"
Select Another Topic

SECURING ... EVERYTHING

Security and privacy by design. Nowhere is this more important than the IoT. Unlike standard business devices such as computers and networks, things do not uniformly conform to set interface or communication standards – even within a given industry. Each device may have its own technology stack with different operating systems and security protocols. Physical assets not previously operating in the digital world may not have inherent security. Nor is there any guarantee a sensor-enabled device comes with security inside the package.

Adding to the complexity, the IoT is distributed by nature. The devices which now constitute a primary delivery vehicle or access point for your products and services are frequently outside the enterprise's traditional scope of control. Even things that just collect data are a risk due to privacy concerns and the potential to serve as a backdoor into the broader enterprise.

Therefore, a comprehensive security plan must reflect the full spectrum – from physical asset management to cybersecurity from the edge to the enterprise. Things, applications, infrastructure and everything in between must be considered.

Access to the Thing

Who and what uses or contacts the thing routinely? Consider human actors (end customers and employees) as well as business systems/processes that integrate directly with the target device or application.

Who is responsible for monitoring and maintenance? Access requirements should consider those responsible for monitoring and maintaining the thing both physically and virtually. The latter may require secure remote access to install software updates, apply security patches and bug fixes, or troubleshoot issues.

Security of the Thing

What constitutes authorized access to the thing? Remember, possession is 9/10 of the law. If applicable, will the enterprise be responsible for securing the physical device? Note that this is not typically an option when dealing with consumer-owned devices.

How will access to related applications/programs be secured? Make sure to determine whether the sensor/device and related applications have built-in authentication and security protocols.

Connections Betwixt and Between Things

Does the thing connect directly or indirectly to other things and how?

Does the thing connect directly or indirectly to enterprise networks? Often, IoT devices connect to broader networks via an IoT gateway. If so, how is gateway access secured and monitored? Consider both device and network side access.

What other systems, processes or things connect to the same gateways and downstream networks? Consider public, third-party and enterprise wireless networks.

Friends of Friends: Nice when socializing. Entirely undesirable in your IoT network. Tracing the path from the edge to the enterprise ensures any backdoors into other applications and environments are identified and locked.

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Data Thoroughfares: To and From

How will data be secured as it moves from the thing to consuming environments? Consider what data will be transmitted from the edge/endpoint through the fog to downstream enterprise applications. As well as data that may be sent back to thing. If the things in question are distributed geographically, or mobile, restrictions on where data can be collected, accessed and stored must also be identified.

Consuming Applications

Which applications will access or use either the data or insights generated? For each, identify which access and usage policies or other restrictions apply.

Explore "To Partner or Not to Partner?"
Continue to "Scalability and Performance"
Select Another Topic

SCALABILITY AND PERFORMANCE

The IoT is complex, chaotic and distributed by design. The IoT also represents an intersection of informational (IT) and operational (OT) technology competencies. Getting traditionally siloed teams such as engineers and equipment operators (in the OT domain) to collaborate with software developers and administrators (in the IT domain) is only the first challenge.

With the IoT, the scope of control increases to encompass both physical equipment as well as application software – with all attendant failure states. Things, the physical assets they attach to, the applications they utilize, the environments they integrate with, and the networks connecting them are at risk of failure and poor performance. Physical equipment breakdowns, network constraints, undersized computing environments, application bugs, system outages … the list goes on.

The IoT ecosystem must be thoughtfully integrated with existing IT and OT systems for purposes of managing the physical assets, ensuring reliability, performance, and maintaining the integrity of the end-to-end ecosystem. Effectively managing this environment requires proactive planning and coordinated operations.

Scalability

Are your systems and resources capable of handling the volume of transactions the IoT application will generate? Are the networks and receiving applications appropriately sized?

What are the key network constraints? Have flexible infrastructures such as cloud environments been configured and tuned to appropriately respond to transient and sustained fluctuations in demand/volume?

How will you simulate and test the performance of the end-to-end solution at scale? Outside of integrated IoT ecosystems it is unlikely standard IT/OT tool kits will include protocols for testing endpoints/things outside of traditional network and operational boundaries.

Physical Asset Management

How will physical assets be tracked, monitored and managed?

How will system failures or outages be detected? Even in an increasingly digitized world, the endpoint device may fail. What is business/system implication if an endpoint device breaks down or discontinues working? Is failover required?

How will resources be deployed and allocated to replace a device that physically fails?

Performance Management

Can existing IT performance management systems cover the IoT ecosystem? How will endpoints outside the traditional enterprise scope of control be monitored (can they be)? How will connectivity and throughput from endpoints to consuming applications (and back) be monitored? Can existing data and analytics environments scale appropriately? What is the network or capacity constraints at each stage of the environment?

Performance management must address all elements from the device itself to optimization of the network.

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Maintenance and Upgrades

How will IoT devices, the networks and applications they connect to be maintained? When considering updates consider: core operating systems, software applications, AI or AI algorithms and analytics routines, security and other routine maintenance patches.

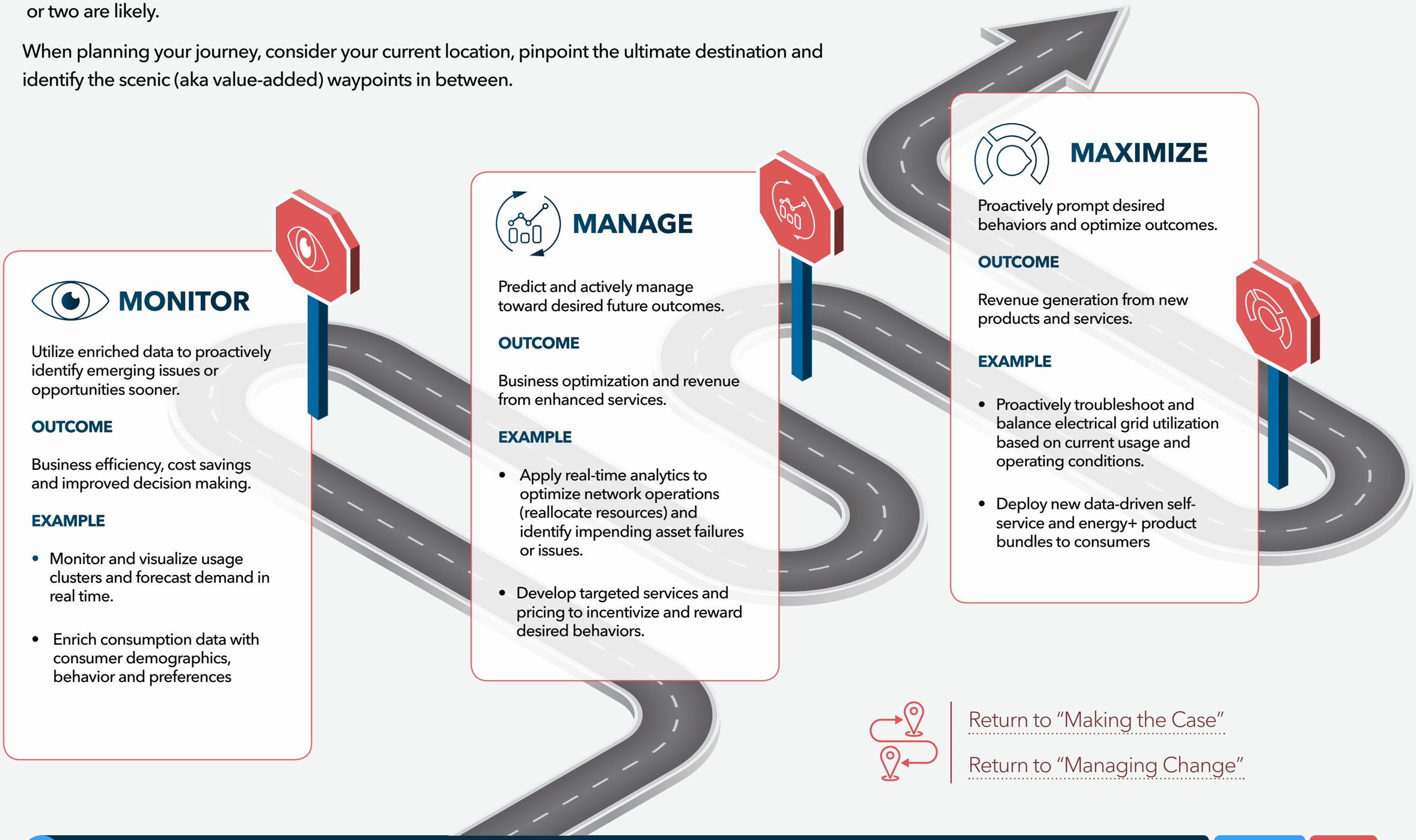
Can endpoint software applications be updated remotely? Is physical access required to maintain the device? How often are updates expected? Also consider whether continuous integration/deployment (CI/CD) and on-demand maintenance is required or appropriate.

Continue to Section Two: "IoT in Industry"
Select Another Topic

THREE STOPS ON THE IoT JOURNEY

The connected enterprise will ultimately deploy a portfolio of IoT solutions across the complete spectrum, from monitoring to maximizing business performance. However, if your organization does not have the enabling infrastructure required to get from A to Z on day one, a series of unexpected detours and a breakdown or two are likely.

When planning your journey, consider your current location, pinpoint the ultimate destination and identify the scenic (aka value-added) waypoints in between.



MONITOR

Utilize enriched data to proactively identify emerging issues or opportunities sooner.

OUTCOME

Business efficiency, cost savings and improved decision making.

EXAMPLE

- Monitor and visualize usage clusters and forecast demand in real time.
- Enrich consumption data with consumer demographics, behavior and preferences

MANAGE

Predict and actively manage toward desired future outcomes.

OUTCOME

Business optimization and revenue from enhanced services.

EXAMPLE

- Apply real-time analytics to optimize network operations (reallocate resources) and identify impending asset failures or issues.
- Develop targeted services and pricing to incentivize and reward desired behaviors.

MAXIMIZE

Proactively prompt desired behaviors and optimize outcomes.

OUTCOME

Revenue generation from new products and services.

EXAMPLE

- Proactively troubleshoot and balance electrical grid utilization based on current usage and operating conditions.
- Deploy new data-driven self-service and energy+ product bundles to consumers

Return to “Making the Case”
Return to “Managing Change”

HOW EDGY IS EDGY ENOUGH?

The power of the IoT comes from the actions it enables. Insight and action can be generated in three general areas: on the edge, in the fog and within the enterprise (aka, "the core"). Considerations for determining the edginess of your solution include the urgency of the required action, the value of the data over time, where action is initiated, and network bandwidth and latency. While many IoT conversations focus on evolve around immediate action, faster is not always better. For example, pre-emptively shutting down a manufacturing line for a non-critical fault that can be addressed during a scheduled nightly maintenance window is likely not warranted.

	EDGE	FOG	ENTERPRISE
ACTION	Action taken by or near the thing (endpoint/edge device).	Action taken between the edge and the enterprise.	Action taken in core enterprise systems (cloud or on-premise).
QUALITIES	• Act in the moment. • Real time, minimal latency. • Respond to immediate threats/needs. • Report action, results, or triggers to the enterprise.	• Transactional. • Near-real time, medium latency. • React to triggering events/transactions. • Filter and aggregate high-impact data/events. • Act within local network.	• Informational. • Medium-to-high latency. • Historical, current and future views • Enterprise reporting and analytics • Application integration and orchestration.
BENEFITS	• Immediacy. • Minimize data movement. • Data security.	• Focus attention quickly. • Reduce bandwidth. • Improve data quality.	• Robust multisource data integration. • Historical, longitudinal analytics. • Cross-functional integration.
EXAMPLE	• Accident avoidance (self-driving car). • Emergency equipment shut-off • Unlock front door (facial recognition).	• Fraudulent transaction alert. • Balance electrical load (smart grid). • Filter sensor data.	• Train predictive algorithms. • Optimize maintenance schedules. • Orchestrate network processes.

Return to "Dealing with Data"
Return to "Taking Action"

WHY AI?

Artificial Intelligence (AI) plays a key role in the IoT. While AI applications may be created from a combination of technologies, they all share the ability to learn from data without explicit programming and to react to new data inputs. This is critical with the IoT as the diversity and volume of data created by the IoT far surpass the ability for a human to manually analyze, identify relevant patterns and act in a timely fashion.

80% of enterprise IoT projects will have an AI component by 2022.
– Gartner

Machine Learning (ML)

Machine Learning (ML) is a category of algorithms that learn from data without being explicitly programmed. ML is particularly well suited for interrogating massive data sets too big or noisy for traditional analysis. ML also addresses combinatorial problems where all the potential combinations of inputs or circumstances that result in a given output or action can not be discretely defined and manually coded.

Computer Vision

Image recognition plays a pivotal part in the IoT. Sometimes identified as the "killer IoT app," computer vision is integral to everything from quality and defect detection in manufactured goods to facial recognition, to analysis of movement of vehicles on the street and football (soccer) players on the pitch.

Natural Language Processing (NLP)

The ability to not only detect but understand the context and intent of spoken and written language with all its inherent vagaries makes NLP another key IoT enabler. NLP is a core component of many types of back-office robotic process automation (RPA) – from reconciling invoices and bill of lading. NLP is also fundamental to increasingly, pervasive customer service chatbots and legal document analysis.

If your organization is not yet versed in these types of analytics, working with an experienced partner or taking an incremental approach is key. Learning to manage an IoT environment at scale while adopting new approaches to AI algorithmic development and deployment is fraught.

Learn More About the Artificial Intelligence of Things (AIoT)
- SAS

Learn More About AI with *Making Sense of AI.*
- SAS

Return to "Dealing with Data"
Return to "Taking Action"

TO PARTNER OR NOT TO PARTNER?

The IoT is complex. Mastery requires a broad range of competencies and skills sets ranging from (but not limited to) data and analytics to wireless communication, software and application development, security, operational systems management and traditional IT. Some experts have estimated that a single IoT project can require engineering teams of at least 50 people and up to 10 partners, on average.

To cut through the complexity, organizations can partner with IoT platform providers or ecosystems for end-to-end solutions. They may also utilize development partners and marketplaces to supplement specific skill sets or capabilities (e.g., device integration).

Your business objective (how and where is value generated), availability and bandwidth of in-house resources, as well as time to market, all factor into partnership decisions. Regardless of the path, a modular approach that provides standard interfaces/APIs for integration and allows discrete functions to be mixed-and-matched like Legos is key.

Potential Advantages

- Market ready platforms tuned to industry applications and standards.
- Low-code environments with some ability to customize.
- Commodity "plumbing" such as device connectivity or specialized data handling (i.e., sensors).
- Integrated security and integration between core infrastructure elements.
- Time to market.

Potential Disadvantages

- Less customized, less differentiated experience.
- Need to integrate with legacy systems.
- Ownership of intellectual property (IP).
- Total Cost of Ownership (TCO): including ongoing maintenance and support.

80%
will leverage an ecosystem vs. "do-it-yourself."
– Industry Week

1/4 will partner with an IoT platform provider.
– Industry Week

Return to "Making the Case"
Return to "Considering the Thing"
Return to "Securing ... Everything"

IoT in Industry

Choose Your Path:

Manufacturing

Retail

Energy / Utilities

Automotive / Transportation

MANUFACTURING

The concept of the industrial internet was nurtured in the manufacturing sector. In 2012, GE[1] predicted that the industrial internet represented a $5.5 trillion-dollar opportunity for manufacturers. The IoT, and more specifically the Industrial Internet of Things (IIoT) which refers specifically to industrial machine-oriented IoT applications, is poised to deliver on that promise.

Acronym Soup: Don't let the swarm of terms concern you. The terms IIoT, Machine-to-Machine (M2M) and Industry 4.0 are sometimes used interchangeably although the terms have slightly different connotations. That said, the core concept for all is the use of pervasive, embedded intelligence to optimize business processes and improve efficiency.

Regardless of the term used, decades of investment in automation – from robotics on the manufacturing floor to instrumented supply chains - means that manufacturers have a leg up on other industries relative to the IIoT. And while manufacturers shoulder their fair share of implementation challenges, the manufacturing sector is one of the leaders in IoT adoption. Indeed, the IIoT is being deployed across a vast array of use cases from product design to optimizing production line throughput and identifying defects before they leave the line to providing preventive maintenance and proactively identifying customer issues before they reach critical mass.

[continued on following page]

[1] *Industrial Internet: Pushing the Boundaries of Machines and Minds* (GE, 2012)

HAPPENING NOW IN MANUFACTURING

FACTORY / PRODUCTION LINE

- Production Quality Analytics (PQA)
- Anomaly Detection
- Fault Detection
- Process Optimization and Control
- Asset/Equipment/Part Tracking
- Predictive Asset Maintenance
- VR-Enabled Quality Control
- First Pass Yield (FPY) Optimization

RESEARCH & DEVELOPMENT

- Digital Twins
- Mixed Reality (MR) Assisted Design

CONNECTED SUPPLY CHAIN

- Continuous Manufacturing
- Optimized Demand Planning
- Logistic Optimization
- Real-Time Inventory Tracking and Monitoring (incl. parts & supplies)
- Warehouse Automation / Robotics

BUSINESS OPERATIONS

- Demand Forecasting and Planning
- Energy Use Optimization
- Environmental Efficiency (Lighting, HVAC, etc.)

WORKFORCE MANAGEMENT

- Field Quality Analytics (FQA)
- Augmented/Virtual Reality (AR/VR) Enabled Operations and Maintenance
- Field Safety and Security

CUSTOMER ENABLEMENT

- Fault Detection
- Asset Performance Analytics (APA)
- Predictive Maintenance

Select Another Industry

Continue to Section Three: "Are You Ready?"

REMOTE ASSET MONITORING AND PREDICTIVE MAINTENANCE

70 countries rely on the C-130 for search and rescue, peacekeeping, medical evacuations, scientific research, military operations, aerial refueling and humanitarian relief. Lockheed Martin, the company which manufactures the C-130, is now able to use AI, IoT and advanced analytics to predict when parts will fail, keeping more aircraft airborne for vital missions worldwide.

The system, which the company calls “intelligence diagnostics” is used to profile individual parts and predict when they might break – insight that could help customers proactively stock the right parts and keep aircraft operational for more life-saving missions.

The system uses data from C-130 customers, Lockheed Martin engineers and part vendors to form a central repository on more than 300 aircraft parts. Using machine learning and IoT analytics, the system learns from the collective maintenance history to form a real-time best practice for aircraft maintenance.

For example, if a fault code triggers the replacement of a certain part, which is later found to be in good working condition 80% of the time, the system learns from this mistake and next time will recommend more robust troubleshooting before replacement. If the customer rejects this suggestion and takes a different course of action, the system learns from that as well.

By the Numbers

- 400 C-130J aircraft globally
- 600 sensors per aircraft
- 72,000 rows of data per flight hour

Key Technologies

- Artificial Intelligence (AI)
- IoT
- Advanced Analytics

Value Generated

- 95% Reduction in Data Clean-up Time
- 1,400 Hours Downtime Avoided in 3 Months

Explore Use Case: “Anomaly Detection”
Return to Manufacturing: “Happening Now”
Select Another Industry

ANOMALY DETECTION

Western Digital is one of the world's largest hard disk drive suppliers and a pioneer in hard disk drive storage manufacturing. To maintain its competitive edge, Western Digital must ensure volume and efficiency in the manufacturing and distribution of its hard disk drives. While their overall manufacturing success rate is maintained at extremely high levels, the failure rate of even a fraction of a percentage results in the production of a million defective drives. Therefore, minimizing customer losses is critical to its operations, and the company's priority has been minimizing the distribution of such defective units.

Using Asset Performance Analytics, Western Digital monitors equipment sensors and tags machine-to-machine data to identify hidden patterns that predict failures.

Western Digital's engineers can perform a series of functions, including data extraction, data conversion and data analysis. All device performance indicators are monitored, so once an exception occurs with the device, the system can issue an alert to the engineers so they can make critical decisions quickly.

By the Numbers

- Millions of Hard Drives

Key Technologies

- Asset Performance Analytics
- IoT

Value Generated

- Increased Precision of Yield Excursion Identification
- Lowered Return Units
- Boosted Customer Loyalty

"With a built-in case management system, the solution gives Western Digital engineers the insights they need to identify possible failures early in the production process and make timely decisions to avoid a yield excursion, ensuring Western Digital hard drives are of the highest quality."

– KH Sim, Director of Hard Disk Drive Analytics

Explore Use Case: "Remote Asset Monitoring"
Return to Manufacturing: "Happening Now"
Select Another Industry

RETAIL

Retailers are no strangers to analytics. The IoT allows retailers to leverage that expertise to create a truly differentiated customer experience across channels, radically optimize their supply chains, guarantee the integrity of delivered goods, and create value-added in-store experiences that integrate the physical and digital world.

Intuitive, relevant and personalized customer engagement remains the penultimate goal for retailers. With the advent of smart digital signage, sophisticated in-store customer tracking using in-store beacons and Bluetooth tokens, always-on data collection through smartphones and tablets and so on, the IoT enables a more intimate view of the customer and the customer's probable intent that ever before. The biggest challenge becomes walking the line between proactive engagement and intrusiveness. As each customer's tolerance of what is too intrusive can vary, striking the balance between privacy and convenience is a key challenge.

The Industrial Internet of Things (IIoT) also has a role to play as retailers increasing collaborate and integrate operations from the manufacturer through the supply chain to fulfillment in the store, at home, or wherever the customer deems fit. The IIoT can also be applied to optimize performance of energy-intensive assets such as refrigeration units or lighting – both in service of food safety (ensuring appropriate temperatures are maintained) and cost savings (minimizing power consumption). In this area, retailers are encouraged to take a page from the IoT playbooks for manufacturing and transportation/logistics.

[continued on following page]

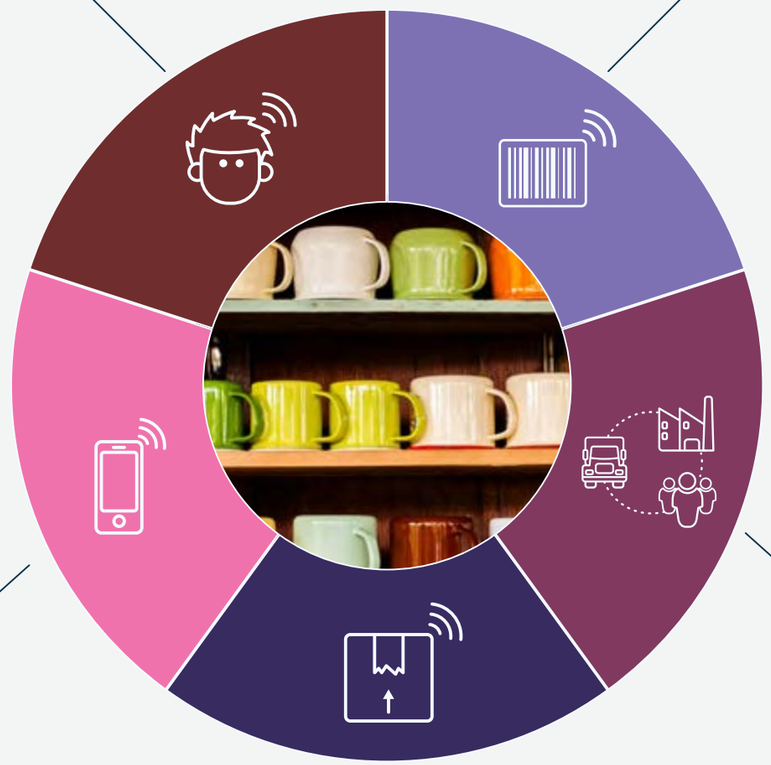
HAPPENING NOW IN RETAIL

CONNECTED CUSTOMER

- In-Store Contextual Marketing
- Shopping List Navigation
- Proximity Marketing
- VR-Enabled Product Evaluation
- Omni-Channel Analytics
- Hyper-Personalization/Customization

SMART STORE

- Foot Traffic Monitoring and Space Optimization
- Automated Checkout
- Real-Time Loss & Fraud Prevention
- Distributed Inventory and Store-to-Store Replenishment
- Predictive Equipment Maintenance
- Environment Optimization (HVAC, lighting, etc.)



SMART PERSONAL DEVICES

- Smart Home
- Personal Wellness
- Virtual Assistants

CONNECTED WAREHOUSE

- Inventory Optimization
- Self-Organizing Inventory
- Real-Time Inventory Replenishment
- Service Level Optimization

SUPPLY CHAIN MANAGEMENT

- Logistics Monitoring
- Supply Chain Analytics and Optimization
- Track-and-Trace
- Predictive Fulfillment

Select Another Industry
Continue to Section Three: "Are You Ready?"

CONNECTED CUSTOMER

For greater convenience and frictionless shopping, retailers can leverage beacon-enabled customer engagement strategies to drive proximity marketing, either directly through customer's mobile applications, interactive digital displays or displayed merchandise itself.

To that end, a large retailer with a diverse online retail presence as well as brick-and-mortar stores through the US, Puerto Rico and Guam wished to get a better grasp on each customer's complete journey. Utilizing advanced analytics in conjunction with new data enabled by the IoT, the retailer is now able to intuitively send the right message to the right customer at the right time, based on their location and shopping preferences.

When a customer opens the store's mobile app in a physical store, the application recognizes the part of the store where the customer is standing. When the customer passes a product they previously bought (in any channel) or searched for online, the application can also remind them of their preference and offer real-time promotional discounts or offers.

The experience extends beyond the physical. By analyzing beacon category, customer contact history, product preferences and historical clickstream (abandoned cart, browsed products, added to cart) and like data, customized offers can incent future engagement both online and in real-life.

By the Numbers

- 700 Stores
- 5,000 Beacons

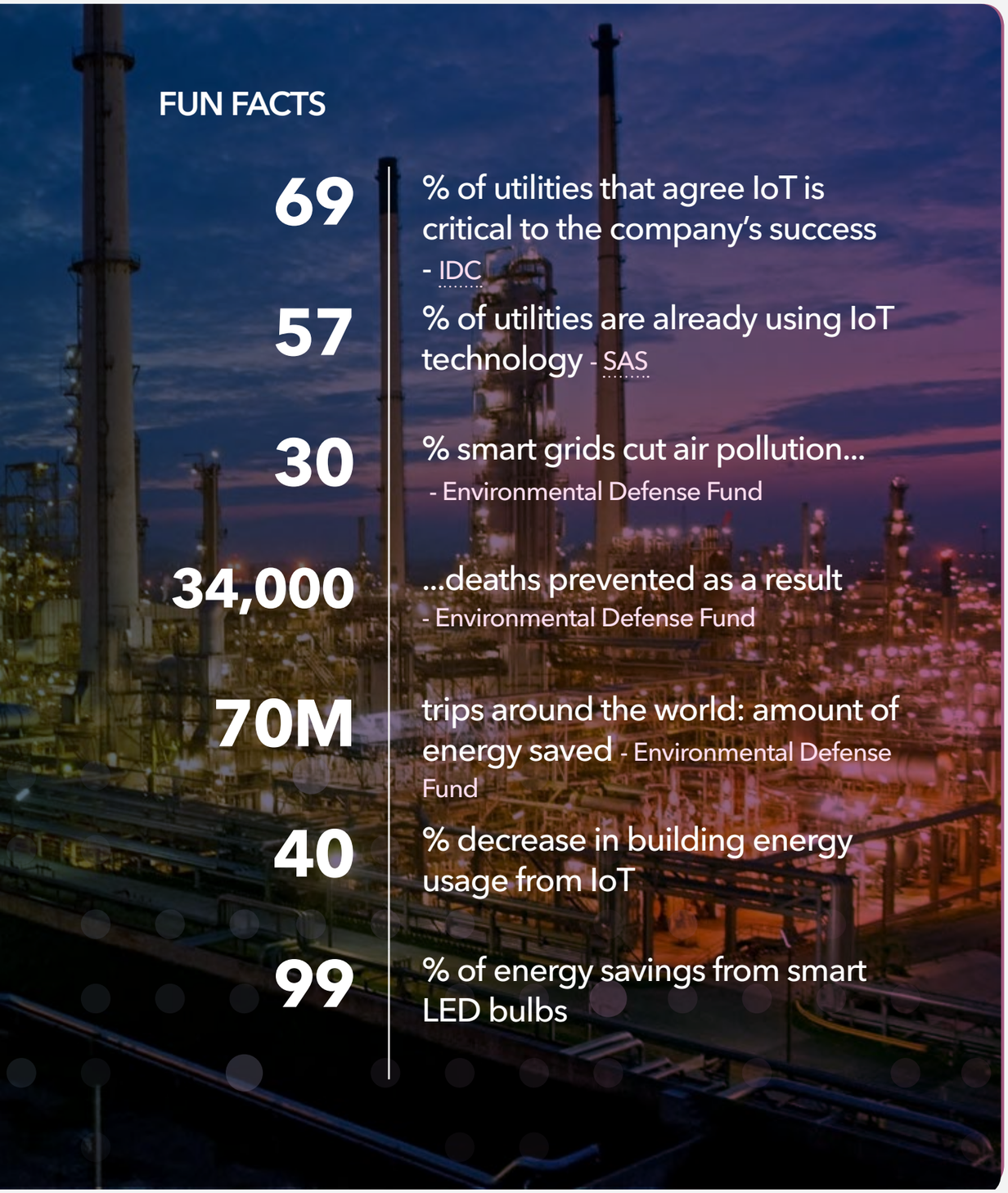
Key Technologies

- Beacons
- Event Stream Processing (ESP)
- Advanced Analytics (Optimization, ML)
- Real-Time Decision Making

Value Generated

- Increased Avg. Transaction Size
- Improved Customer Satisfaction
- Increased Sales
- Reduced Cart Abandonment

Return to Retail: "Happening Now"
Select Another Industry



ENERGY / UTILITIES

Continuing changes in the power generation, transmission and distribution landscape make the energy and utilities sector one of the biggest potential benefactors of the IoT. From accurately forecasting demand, integrating and balancing alternative energy sources and entrants, engaging the emerging "prosumer," providing value-added services that keep consumer comfortable at the lowest cost to ensuring the power does not go out during a storm or unexpected grid failure, the IoT has a role to play. It is in the energy and utility space that the IoT may also have an immediate impact on the global climate and resource challenges that face our amazing planet.

Of course, with great opportunity comes great challenge. While the IoT is already proving its value, key challenges to widespread adoption for utilities include:

- Maintaining reliable connectivity.
- Integrating IoT technology into complicated legacy systems.
- Modernizing data security.

[continued on following page]

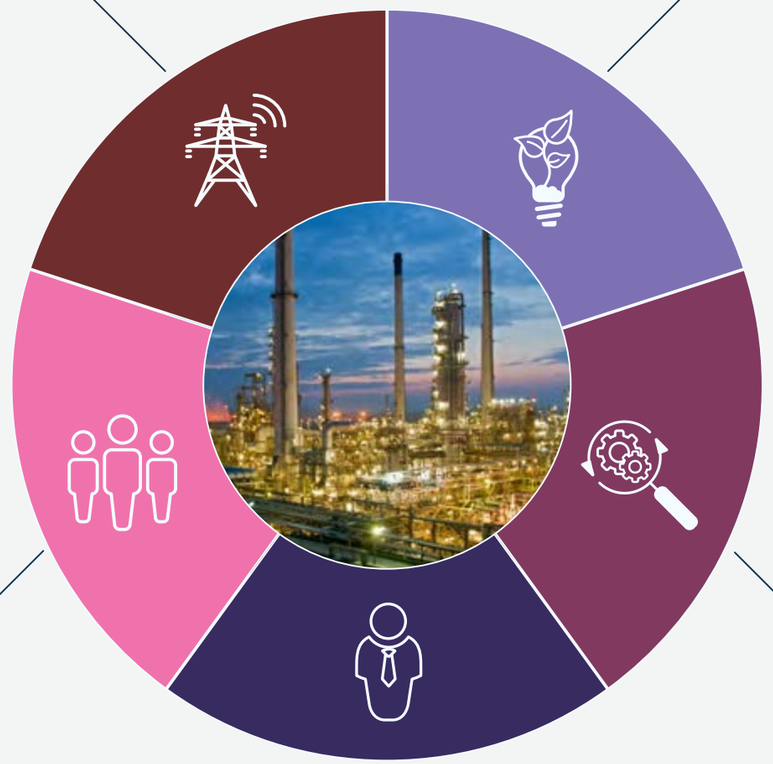
HAPPENING NOW IN ENERGY / UTILITIES

GRID

- Phasor Measurement Unit (PMU) Monitoring & Analytics
- Grid Monitoring & Analytics
- Microgrid Optimization
- Distribution Asset Health Monitoring
- Smart Generation and Outage Management

RENEWABLES

- Distributed Energy Resource (DER) Monitoring
- Electric Vehicle (EV) and DER Optimization
- Distribution Network Automation



WORK FORCE

- Demand Response Management
- Work Management/ Optimization
- Mobile Workforce Management

PROSUMER

- Customized Pricing & Incentives
- Energy+ Product / Service Bundles (Smart Customer Devices)
- Home Optimization Demand Response
- Smart City

BUSINESS OPERATIONS

- Fraud Detection
- Cybersecurity
- Asset Performance
- Predictive Asset Management
- Supply Chain Management

Select Another Industry

Continue to Section Three: "Are You Ready?"

LOAD FORECASTING

SRP, one of the nation's largest public power utilities serving approximately 1 million retail customers in the desert, knows the answer to keeping everyone cool on even the hottest days. It analyzes data from production equipment sensors, customer usage and even the weather itself – to anticipate demand and optimize the production of its generating resources.

SRP avoids unplanned downtime by accurately determining when combustion turbines are running in order to schedule required maintenance. SRP also applies analytics to predict power supply and demand, allowing its Supply and Trading Group to use a variety of data, including weather, supply, demand and outage, to accurately purchase energy to meet customer demand – or sell excess power to keep costs down.

By the Numbers

- 100 degrees F, 100 Days a Year
- 1 Million Customers
- 100s of 1000s of Combustion Turbine Sensor Data Points Per Second

Key Technologies

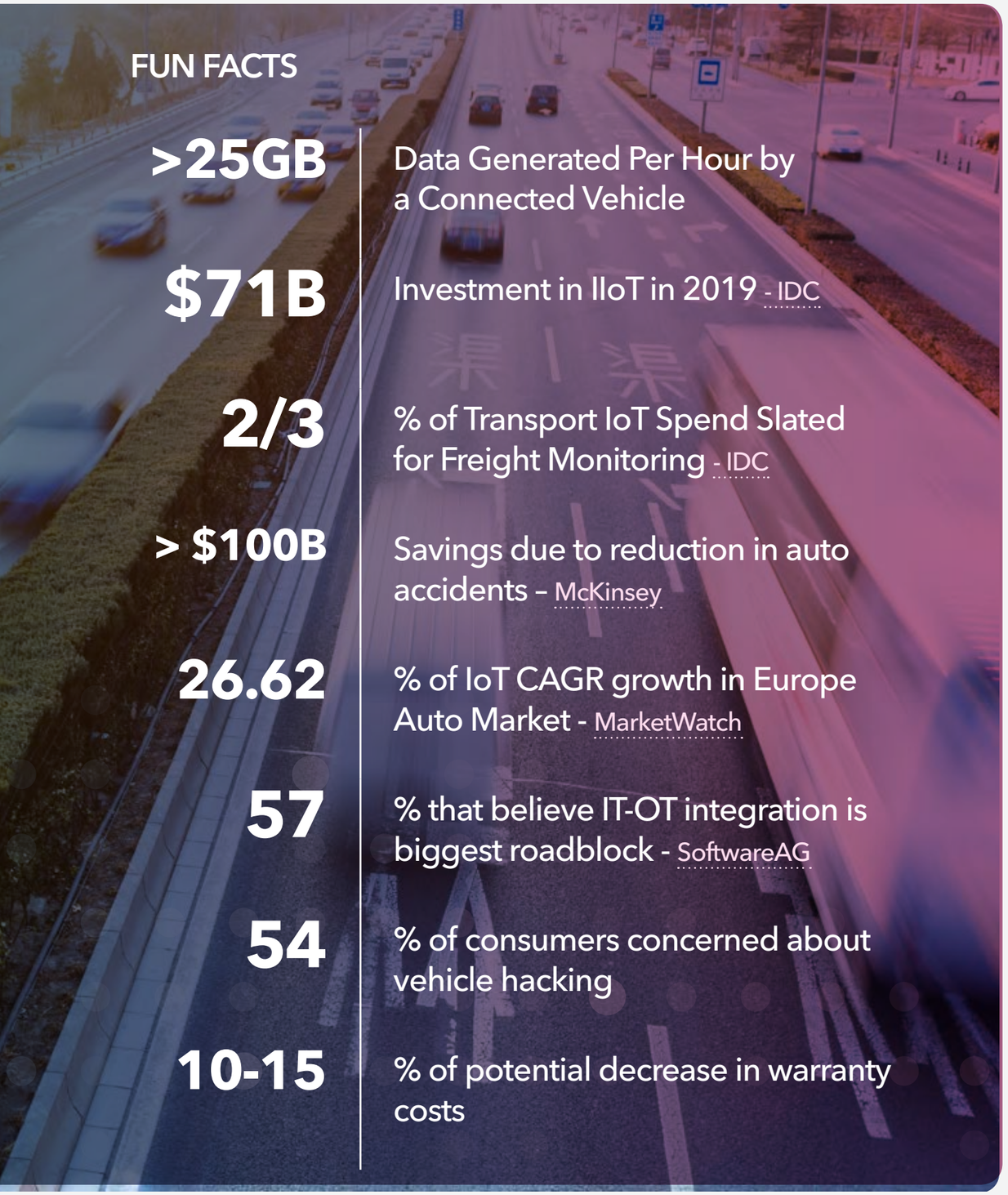
- PI Solution Integration
- Predictive Analytics and Forecasting
- Data Visualization

Value Generated

- Prevents unplanned generator downtime.
- Improves compliance with warranties for critical assets.
- Balances planned downtime across dozens of power plants.
- Enables traders to better determine when to buy or sell power to meet demand.
- Helps traders lock in better prices.

See More:
Old Dominion Electric Cooperative (ODEC): Better Forecasting with Analytics

Return to Energy / Utilities: "Happening Now"
Select Another Industry



AUTOMOTIVE / TRANSPORTATION

The driverless car: a sensational IoT case study. However, when it comes to the automotive and transportation industries, the IoT has more to give. From vehicle and engine design to optimizing routes and ensuring the integrity of transported goods along the entire supply chain to preventive maintenance that keeps assets on the road longer, the IoT is becoming pervasive.

And it's not just Industrial IoT (IIoT) applications that are generating value. By allowing for real-time, location-aware contact with consumers, the IoT is enabling new personalized products and services such as the pervasive deployment of In-Vehicle Infotainment (IVI) systems. Not to mention, the ability to apply augmented reality supports entirely new immersive customer experiences. Want to customize your new vehicle without having to hit up a specific showroom? Augmented reality to the rescue! Experience the potential feature and customize your ride without ever leaving (or, potentially, entering) a showroom or hitting the road.

Given the nature of transportation assets, network and data management challenges, as well as increases security risks abound. To garner the full benefits of the IoT, transportation companies must adopt:

- Better network intelligence
- Automation
- Data security

Of course, all is not bad news as enterprises in this sector are often dealing with assets and components that were born digital.

[continued on following page]

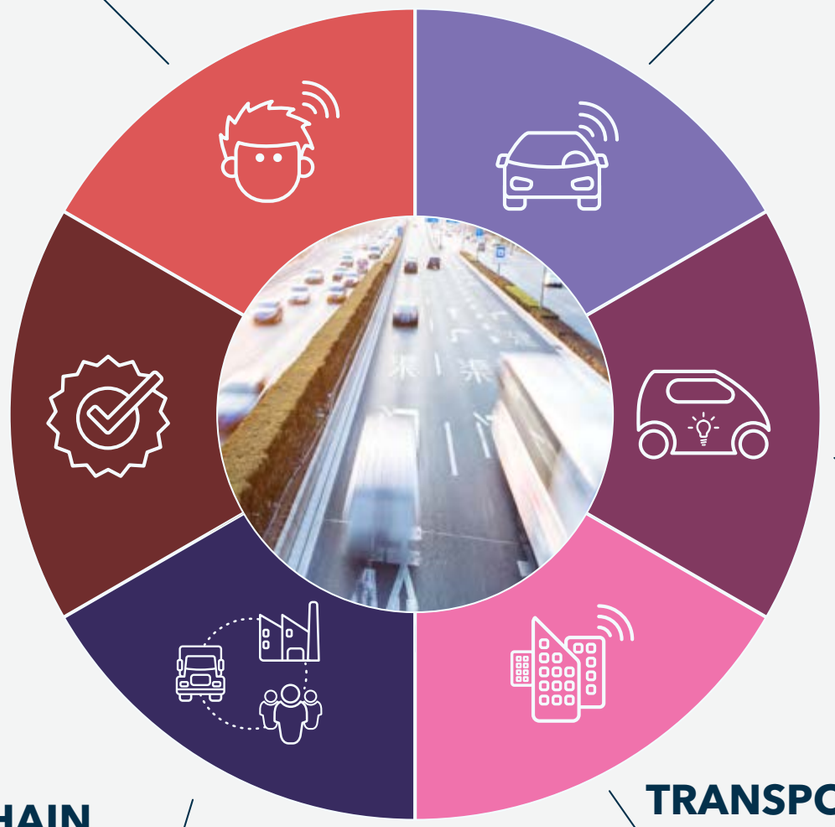
HAPPENING NOW IN AUTOMOTIVE / TRANSPORTATION

CONNECTED DRIVER EXPERIENCE

- Smart Mobility Services
- In-Vehicle Infotainment (IVI)
- Contextual Affinity Partner Marketing
- VR-Enabled/Immersive Product Customization

CONNECTED VEHICLE

- Connected Navigation
- Predictive/Networked Parking
- Enhanced Auto-pilot / Autonomous Driving
- Automated Collision Prevention, Related Services
- Automated Platooning (Commercial Fleets)



CONNECTED QUALITY CONTROL

- Predictive Maintenance
- VR-Enabled Product Design
- Recall Optimization
- Early Warranty Detection

CONNECTED FLEET

- Physical Asset Management
- Performance Monitoring & Optimization
- Predictive Maintenance
- Real-Time Route Optimization
- Field Service Optimization

SUPPLY CHAIN MANAGEMENT

- Physical Asset Management
- Product Monitoring (distribution)
- Container Tracking/Monitoring

SMART TRANSPORT/CITY

- Smart Light Optimization
- Traffic Control/Flow Optimization
- Emergency Deployment
- Smart Grid Integration

Select Another Industry

Continue to Section Three: "Are You Ready?"

ASSET MONITORING AND MANAGEMENT

Rijkswaterstaat, the Ministry of Infrastructure and Water State, is responsible for public works and water management in the Netherlands, including the construction and maintenance of waterways and roads.

Because over 20% of the landmass in the Netherlands is underwater maintaining a clear view of current environmental conditions is key. To that end, Rijkswaterstaat is developing a reliable and agile network to extract value from IoT assets, enabling deeper insights about traffic flow. By analyzing information gathered from thousands of sensors deployed on bridges, dams, dikes, locks and storm surge barriers, Rijkswaterstaat gains a clear, current view of the operational status of the country's numerous roadways and infrastructure.

Utilizing the IoT allows Rijkswaterstaat to more efficiently manage the transportation infrastructure in a country with one of the highest population densities in Europe. And ultimately, to protect the Dutch people and infrastructure from water, as the county is especially prone to flood events.

By the Numbers

- 20% Land mass underwater in Netherlands
- Thousands of sensors on ridges, dams, dikes, locks and storm surge barriers

Key Technologies

- Event Stream Processing
- Advanced Analytics
- Visualization

Value Generated

- Increased insight into operational asset performance
- Decreased operational costs
- Enabled proactive maintenance
- Managed and optimize transportation flow
- Kept Dutch citizens safe and mobile

"SAS Analytics supports us in many ways, including helping us understand how many miles of highways are operational and whether or not we have enough sand available in the event of rising water…Having that sort of vision into our data makes a lifesaving difference."

– Bas van Essen, Head of RWS Datalab

Explore Use Case: "Predictive Maintenance"
Return to Automotive / Transportation: "What's Happening "
Select Another Industry

PREDICTIVE MAINTENANCE

Every day, millions of trucks transport fuel, produce, electronics and other essentials across highways. It is no surprise then that Volvo Trucks and Mack Trucks (subsidiaries of the Swedish Manufacturer AB Volvo) are invested in keeping their customers trucking.

Analytics and the IoT enable Volvo and Mack to maximize vehicle uptime and minimize the costs of service disruptions. Volvo Trucks' remote diagnostic service monitors trucks on the road to detect if anything is amiss. Thousands of sensors on each truck collect streaming IoT data in real time to provide context. This data includes where the event happened and what conditions were present during the fault, like altitude, ambient air temperature, truck gear, RPM level and torque load, to give the information context for diagnosis.

The system quickly diagnoses any fault and its severity with detailed information and a recommended action plan. Agents in Mack's 24/7 Uptime Center explain the results to the customer and develop a plan for addressing it with the least disturbance. Agents may send detailed repair instructions to a local repair facility to help it complete the repair more efficiently and effectively. If the customer performs their own repairs, the detailed information can be sent directly to them. If an issue is software-related, the truck can be updated remotely – without disturbing operations – and quickly returned to its mission.

As a result, they help customers recover from problems faster while preventing problems from arising in the first place.

By the Numbers

- 175,000 Trucks
- 1000s Sensors on every Truck
- >20M measures per day
- >300K faults per day

Key Technologies

- Asset Performance Analytics
- Event Stream Processing
- Data Visualization/Visual Analytics

Value Generated

- 70% Reduction in Diagnostic Time
- 25% Reduction in Repair Time

"Our engineers can now see issues before they impact customer operations and change the truck's design, so we have the best product on the road."

– Conal Deedy,
Director of Connected Vehicle Services
for Volvo Trucks North America

Explore Use Case: "Asset Monitoring and Management"
Return to Automotive / Transportation: "What's Happening "
Select Another Industry

Are You Ready?

The IoT is digital, distributed and daunting. Are you ready?

The Checklist

DEFINED THE OPPORTUNITY

The potential of the IoT is vast. This makes it easy to craft broad strategic visions but can cloud the field of view when identifying where to start. Begin by identifying whether business optimization (process efficiency, cost reductions) enhanced products and services, or a net new business model is the aim.

And while the IoT is complex your business case should not be. Focus on the ABCs: today we do A, tomorrow we do B, resulting in C. Remembering of course that the story matters. Today we fix our trucks after they have already broken down. Tomorrow, we will address emerging issues before they cause an emergency outage. This will result in higher uptime for our customers.

- If you can't tie the proposed solution to a defined corporate objective, begin here.
- If you can't clearly articulate how new practices will deliver the proposed value, begin here.

ENLISTED A COLLABORATIVE TEAM (INTERNAL PARTNERSHIPS)

Identify key stakeholders required to support and implement your vision. Your IoT project should tie clearly back to established corporate objectives and programs. Thereby providing a clear path to identifying the appropriate executive sponsors.

It is equally critical to identify the groups who will be required to either contribute to the solution, whose work will be affected by it and those expected to maintain it. Gather representation and input from those with their "feet on the street" to those in the C-Suite to ensure both early buy-in and identify hidden gotchas that could derail the project later if not proactively addressed.

Increasingly, program and project teams incorporate representatives or minimally solicit input from the end customer or business partners to whom the product/service will be delivered or is intended to benefit.

IDENTIFIED KEY ENABLERS & CONSTRAINTS

Creating an executable, achievable strategy requires clarity regarding your organization's current capabilities and constraints. Your organization's current capabilities should be evaluated in the context of proposed initiative(s), rather than for gross concepts.

This will inform a roadmap for execution by allowing you to realistically align incremental projects with current capability; as well as providing justification regarding when to engage external partners and solution providers.

Evaluation should include a high-level assessment of your organization's current engagement, capabilities and skills relative to:

- Business Enablement and Business Process Reengineering
- Data Strategy (Infrastructure, Governance and Management)
- Analytics
- Core IT and OT Competencies
- Security and Privacy Practices (including cybersecurity)
- Ability to Manage Change
- Existing Customer and Partner Relationships

ENLISTED EXTERNAL PARTNERS

For most organizations, the IoT is a partnership play. Enterprises may choose to collaborate on solutions using partner ecosystems purpose-built for their industry and/or target use cases. Or, supplement specific commodity or specialized skills through targeted partnerships.

Understanding what elements of the solutions drive long-term value for your business (i.e., is it the device itself, delivery of differentiated data-driven services, or merely connectivity) helps to balance time to market and cost against long-term value and IP considerations.

CREATED A PROJECT ROADMAP, COMPLETE WITH WAYPOINTS

Done right, your IoT roadmap will consist of a portfolio of projects to be delivered in deliberate, consumable stages. Identifying a portfolio of increasingly mature capabilities allows for a steady progression towards a holistically connected enterprise. Most importantly, a phased IoT strategy that meets the organization where it is at and delivers steady, incremental benefit is also far more likely to succeed.

In developing the plan, pay close attention to crossing the digital divide. Wherever possible, create opportunities for interim deliverables and checkpoints. Do not wait until the product or service is released to garner input from either internal or external customers.

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