

squeaks™

Industrial IoT Messaging

Stay Informed with Squeaks

Overcoming IIoT-IO&O

(Overcoming the Industrial Internet of Things – Information Overload & Overburden)

White Paper

June 11, 2016

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Contents

Executive Overview 3
The Biggest Challenge of Data-Driven Manufacturing 4
Industrial IoT Messaging Essentials 10
Complementing Existing Communication Mediums 12
Expected Outcomes 14
Solution Overview – Stay Informed with SQUEAKS™ 15
Sample Solutions 19
Quality Assurance and Notification 19
Broadcast Hourly Production Status 19
Lineside Part Call Replenishment 20
Anticipate Machine Service Needs 20

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Executive Overview

Since 1986, IGear (and APS, the founding company) has deployed control and information technology solutions for leading manufacturers to optimize overall equipment effectiveness and employee efficiency. Over the past thirty years, the information technologies utilized to ensure product quality, document traceability, reduce unplanned downtime and eliminate waste have evolved from mimic panels, Andons, stack lights, radio/paging systems, HMIs, dashboards, email, MES systems, and text to big data, predictive analytics, mobile, cloud computing and now the Industrial Internet of Things (IIoT) or Industry 4.0 as it is called in Europe, to cite a few.

While the consequences of product defects, unscheduled downtime and waste (inefficiencies in general) has grown 6-10 times, the amount of data generated to help prevent said production anomalies has grown exponentially over this same period of time. No doubt, decision making has become increasingly dependent on data. Today, however, this data is being generated at an overwhelming velocity, volume and variety of formats. It has become increasingly challenging for team members to comprehend it all – especially without some concise layer of consolidation and abstraction, such as a visual one.

With the advent of IIoT sensors, big data and predictive analytics, we have reached a point of diminishing returns – decision fatigue – where employee performance is actually deteriorating as there is no respite from the relentless barrage of asynchronous communication. There are simply too many data silos in which valuable patterns/concerns are hidden and go undiscovered or conversely too much information (noise) is thrown at team members to which point some of it is ignored in order for individuals to get through the day. Unfortunately, the consequences of that one missed or overlooked piece of data can be consequential as downtime is measured in thousands of dollars per minute and quality recalls/fines are measured in millions of dollars per incident.

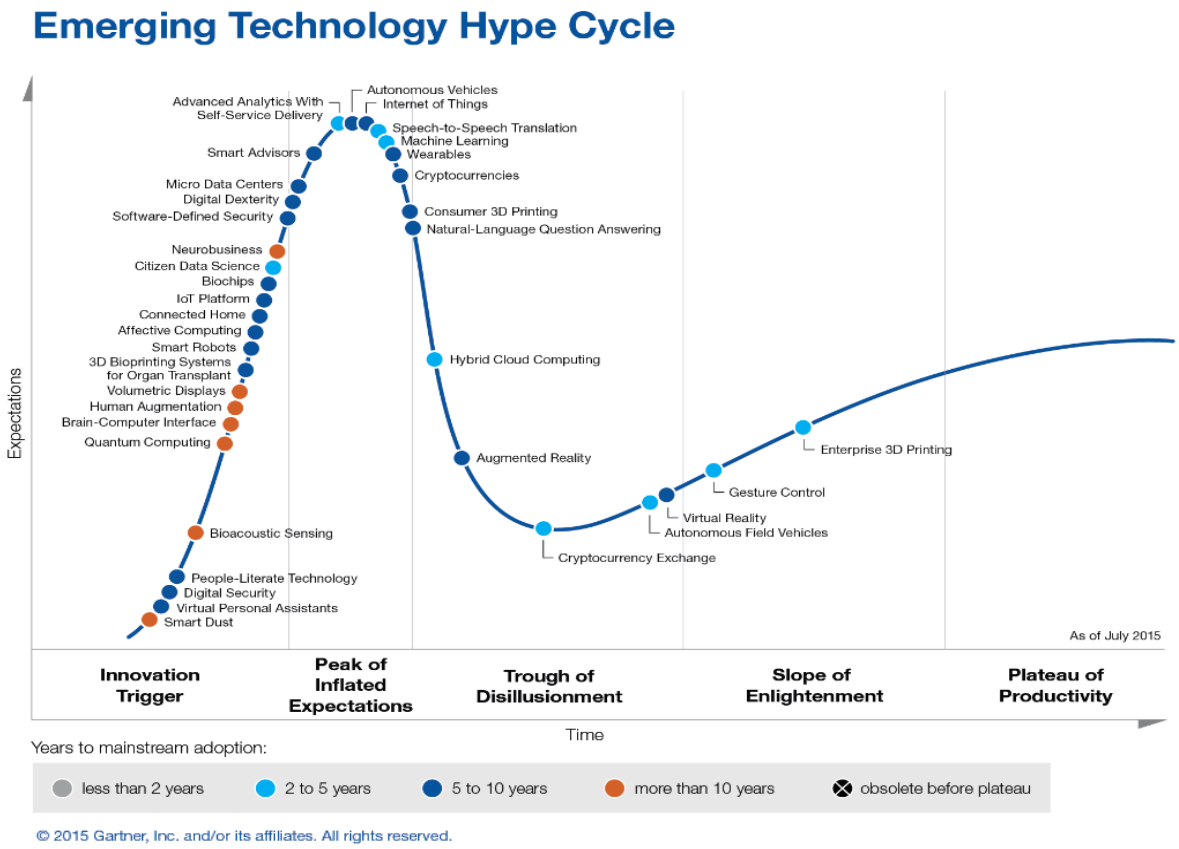
Overcoming IIoT-IO&O (Industrial Internet of Things – Information Overload & Overburden) speaks to the benefits of connecting people and machines while at the same time eliminating wasted time associated with information overload and overburden. Although a torrent of information already exists, and continues to grow, people can only sip so much at a time. Transforming this deluge of data from smart machines and sensors into relevant, actionable information will improve decision making; allowing team members to stay ahead of imminent problems.

IIoT Messaging, similar to commercial messaging apps but with a robust manufacturing twist, allows users to select information based on their roles and responsibilities – essentially follow the news, events and concerns generated from both people and machines that they need to know – the right information at the right time. IIoT Messaging allows people to get more done in a day by actually doing fewer things at once. Industrial IoT Messaging delivers actionable information to the right people at the right time in the form of short, rich, multi-media messages, thus transforming how work gets done. With IIoT messaging, better decisions can be made in sync with the pace and consequential realities of manufacturing.

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The Biggest Challenge of Data-Driven Manufacturing

The widespread deployment of low-cost sensors, smart machines, big data and analytics, wearables, and the Industrial Internet of Things (IIoT) has generated a great deal of excitement about the future of manufacturing, per the Gartner, Inc. Technology Hype curve below. To realize the full potential of these emerging, value-add information technologies, big data must be made small (manageable, relevant and actionable) so team members are not crushed.

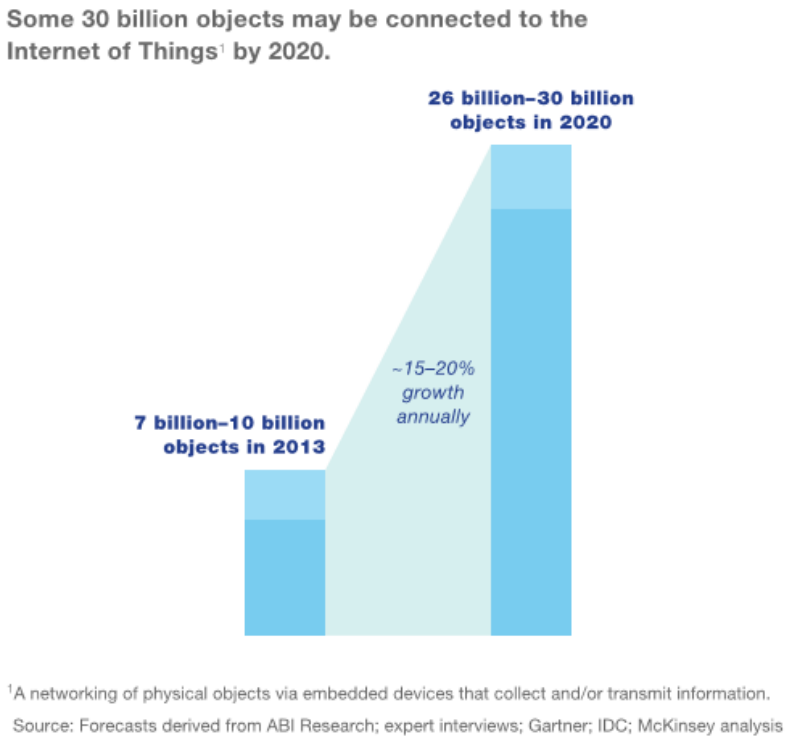


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Fundamental to the next generation of manufacturing is the use of timely data to reduce costs, ensure and document quality, eliminate waste and dramatically improve employee productivity. Data-driven manufacturing is indeed the next wave and it will drive improvements in efficiency and adaptive, responsive production systems along with integrated supplier-partner service relationships. While there are a multitude of challenges ahead, none is more important than getting the right information to the right people at the right time, wherever they are, so they can be informed on what matters to them, based on their responsibilities, allowing them to stay ahead of impending production concerns in a synchronized, non-stressful manner.

This next phase of the industrial revolution will consist of a universe of connected machines (generically defined as intelligent industrial products, sensors, software applications, big data and analytics) that communicate with each other and with people over the same channel via a secure network. The IIoT is a subset of the greater Internet of Things (IoT) market space. In regards to the size of the IIoT space, on

a daily basis manufacturers are processing more terabytes of data than the largest social networks combined. This trend will only continue based on forecasts derived from ABI Research, with input from Gartner, IDC, and McKinsey below, with similar forecasts from Cisco and the World Economic Forum. In addition to the growth projected in the number of "machines" or "data sources", the actual volume of data is growing at even a greater rate!



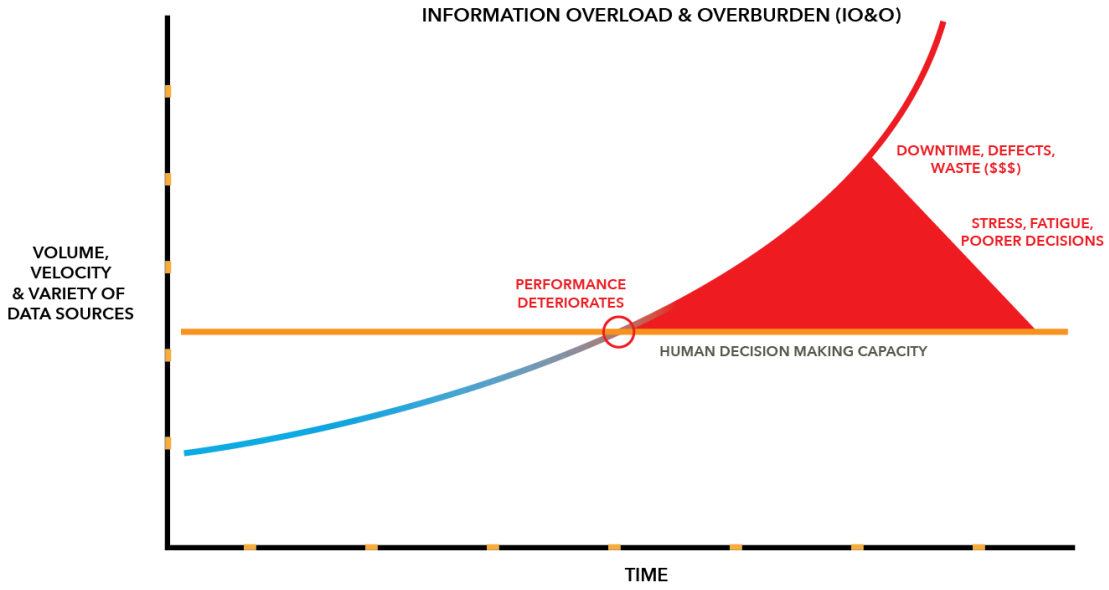
So how big is "big data" in regards to the size of the IoT market? Keep in mind, data was getting seriously "big" even before IoT devices/machines entered the picture. In 2012, EMC and IDC estimated that the "digital universe – digital data" would double every two years to reach 44 ZB (a zettabytes is a trillion gigabytes) by 2020. What's startling, however, is now Cisco and IDC estimate the amount of data generated by the Internet of Everything – IoT devices – which encompasses all machine-to-machine and people-to-people connections to exceed 403ZB by 2018. That's an order of magnitude increase in the previous forecast made just 4 years ago! An additional concern is that according to IDC, by 2018, 50% of IT networks will transition from having excess capacity to handle the additional IoT devices to being network constrained with nearly 10% of sites being overwhelmed.

Adding to the complexity in manufacturing is the fact that most of the data comes from a variety of sources with disparate technologies all at varying speeds, resolutions, formats, and using different communication protocols and methods. Capturing the data, within an infrastructure or technology that works with both current and legacy technologies is just the beginning of the challenge. Once captured, the vast amounts of data must be processed or filtered based on team or user-defined rules and selection criteria. And then, for the data to be actionable in a meaningful manner, it must be concisely directed to the right people at the right time based on an individual's role and responsibility.

Although the number of devices and associated volume of data is growing exponentially, the ability of the human brain to process all of this data in real-time isn't keeping pace. Compounding matters, legacy plant communication mediums/systems are incapable of funneling the vast amounts of data to the right people in a personal and interactive manner. As a result, entirely too much time is wasted by employees by either a) ignoring distractions or noisy communications (Information Overload), and b) searching for information that is buried in dispersed data silos (Information Overburden).

In his book, The Organized Mind, neuroscientist and psychologist, Daniel Levitin discusses Information Overload (IO) – the notion that we are trying to take in more information than the brain can handle. He writes that, "We used to think that you could pay attention to five to nine things at a time. We now know that's not true. That's a crazy overestimate. The conscious mind can attend to about three-four things at once. Trying to juggle any more than that and you're going to lose some brainpower." This information overload also leads to "decision fatigue", where we become mentally tired from making inconsequential decisions on irrelevant information.

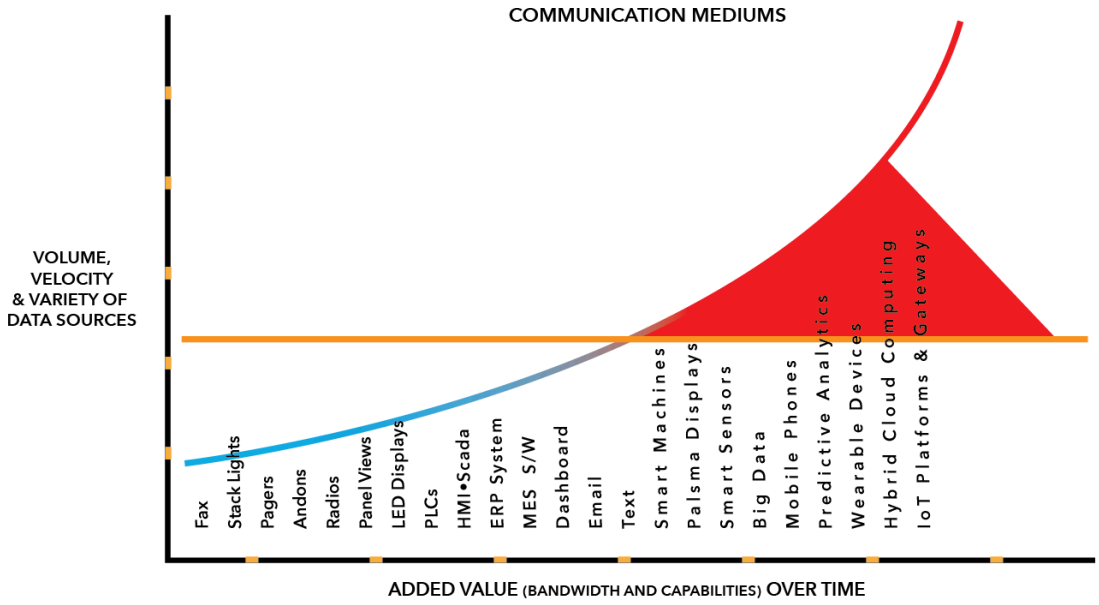
When overloaded with more information than one can process, performance will deteriorate as people actually become confused, ignore information that may be valuable, and make poorer decisions as illustrated below.



Toyota Motor Manufacturing, with its *Toyota Production System* formally documented in 1973 along with other leading lean manufacturers, have always recognized this phenomenon in regards to employee productivity and they have strived to keep communication clear and visual. For example, at the centerpiece of the Andon communication system are simple lights, typically organized per workstation, that highlight a problem, as it occurs, in order to immediately introduce countermeasures to prevent recurrence. In lean manufacturing terms, fast-forward to the main objective of IIoT Messaging which is to essentially do the same while eliminating overburden *(muri)*, inconsistency *(mura)* and eliminate waste *(muda)* in the area of timely communication to optimize employee productivity.

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Over the years, lean manufacturers have strived to keep plant-wide communication systems simple and to-the-point with at-a-glance visualization mediums/methods. Unfortunately, these Andon-like communication methods/mediums along with fragmented software applications (each requiring separate logins/authentication), radio systems, and other legacy communication methods cannot keep up with the growing number of data sources (smart machines, sensors, various teams, etc.) let alone with the rising volume of data associated with rich, value-add information technologies. The following illustrates how common manufacturing communication mediums have evolved or emerged over time in efforts to address growing data demands and plant-wide communication requirements.



IIoT Messaging complements, or minimizes the shortcomings of today's communication mediums by providing an effective mobile medium to communicate amongst team members while leveraging their comfort and preference with today's social messaging/communication-type apps.

The inability of today's communication mediums to effectively process and deliver actionable information in a synchronized, filtered manner is costing manufacturers hundreds of thousands of dollars per year in downtime and lost productivity. Inefficient communication is one of the greatest waste activities within a plant. Manufacturing plants are awash with more data than ever before, and making that data actionable is THE challenge. Everything, all of the time doesn't work.

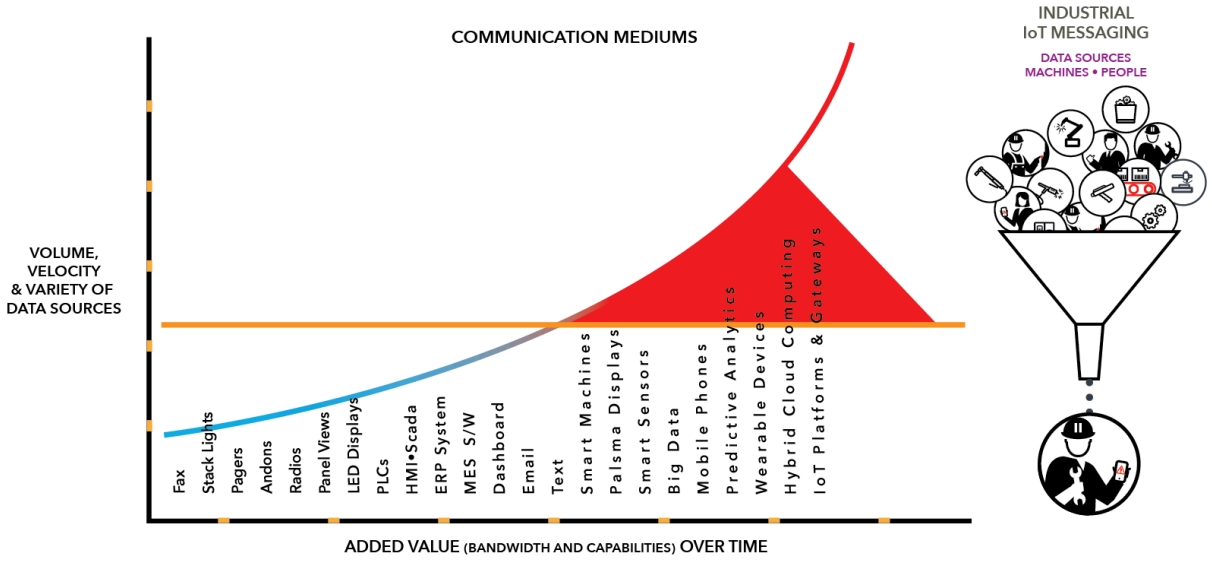
Plant communication not only has a direct impact on time-based metrics such as unplanned downtime, cycle time, response time, TAKT time, changeover, OEE, etc., it also has an impact on costs or waste associated with overproduction, in-plant transportation/movement, processing of orders, rework, product defects, and employee safety. In manufacturing, time is money. Front-line employees and management alike have no time to waste.

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The cost and consequences associated with inefficient communication and lost productivity continues to grow at an alarming rate. In 2015, Thomas.net placed the costs of downtime as high as $22,000 per minute in a recent tier one automotive survey. This is up from $8,000 per minute in 2005. It is just obvious that the reduction of unscheduled downtime and other forms of waste associated with inefficient communication will have a direct and positive impact on an organization's bottom line.

Given the limitations of today's communication mediums, the sheer magnitude of the information growth rate presents real challenges. From a user perspective, it can be incredibly frustrating to be inundated with emails and text alerts that don't apply to what you need to get done now. Mass broadcasts from Andons, stack-lights and radio pages can be equally distracting and cause even more energy waste in the time expended ignoring these signals, rather than responding to them. Equally frustrating and time consuming is wading through reams of irrelevant data (clutter) in various data lakes, in order to find that crucial piece of information you are looking for at a given moment in time.

Industrial IoT Messaging, however, makes the growing volume, velocity and variety of information – from both machines and people – manageable, relevant and concise. IIoT Messaging allows individuals to ride the wave of growing information without being crushed.



Harnessing the growing amounts of information can deliver a true competitive advantage. Harnessing the maximum power generated out of IIoT will require manufacturers to go a step beyond connecting machines and sensors that feed production displays, monolithic MES or HMI software packages, databases and analytics which undeniably provide insight into the data gathered. IIoT Messaging, however, takes the data gathered a step further by turning that insight into employee engagement, collaboration, commitment and action.

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Given the consequential nature of time, manufacturers must convert the valuable information gleaned out of the IIoT into meaningful action in real time. IIoT Messaging engages humans and machines in conversation and collaboration, and does just that.

While it's true that the proliferation of smart machines and sensors, big data, analytics, and mobile devices is making communication within a plant increasingly complex, users still want communication to be simple, personal and interactive. They want to connect – anywhere, anytime, using a variety of media, devices and operating systems. They want access to media-rich, easy to use, consistent, effective and relevant information that matters most to their individual needs. Users desire an exception-based, consolidated messaging/communication system that will organize the vast, variety of data and translate it into meaningful information for immediate action.

IIoT Messaging is a communication solution that can tackle today's explosion of data. It can make people more efficient, leading to better outcomes and results by enabling clear thinking and better decision making. IIoT Messaging leverages the best of social networking with a manufacturing twist. It allows people to have a sense of belonging to a community and stay up to date on what matters to them in a concise, visual manner.

IIoT Messaging keeps people informed on what matters to them most, without crushing them. With IIoT Messaging people get more done in a day by doing fewer things at once – less stress.

IIoT Messaging leverages mobility in manufacturing in ways similar to ways Twitter and Uber application platforms have changed their respective industries. Just look at what "mobility" and the "cloud", along with social networks and iPhones have done to newspapers, the U.S. Postal Service, the evening news, taxis and dating.

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Industrial IoT Messaging Essentials

A comprehensive Industrial IoT Messaging system allows you to stay ahead – eliminating information overload and overburden – leading to clearer thinking and better decisions. IIoT messaging makes it easier on your brain to do your job by helping you organize your day, your priorities. Instead of spending energy ignoring distracting signals/communications (constant stimulation and overload) or sorting through clutter (time consuming and burdensome) to get to valuable data hidden in various data silos, you can concentrate on consequential matters at-hand while effectively collaborating with team members, rest-assured that nothing is going to fall through the crack.

In a manufacturing setting, IIoT Messaging should incorporate these five (5) fundamental capabilities.

1. *Capture Data from Machines and People.* Data broadcasts from both machines and people should be consolidated within the same medium, same channel(s). Today, so much of the data people need to effectively do their job is scattered about in too many different sources. Machine broadcasts are typically separate from broadcasts from humans. With so much insight to be gleaned from real-time machine generated data, it is only logical to merge the information from machines with the conversations taking place amongst people. Bringing a somewhat human touch to machines and integrating machine data with human dialog leads to richer insight and better decisions.

2. *Filter Across Data Sources.* Consolidate the data in one place, eliminating the noise. It's not Information Overload. It's Filter Failure. A valid perspective may be that the problem really isn't information overload. Rather it's the failure to reduce the amount of irrelevant information people receiving by putting filters in place to remove low-quality noise (distractions) and replace it with high value and relevant snippets of information. Complex Event Processing (CEP) combines data from multiple sources to infer events or patterns that suggest more complicated circumstances or greater meaning.

   The goal of CEP is to identify meaningful events (such as predictive trends from machine intelligence or simple machine alerts) and respond to them as quickly as possible. The ability for a CEP to filter events based on specific user defined parameters ensures the information stream is relevant to the users real time needs. With self-service filters processed by a CEP engine, people decide the noise to signal ratio, and thus overcome the potential for information overload and overburden.

3. *Simple, Yet Rich Data Visualization*. Everyone in a manufacturing environment appreciates the value of time. Downtime, cycle times, OEE calculations and so many other critical key performance metrics use time as their basis. Communication, therefore, needs to be simultaneously to the point, concise, at-a-glance, and yet rich and meaningful. Complex data must be made simple and visual to facilitate clear thinking. When Big Data is made small;

cognitive overload is reduced. The increased stress of information overload is the enemy of productivity. Productivity increases when highly complex data when is presented in a well-structured, visually appealing, concise format. When sharing information with fellow employees you can optimize actionable insight by alternating text with the use of Andon-like icons, graphs, charts, videos, photos, and other multi-media methods to illustrate or highlight key points. The goal is to be simple, yet persuasive. Visualization helps team members detect production inefficiencies and product quality concerns hidden in the patterns and anomalies of the vast volumes of data that otherwise would be an impossible slog to mine.

4. *Clarify Ownership & Accountability.* It seems logical that a communication system should incorporate closed-loop feedback mechanisms. However, most of today's legacy mediums are open-loop, with no clear ownership or accountability for a given alert/call for action. As a result, the communication, although well intended, has the potential to end up undiscovered, leaving the sender/originator wondering who picked up or received the message. An effective communication system should incorporate date and time stamps, clarity of ownership, and drive accountability. Such a trail will continuously improve employee responsiveness. Industrial IoT Messaging eliminates the "he-said, she-said" and "I didn't knows".

   Many of today's manufacturing systems and social medial tools lack a structured framework for reviewing and handling information for immediate and future review. This lack of organization is one of the primary contributors to information overload. When organizing information by teams, labels, asset ID's, etc., with clarity as to who is working on the problem, productivity improves. It becomes much easier to search, find and act upon the information to expedite a resolution or simply understand that someone else has taken ownership and you can move on. In general, people truly want to serve – to be a hero and solve problems. IIoT Messaging empowers employees, drives accountability, and instills an ownership behavior.

5. *Spur Collaboration.* An IIoT messaging system should allow individuals to easily interact with fellow team members through conversation utilizing some of today's effective social media conventions. We know people enjoy expressing themselves, and appreciate being heard and contributing to the organization's goals. As such the messaging medium should encourage this human interaction and allow individuals to share insight beyond that of the simple call push button station or an impersonal Andon display board - common convention in today's legacy systems. The medium should be personal and engaging while promoting teamwork and a sense of belonging. It should facilitate the ability for experts, and integrated supplier partners, to join a conversation in efforts to expedite a resolution to a problem.

   The system should make it easy for team members to post a message in broadcast mode and receive/respond to broadcasts from others. This keeps everyone who needs to be in the loop on the same page. When people collaborate there is instant gratification. They become committed to their fellow team members, communication becomes contagious, productivity improves and great things happen.

Complementing Existing Communication Mediums

The advent of mobile commercial/consumer messaging has changed forever the way people communicate and search out information that matters to them in their personal lives. Similar change is arriving in manufacturing. Things are really speeding up and getting more complex. Per Big Data 2013 - the amount of stored information is growing four times faster than the world economy, while the processing power of computers is growing nine times faster. Little wonder that people complain of information overload and overburden.

Ironically, however, how often have you heard the line from the movie, "What we have here is a failure to communicate?" The failure to communicate is the single most universal reason given for problems that develop in a manufacturing plant. Given all the advancements in information technology, it is counterintuitive that communication is the problem. In reality, however, legacy communication methods/mediums commonly found in manufacturing are stuck in the past and incapable of keeping up with the looming data explosion brought upon by the emergence of smart machines, high-speed wireless networks and the Industrial Internet of Things (IIoT).

As more smart devices and machines are added to the shop floor, the amount of data generated is far greater than that which is translated into constructive, proportional action. Legacy communication systems simply cannot keep pace with the growth of data rich devices and machines. None of these systems have the capability to capture, process, and funnel information to the right people at the right time in a manner consistent with how people communicate or select/get their news today.

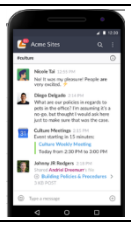
To process the growing amounts of data, manufacturers need a better way to tap into and deliver information that matters most. The investments made in communication systems to-date, though substantial, have fallen short on effectively harnessing and presenting the rich content available to help people engage, interact, connect and contribute to plant-wide improvement goals.

Today the per-capita expenditure for information in manufacturing is roughly $3,000/year. This means an average mid-size manufacturer with 100 employees invests $300,000 per year on communication and notification systems. We also know that within this same manufacturing model there is approximately $200,000 of annual expense incurred in underutilized personnel (monitor room operators, radio dispatchers, and middlemen) to man these less-than-effective communication mediums. Yet, in spite of these capital investments, the loss associated with poor communication still exceeds $240,000/year for a typical mid-size manufacturer based on two minutes of downtime per month, measured at $10,000/minute.

Given the dynamics of the factory floor, where immediacy matters most – real-time communication is critical. It is here where critical information (downtime events, quality alerts, calls for maintenance or parts, etc.) must rely on dated, one-way, impersonal communication systems that depend upon a responder being within line-of-sight or hearing distance. That these systems are hardly recognizable by the millennial generation transitioning into the workforce only complicates the situation further.

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The following table highlights communication mediums common to manufacturing and the shortcomings that IIoT Messaging overcomes in complementary fashion.

Today's Legacy Communication Mediums	Complementing Today's Mediums (Closing the gap with IIoT Messaging)
Andons, Production Displays, Marquees 	Open-loop, broadcast systems. Alerts go unnoticed as the information shared requires one being within line-of-sight or hearing distance. Tend to be distracting or noisy as static trigger logic isn't updated over time. Not collaborative or social.
Stack lights, end-of-line LED counters and timers 	To stare and wait for a light to come on is not personal or interactive. No clarity of ownership. No collaboration. Hard-wired, simple alarming/signaling that can lead to false or ignored alarms. Limited information shared while the price for content delivered is relatively expensive to install and update.
Radios, paging systems 	Limited number of channels. No clarity of ownership or audit trail with date/time stamps. These systems lack automated escalation techniques. Cannot attach rich multi-media files (video, photos, charts/analytics, etc.) that provide further insight into the problem.
HMI, MES and analytics software 	Wealth of data, but too much clutter to sift through. Expensive licensing and integration fees. Typically not the exception-based views. Nearly need a graphic designer degree to build screens, alerts, etc. Multiple logins make it burdensome to get to the information that matters most. Must be at the screen location to get information.
Email 	Inherently slow response times as people don't regularly check emails. People can accidently be dropped out of the chain. No structured framework for collaboration or escalation. Millennials simply avoids email as it is subject to spam and not very social.
Text 	Private, no transparency. Does not foster team collaboration. Individuals cannot select/follow what is most relevant to them. Not exception-based. Inability to track or report on resolution/response time which drives continuous improvement and accountability.
Commercial Messaging Apps 	These systems do not incorporate machines and people collaboration. There is no clarity of who owns a given event/message and there is no date/time stamp audit trail of the communication process maintained. No concept of completion, closed-out, escalation or tracking of responses/performance.

In summary, most of the current manufacturing communication channels are open-loop. They are reminiscent of the bygone evening news or newspaper broadcast approach where information/news is delivered to a fixed location. More often than not, today's systems tend to be distracting and lack clear ownership, accountability and status feedback mechanisms. Monolithic HMI/MES/analytic software packages contain valuable information, but unfortunately a team member has to plow through 80% of the content to get to the 20% that matters. Email and text are simply too private and do not facilitate team collaboration. Group emails and texts can be lost and lack the closed-loop audit trail accountability necessary to retrieve valuable information at a later date.

Although advancements have been made in each of these communication methods; they simply cannot keep up with the explosion of data and individual needs. When compared to proven mobile messaging apps that we have all grown comfortable using outside of work, the manufacturing approaches deployed to-date are expensive and marginally effective. IIoT Messaging complements legacy communication systems and the emerging IIoT landscape of technologies by transforming data into actionable information, leading to higher productivity and a more engaging work experience.

Expected Outcomes

Manufacturers will benefit from applying technologies similar to the proven messaging/collaboration apps that have become commonplace in recent years – *provided these solutions are adapted to the pace and accountability requirements of manufacturers*. With Industrial IoT Messaging, manufacturers can expect actionable, meaningful information to be directed to the right people at the right time on any device, anywhere, in a concise manner so people can parse the information they need to do their job most effectively. This novel interaction between machines and people will introduce completely new ways of working in manufacturing, especially on the plant floor.

When people and machines communicate as one and in real-time, great things happen:

- Improve Uptime, Overall Equipment Effectiveness (OEE)
- Six-Sigma Product Quality resulting in Less Scrap and Rework
- Lower Operating Costs (personnel, material management and flow, floor space utilization)
- Continuous Improvement and Heightened Workforce Engagement

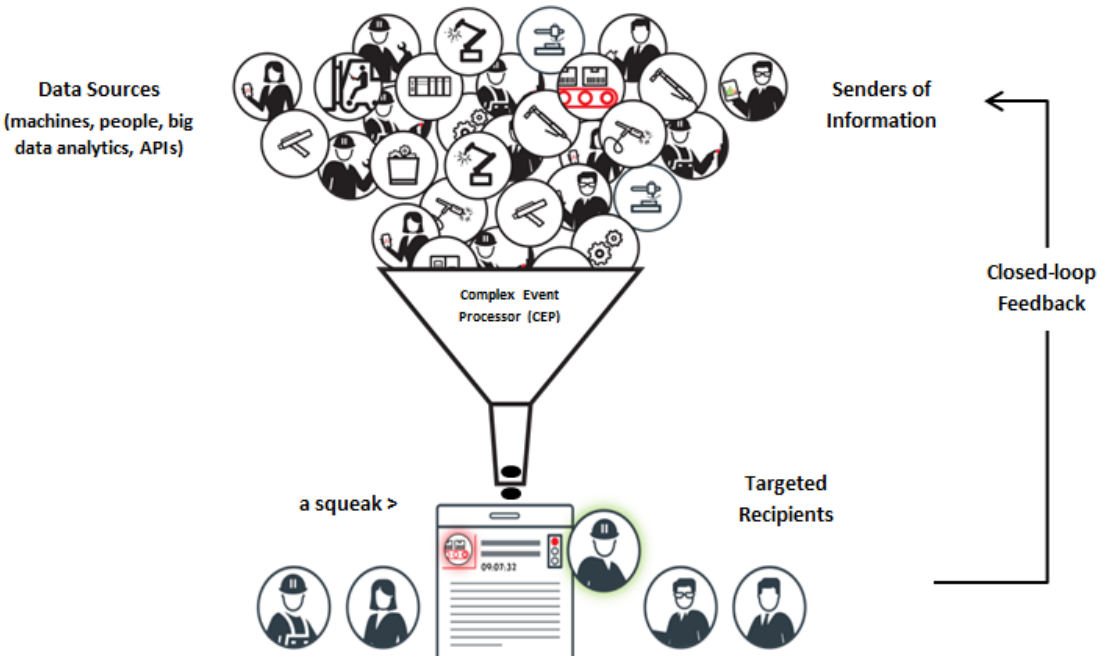
Industrial IoT Messaging will deliver on these opportunities by enabling manufacturing enterprises to capture and process the growing volumes of data about machines, processes, products and team members, while radically improving operational agility. Made simple by algorithms, rules and analysis across multiple data environments that lead to laser-focused prescriptive actions, Industrial IoT Messaging keeps front line employees and management in the know on events driven by both; a) simple conditional alerts, and b) complex event triggers. The true power of IIoT Messaging comes from a combination of generating insightful data from industrial equipment, and its ability to share the data between selected individuals, in a mobile environment, that leads to clarity, ownership, accountability, interaction. This makes for increased productivity of both machines and people.

Solution Overview – Stay Informed with SQUEAKS™

SQUEAKS consolidates real-time information from people and machines into relevant communication threads and improves employee productivity and financial results. SQUEAKS eliminates plant-wide communication inefficiencies (waste) by sharing information that matters most with the right people at the right time, anywhere – with machines part of the conversation. SQUEAKS™ overcomes the communication challenges associated with information overload (noise) and overburden (clutter) brought on by the explosion of data. With SQUEAKS, everyone works better as meaningful information flows seamlessly between people and machines in a user-selected, closed-loop manner thereby fostering collaboration and instilling ownership.

SQUEAKS makes it possible for modern and legacy manufacturing equipment to automatically broadcast squeaks (short multimedia messages) when monitored conditions or events trigger service requests, quality alerts, inventory replenishment needs, production alarms, or scheduled production updates. The setup, configuration, and maintenance of automated machine and process squeaks is made easy using a powerful Complex Event Processing (CEP) engine coupled with an intuitive user interface. The CEP engine applies business logic to machine data. Via an intuitive and graphical interface, the CEP engine empowers users to create and maintain rules on their own.

The CEP engine combines data from multiple sources to infer events or patterns that suggest more complicated circumstances, while at the same time making the communication simple and clear, leading to quicker response times. The goal of CEP is to identify meaningful events from machines (a malfunction condition, event or trend) and from people (a line operator calling for assistance) and then direct these events in the form of a structured text message to the right people at the right time to facilitate interaction and better decisions. SQUEAKS™ includes prebuilt connectivity to nearly any software, machine, or device protocol commonly found in manufacturing.



SQUEAKS™ empowers plant personnel to publish a squeak when they observe conditions requiring the assistance of others or when they simply need to collaborate with other team members. SQUEAKS™ includes hashtags to allow team members to easily follow and filter information relevant to their job roles. For example, a member of the maintenance team may be following squeaks containing #ServiceRequest. A quality supervisor may be searching for all squeaks containing #QualityAlert. And a production manager may be looking for scheduled #ProductionUpdate squeaks that make visible plan-versus-actual production output for a cell or line within their span of responsibility. Team members who use SQUEAKS™ choose to follow those machines, processes, and people which are important to their specific job function, in a self-service fashion.

Given our more complex manufacturing processes and the arrival of more data-rich equipment, the need for clear, to-the-point communication based on one's role is more significant than ever. Coupled with the growing workforce skills gap plus heightened customer expectations, the synchronized communication between people and machines is paramount.

To maintain a competitive advantage knowledge-based workers and smart machines need information delivered in an expeditious, laser-focused manner allowing employees to focus and solve one problem at a time. Bombarding individuals with more information than they can process actually depletes energy and clouds thinking.

SQUEAKS helps you get more done in a day by doing fewer things at once.

1. *Follow only the most information you need to stay ahead as defined by your people, your teams and you.* People communicate concisely when parts are needed, quality is an issue, production is below target, etc. With lean manufacturing clear and timely communication is essential. There is very little margin for error when even the most short-lived production delay or downtime can have expensive consequences. SQUEAKS™ facilitates the sharing of meaningful information concisely and provides at-a-glance feedback. The organization of information is brief, exception-based (red vs. green) – with minimal clutter – and individually selected (allowing individuals to follow what is most relevant given their responsibilities), ensuring everyone is on the same page, but not overloaded.

2. *Information is filtered across data sources (machines and people).* Machines converse (join in the dialog) when an alarm occurs, or data trends predict the need for action, or on traceability records matters, etc. Today's machines are huge repositories of valuable data and key performance measures. With SQUEAKS, manufacturers have the opportunity to harness this real-time data and translate it into action to minimize downtime, predict service activities, alert personnel of warnings, and glean root cause insight into machine malfunctions. Within the context of lean manufacturing, there is a Japanese term, Jidoka, which means "automation with a human touch". You can think of SQUEAKS as "communication with a machine touch".

3. *Communicate visually, concisely and yet with rich, multi-media content.* As with the simplicity of an Andon and the richness of an MES dashboard; SQUEAKS communicates in a simple manner, but with

the richness of multi-media such as photos, videos, charts, etc. Complex data and production problems are made simple and visual to facilitate clear thinking and propel action with many of the simple, at-a-glance icons and color schemes/labels to draw attention to key point of concerns as utilized by the Andons, for example. With SQUEAKS, communication is simple, yet persuasive.

4. *Verify ownership and accountability.* Squeaks™ instills an ownership behavior. Team members are accountable to each other. There is no more "he-said, she-said" or "I didn't knows". Response times are tracked to drive continuous improvement. Every communication/message is date and time stamped. Actions/comments are date and time stamped at every stage until a given issue is closed-out and marked complete. Unlike any other communication medium, ownership of the squeak (event, message, and call to action) is clear and there is an unprecedented level of feedback and responsiveness. The status of the squeak is tracked from start to completion with total transparency. With SQUEAKS there are no more dropped balls.

5. *Spur team member collaboration.* Once you have people and machines squeaking, corrective action is accelerated, knowledge and expertise is shared in real-time, and better decisions are made. It has been said, "Team beats talent when talent isn't a team." Open communication fosters collaboration allowing knowledge to be shared and challenges overcome together. SQUEAKS™ spurs collaboration. Public and private teams/groups along with external subject matter experts stay connected to what is important in a secure fashion. Escalation settings elevate awareness, as required, and filters (rules) reduce distractions.

6. *Better decisions drive better outcomes.* When people are informed they make better decisions and better outcomes result. Armed with the required information to do their job, people unite around common purpose with a heightened sense of urgency and knowledge of what is important. With SQUEAKS, everything is clear. The right people are engaged and working together in a more energized way - and machines are part of the team. Great things happen when employees become more empowered, interactive, accountable, and everyone is on the same page. Performance metrics and analytics reveal individual and team responsiveness and contribution to the organization's goals.

In a complementary fashion, SQUEAKS™ consolidates timely, exception-based information from disparate monitoring, analytics software application and data collection systems into one, concise, easy-to-act-on view of all of your plant data. This advances workforce engagement, at-a-glance visibility and plant-wide productivity. SQUEAKS™ empowers employees to make better decisions, quicker.

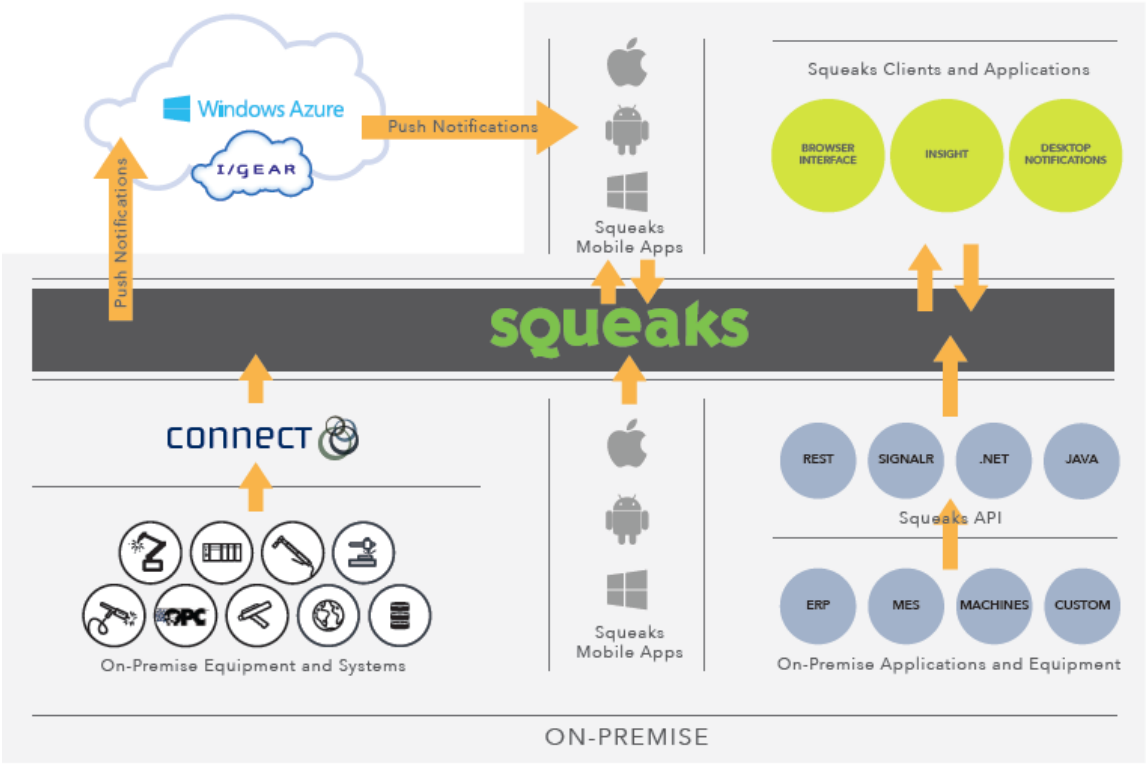
A squeak can contain rich content such as web links, photo images, or videos that may be helpful to people responding to real time issues and requests. An example of this might be a machine that squeaks a service request that includes a video link to assist maintenance personnel in performing required service actions. Another example might include a lineside operator who - when noticing a quality concern, uses their smartphone to take a photo of a defective assembly and then squeaks it along with a brief message including the hashtag #QualityAlert.

Extending beyond the capabilities of common messaging apps, SQUEAKS™ provides the means for effective closed loop communication. The "Got It" function allows people to accept a request or acknowledge ownership of an issue. Escalations can occur either automatically based upon pre-configured time parameters or manually when initiated by users. Escalations may take the form of broadcast to all followers but can also include the"@ mention" function to be directed to specific team members. Escalation priority is set using a straightforward red, yellow, green indicator. A simple "Complete" function allows properly authorized users to mark an open request or issue as finished.

All squeaks are maintained with date/time stamps and audit history to enable an invaluable set of analytics and reporting capabilities to assist in continuous process improvement initiatives as well as to support productivity reporting requirements.

SQUEAKS™ enables manufacturers to embrace and manage the information explosion with the arrival of smart machines, big data, the Industrial Internet of Things (IIoT), cognitive systems, etc. Although these legacy communication mediums have incredible merit, they are simply not equipped to handle the growing information traffic jam. Because they are increasingly incapable of getting the right information to the right people at the right time – without assaulting or overloading their minds, they represent a significant information processing/communication challenge.

SQUEAKS™ is the software app that makes sense of all of the data and ensures the communication battle is won in today's digital manufacturing environment – with a special emphasis on winning on the shop floor, where there is so much information and so much happens at real-time speeds. The following illustration provides an overview of the SQUEAKS platform and how an event may be captured and turned into a squeak.



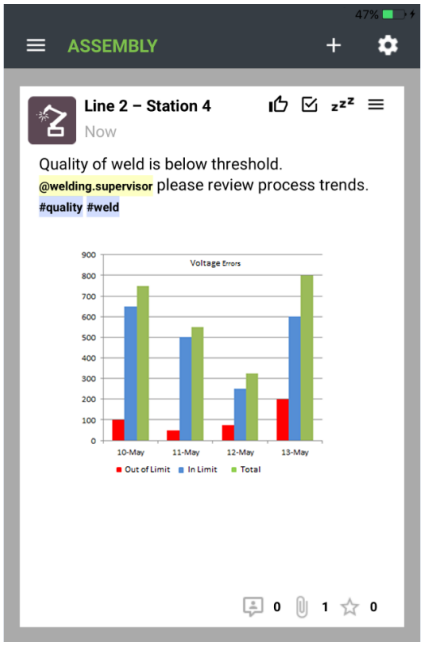
Sample Solutions

The following sample solutions illustrate the capabilities of SQUEAKS™ to tap into a wide range of data sources and seamlessly communicate information between people and machines in a collaborative, at-a-glance, closed-loop manner.

Quality Assurance and Notification

A tier one automotive supplier captures product quality from operators and machines directly and notifies teams when issues arise requiring heightened management awareness.

- Automate and embed quality management in production processes
- Notify the right team members instantly when a quality issue is detected
- Highlight the severity of the problem with photos
- Alert management through predefined escalation rules



Broadcast Hourly Production Status

A rolled metals manufacturer communicates hourly production goals and communicates actual performance to ensure daily targets are met and shared in a personal, mobile ANDON manner.

- Production, cycle, TAKT times goals are shared with everyone on the line
- Status results are shared to ensure everyone is aligned to achieve goals
- Graphs and charts are incorporated to make the information visual
- Keeps people well informed even when they are in meetings or traveling
- Alert the team when actual results fall below plan to accelerate corrective action

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Lineside Part Call Replenishment

A tier one automotive supplier orchestrates an efficient lineside part call replenishment process.

- Automate just-in-time part call replenishment to avoid inventory related production delays
- Incorporate proven Kanban methods to minimize components inventory at each station
- Improve workflow processes and replenishment efficiency
- Enable visibility, reporting, and analysis of the lineside material logistics process to support continuous improvement

Anticipate Machine Service Needs

A discrete parts manufacturer reduces overall maintenance costs and avoids unplanned downtime.

- Proactively monitor equipment to predict maintenance needs based on run times and machine conditions
- Plan preventive service before unscheduled downtime leads to production gaps and stoppages
- Include video instruction to assist service personnel in correctly executing maintenance actions

