SOLUTION BRIEF

How to Use Intrinsically Safe IoT in Hazardous Locations

By Aegex Technologies

aegex™ TECHNOLOGIES

NexVu™ AEGEX TECHNOLOGIES IoT

Challenges in Building an Industrial Internet of Things for Hazardous Locations

Industry 4.0, IoT, Cloud, Advanced Analytics and Machine Learning. These concepts are changing the landscape of process manufacturing and industrial machine maintenance. And while there is much buzz around these ideas, in certain real-world manufacturing applications they are complex and difficult to implement. “Hazardous locations” are defined as places where combustible atmospheres with volatile or explosive compounds, gases, liquids, fibers or dusts exist and require specially certified equipment for safe operation. In process manufacturing environments, this includes areas designated as hazardous locations or that could become hazardous in the event of an emergency. For locations classified as high risk, or Zone 1 or Division 1, there has been a limited supply of specialized equipment, sensors, and communications devices rated as “intrinsically safe”; and what is available on the market is expensive and time-consuming to set up and deploy.

Other challenges include:

- How to gain context around the issues that collectively point to the potential for a larger, more serious issue
- How to facilitate communications and collaboration among field workers and experts
- How to more effectively transfer knowledge during shift changes
- How to access real-time e-learning and expert input for new workers in the field

How can we help people and machines in hazardous industrial environments communicate with one another and learn to respond to data to solve large-scale problems?

Bringing Digital to a Paper-Based Legacy

Deploying an IoT solution for hazardous locations is a very different challenge than for other industrial environments. To begin with, traditionally all data capture in hazardous zones has been paper-based due to the high risk of any electronic communications or computing devices potentially causing a spark. This means not only have workers been limited in their communications and have been historically isolated from being able to reach out in real time for expertise, but all records have been captured on paper and transcribed directly by the worker or by third-party transcriptionists.

Challenges from this include:

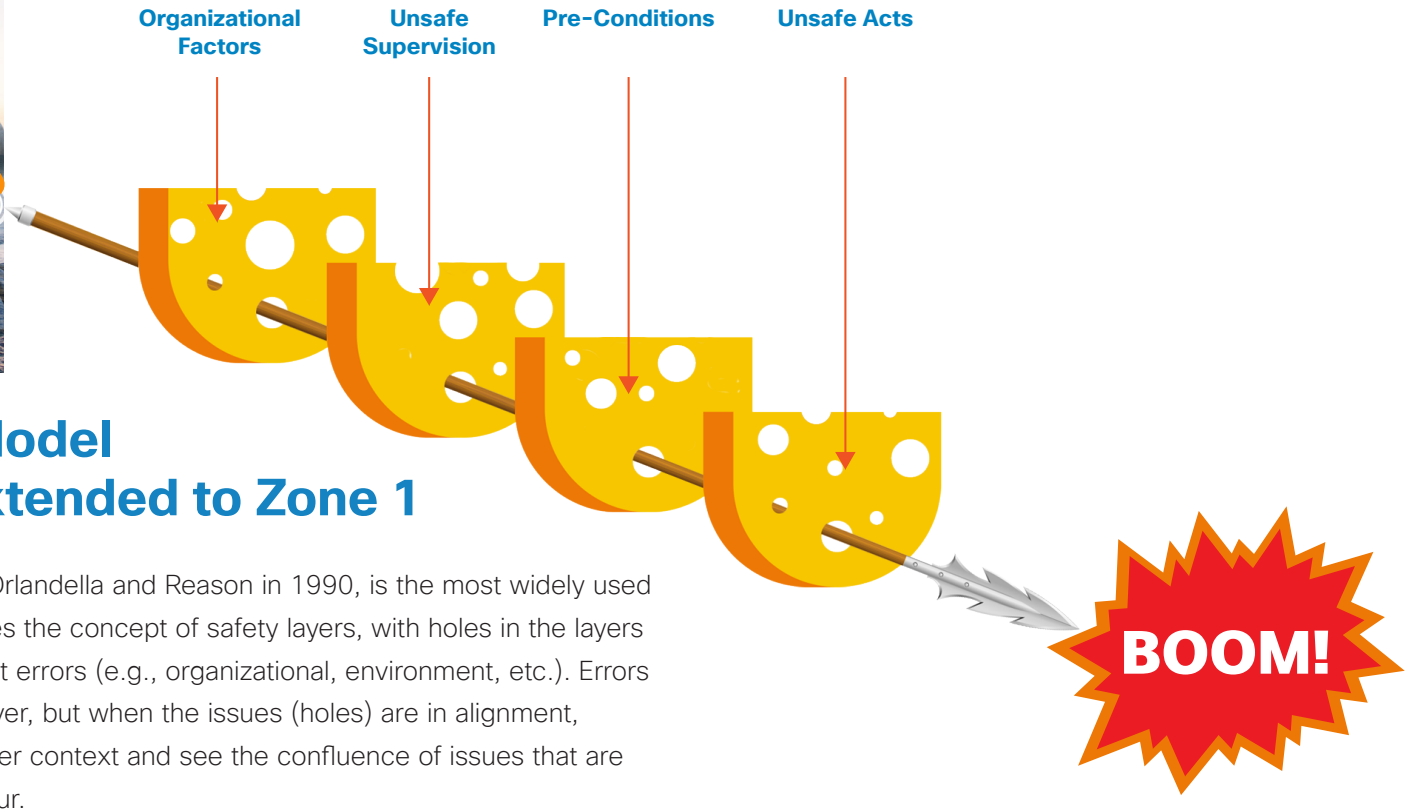
- Errors in transcription
- Delays in communicating critical information
- Time-consuming record keeping of inventory and maintenance records

According to McKinsey, digital advancements could improve efficiency 15 to 20 percent. [1]

In addition, the need to move beyond paper-based data capture has been accelerated by the Great Crew Change that's been taking place over the past several years. As tens of thousands of workers retire from the industry, the new entrants are digital natives who expect a connected, mobile work environment. With this wave of new workers comes a need for better efficiency to account for the loss of so many roles. And with the need to get new workers out in the field quickly comes a demand for real-time support, collaboration, and access to e-learning.

By bringing certified intrinsically safe communications devices and sensors into hazardous locations, these challenges can be addressed head on.

[1] Source: McKinsey https://www.mckinsey.com/business-functions/operations/our-insights/industry-4-0-demystified-leans-next-level



The Swiss Cheese Model of Process Safety Extended to Zone 1

The Swiss Cheese Model, developed by Orlandella and Reason in 1990, is the most widely used accidental analysis model. The model uses the concept of safety layers, with holes in the layers corresponding to deficiencies due to latent errors (e.g., organizational, environment, etc.). Errors and issues (holes) can be happening all over, but when the issues (holes) are in alignment, accidents happen. The goal is to gain better context and see the confluence of issues that are mounting up before serious problems occur.

If tools such as intrinsically safe IoT sensors can be used to provide appropriate context and identify impending issue (hole) alignment, then larger issues might be prevented before they occur, thus avoiding costly downtime or even more serious incidents.

Intrinsically Safe Versus Explosion-Proof

Intrinsically Safe (IS) devices are rigorously designed to operate at power levels low enough that the potential for incidental arcing is physically eliminated under normal conditions.

Explosion-proof devices are typically pre-existing equipment designs where the cases have been sealed to keep out flammable gases.

Look for the Ex logo and Intrinsic Safety Certifications: ATEX / IECEx Zone 1; certified by SGS to UL 913 Class I, II, III Division 1 Groups A-G; IP6X and IP65 for hazardous locations.

Introducing IoT for Hazardous Locations

To identify and mitigate potential “holes” to make hazardous location operations safer and more efficient, Aegex has developed the NexVu IoT Solution for Hazardous Locations. After significant field trials, the solution is based around the following key and unique components:

- **Intrinsically Safe certified** sensors and communications devices for all zones, classes, and divisions
- **Combination** of specific-purpose, low-priced devices in vast quantity
- **Overlay** of device-centric, gateway-centric, mobile-centric, and cloud-centric machine learning devices
- **Alternative** device architecture to accommodate AC or DC power due to lack of AC availability in hazardous locations
- **Availability** of wireless communications
- **Ease and affordability** of installation
- **Flexibility and customization** to monitor the right “things”
    - Swappable sensors on specific devices to meet specific monitoring requirements
- **Redundancy**
    - Back-up DC power due to mission-critical nature of sensing requirement
    - Second and third communications module to ensure connectivity
    - On-board cache memory to retain data
    - Overlay of alternative sensing devices to augment failed primary sensing devices (i.e., humidity sensor as a back-up to moisture detection)
- **Monitoring** of micro-climates within large-scale environments
- **Consideration** for massive geographical areas (“meta-scale”), yet monitored on a human scale
- **Infrastructure complexity**, including
    - Physical attributes (i.e., concrete structures versus pipes and conduits found in an industrial complex)
    - Topography including natural and man-made features that impact micro-climates, signal strength, limits to access by humans, or other constraining or impactful features

Introducing IoT for Hazardous Locations *continued*

Taking into consideration all of these dynamically changing factors makes modeling a “meta-scale” IoT solution for hazardous environments extremely difficult at best. HazLoc environments such as refineries, chemical plants, and pharmaceutical plants are all meta-scale locations that can cover multiple square kilometers and, therefore, require a unique approach.

Machine learning can help. Machine learning is a fundamental part of an IoT infrastructure, where various pieces of equipment “learn” to detect or identify anomalies from a previously established norm, either independently or through other contextual inputs derived from other sensing devices. This type of artificial intelligence (AI) uses algorithms that iteratively learn from data, automating analytical models for data analysis or for creating an actionable event.

The key point is understanding where the machine learning needs to take place to empower an organization with the right actionable information, rather than mountains of anomalous yet invaluable data. With an appropriate system architecture, device-to-system machine learning, and a block chain-distributed database interfaced with the NexVu IoT Solution, this meta-scale platform could empower hazardous industries to make concrete improvements in operation and productivity. For example, chemical plants could better manage energy consumption and dynamically trade power with local utilities.

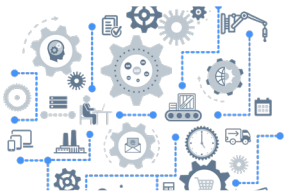
NexVu™, the Aegex Internet of Things (IoT) Solution for Hazardous Locations

NexVu™, is comprised of multiple components – hardware, software and environment - that collectively yield the essential information for efficiently and safely managing large-scale industrial operations with explosive environments.

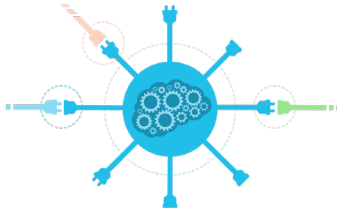
The components of the platform include:

aegex10™
Intrinsically Safe Tablets

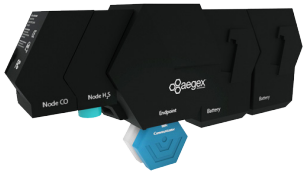
Meta-Scale IoT Platform
Aegex Test Facility



Architectural Integrity



Applications and APIs



NexVu™
Intrinsically Safe Sensors

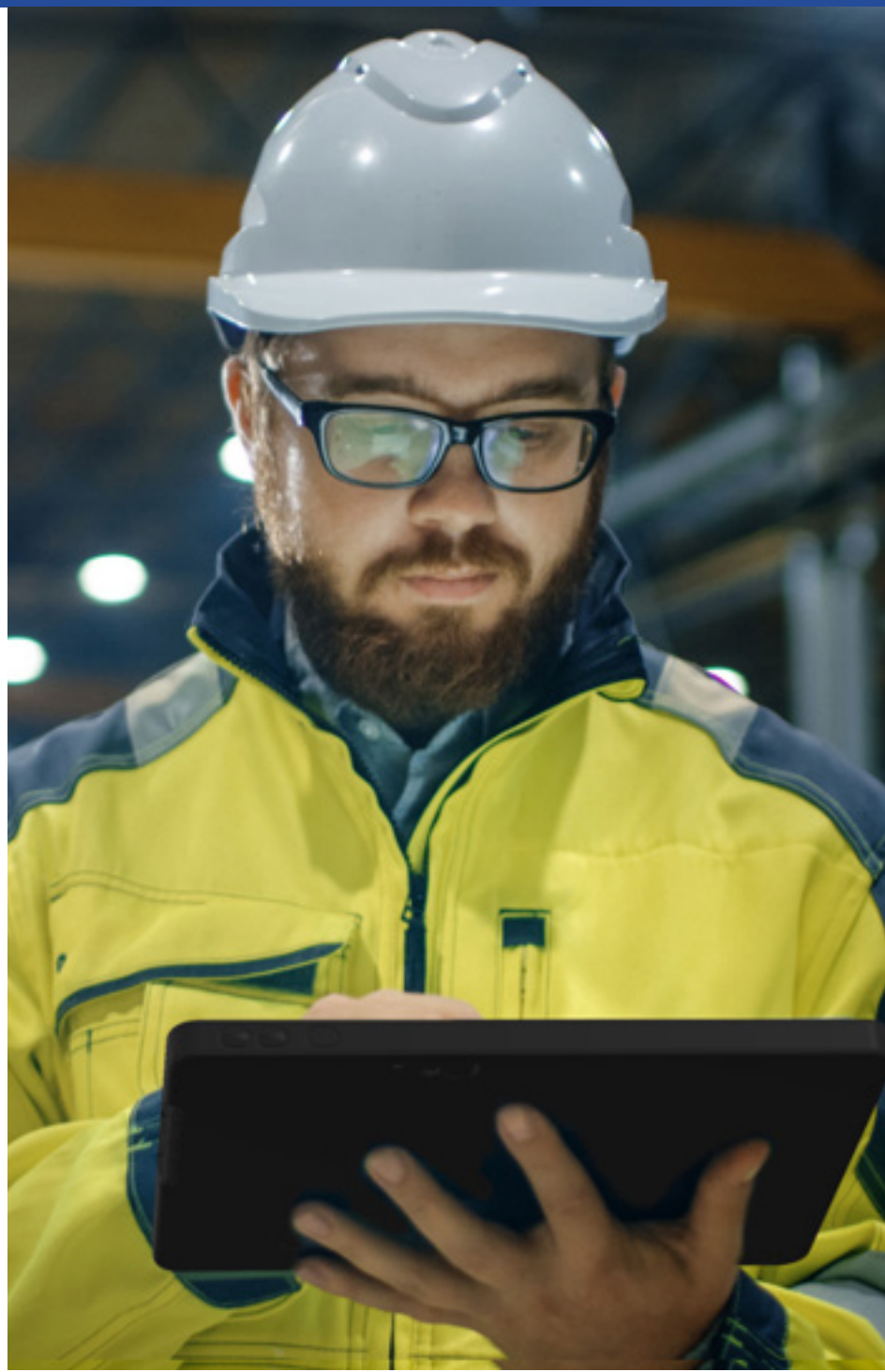
These elements working together form a comprehensive platform for understanding and managing Internet of Things and Internet of Everything operations in hazardous industrial locations where only intrinsically safe devices and equipment that cannot ignite an explosion are permitted. NexVu delivers a deeper look – the next view – into hazardous operations, delivering more comprehensive, customizable data that triggers machine learning and can be utilized for better decision making.

Adopting Microsoft's "Cloud-first, Mobile-first" strategy, Aegex has built NexVu on the Microsoft Azure Cloud for the most hazardous locations of some of the largest global industries, including oil and gas, chemical, pharmaceutical and others with combustible operating environments. NexVu serves as an Internet of Everything (IoE) - the networked connection of people, process, data and things - for hazardous environments.

1.aegex10™ Intrinsically Safe Tablet

Aegex believes the first step in connecting everything in a hazardous environment is connecting people to the cloud. To do this, Aegex developed the aegex10™ Intrinsically Safe Tablet, a Windows 10 tablet that can be used in the most explosive (Class I, II, III Division 1 and ATEX/IECEx Zone 1) industrial environments in oil and gas, chemical and other industries' hazardous locations.

Due to restrictions on electronic devices in hazardous locations, the Aegex10 IS Tablet becomes the basis of tablet architecture, where the device captures data and delivers actionable information directly to a user without the need for communications to a cloud- or enterprise-level interaction. Moving users away from pens and clipboards and toward smart devices empowers the human element of an IoT platform in a hazardous location.



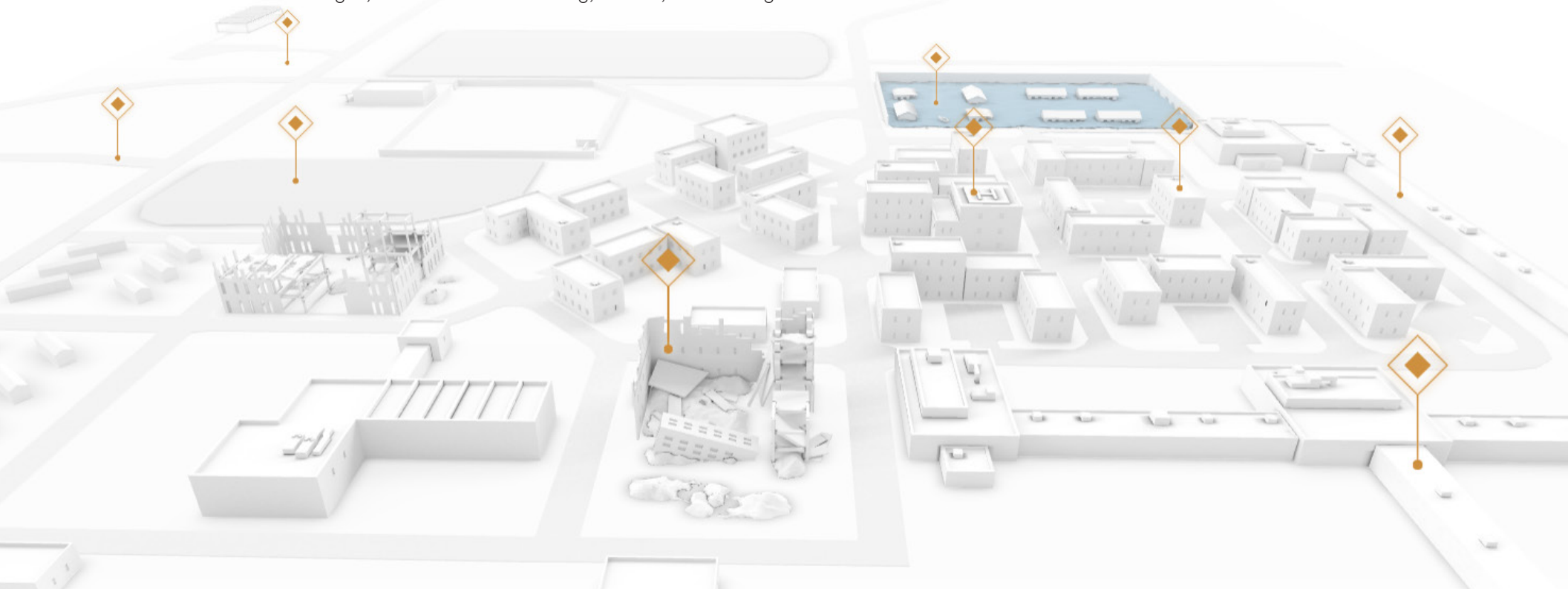
2. Meta-Scale IoT Platform – Aegex Test Facility

To create a model of an IoT for Hazardous Locations, the test facility must be of the size and scope to mimic real-world challenges. The only test facility that meets hazardous industries' unique challenges is the world's largest privately held "city" for training first responders, special forces and other teams for disaster planning and recovery: The Guardian Centers.

Aegex collaborated with the Guardian Centers to develop and perfect a meta-scale solution to meet this complex challenge of building an IoT for hazardous locations. Aegex has installed at the Guardian Centers a number of NexVu IS sensors of different types to detect various gases, temperature, wind speed, humidity, etc. that feed data to a central hub for processing and analysis. A Microsoft Power BI dashboard displays the test data to turn it into useable information, and Microsoft Azure syncs it with the cloud.

3. Realistic Testing

Through this realistic testing process, Aegex is perfecting the NexVu IoT Solution for Hazardous Locations and has been providing proof of concept for customers in the oil and gas, chemical manufacturing, utilities, and other global industries with hazardous location environments.



4. Platform Applications Suite and APIs

A successful IoT platform is not simply about connecting things, but also people. Individuals are at the heart of data capture, collaboration, and consumption. Today's mobile workers are looking for electronic data capture, communications with other fields workers, collaboration with experts, and immediate access to knowledge bases and e-learning. Armed with the right mobile communications devices, individuals can spot anomalies (a puddle, rust, etc.) that can take an order of magnitude of sensors to identify. Extensive field trials have pointed to a collection of Applications and APIs that contribute to a holistic view of a large-scale operation.

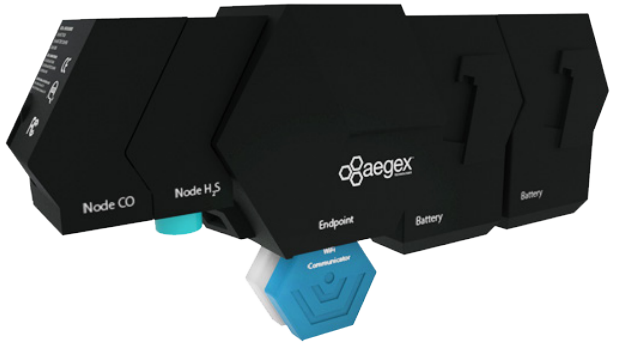
When configuring the Aegex10 IS Tablet with various tools, including bar code capture, RFID capture and thermal imaging, the tablet helps consolidate the number of devices deployed, and ensures that communicating such remote information is on the same secure protocol as other applications deployed on the tablet. Further, using tools such as NFC adds to the legitimacy of the data capture by confirming the location of individuals with date and time stamps. This contributes to robust and accurate compliance documentation and validation.

Additionally, certain other applications not specific to tasks, such as maintenance and operations applications, contribute to a robust IoT platform. These include tools that add to the contextual value of data captured.

Benefits include the ability to:

- Preload partner apps for vertical applications
- Use Skype for Business for field collaboration
- Employ Microsoft Cognitive APIs (https://www.microsoft.com/cognitive-services/en-us/apis) such as facial recognition for secure login or emotion recognition to monitor worker distress or suitability in hazardous situations

5. NexVu Intrinsically Safe IoT Sensors



Simply plugging in a gas sensor or anemometer is not feasible in a hazardous area. Power outlets do not exist in hazardous locations because of the risk of spark in combustible atmospheres; therefore, only devices with the right certifications can be used.

To capture as much information as possible at any given location, the NexVu IoT Solution is built on the following concepts.

1 ▪ Hybrid Cloud / On-Premise Solution: Any existing device or future device (no matter the manufacturer) should integrate into a single cloud solution. Azure, for example, operates as a fully cloud-based solution or independent enterprise on-premise solution as certain protocols may require, or even an intelligent hybrid of the two.

2 ▪ Interrelationship between Sensors and Gateways: When devices are deployed, an interrelationship between sensors and gateways is required to manage remote devices and the diversity of environmental limitations.

3 ▪ Multi-data Sensor Capture: Each device deployed should capture a broad array of data, not single-device, single-data input. The cost of deploying a single sensor into a refinery is too high to gain pervasive information; therefore, any single device and its adjacent devices should capture dozens of different types of data to ensure contextual machine learning is accurate and valid.

Given the variety of hazardous environments that can exist across industries and even within single facilities (unlimited numbers of compounds, 14 critical gases that do not rise, dusts, particulates, fibers, etc.), flexibility and customer-specific customization is necessary. The challenge is that this mass customization must take into account certain architectural requirements. Additionally, sensors and devices must take into account the lack of availability of power and the lack of robust or even uniform wireless communications. Lastly, a successful IoT deployment relies on pervasive data; therefore, cost of acquisition, deployment and integration become constraining factors.

5. NexVu Intrinsically Safe IoT Sensors *continued*

To achieve a viable IoT Platform for Hazardous Locations, Aegex applied its patents-pending intellectual property developed for the Aegex10 IS Tablet to the NexVu IoT Solution, with the ability to mix and match types of specific sensors, radio options and power options to create a sufficient base platform to inexpensively deploy in a remote location or meta-scale complex.

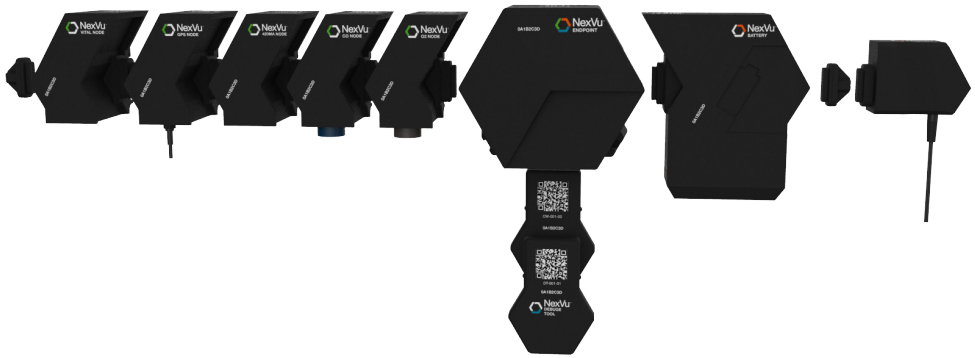
After extensive development and testing, the final product, the NexVu IoT Solution for Hazardous Locations, has been produced and marketed as a safe, simple, complete solution for gathering, processing and distributing all types of data in hazardous operating environments.
NexVu is configurable for any type of hazardous area to gather information that will provide a more complete picture of the conditions surrounding that operation and help operators make better decisions about safety and efficiency that will improve productivity and performance.

With each battery-powered NexVu endpoint having the capacity to attach up to 32 nodes incorporating 40+ different sensors, NexVu can assess the complete operating picture of a hazardous area. The intrinsically safe and “smart” sensors do not need prior programming – they are automatically recognized in the Cloud with pre-established hazard thresholds.

5. NexVu Intrinsically Safe IoT Sensors *continued*

The NexVu IoT Solution for Hazardous Locations is not assumed to meet all unique requirements of all hazardous facilities, and, therefore, remains an open standard for other sensing devices. Based on research, some of the fastest returns can be generated by monitoring:

- Annulus Pressures
- Production Chemical Monitoring
- Corrosion Monitoring
- Critical Equipment Health Monitoring
- Gas Monitoring
- OEM Equipment Monitoring
- Employee status



Sensors detecting different gases, temperatures, pressures, etc. can provide myriad data that, together, give a holistic view of plant operations. Individual data points, such as wind direction and speed at various elevations, when combined with other data and machine learning, result in the big data that identifies “holes” that could lead to issues and helps improve processes and overall efficiency safety and productivity.

The Aegex NexVu IoT Solution Developer’s Kit, engineered and tested by Aegex’s R&D and manufacturing division, AegexLabs, contains the basic elements of the NexVu IoT Solution and enables engineers to better understand the NexVu modular design and flexibility for capturing data that enables greater analytics and operational efficiency. The NexVu Dev Kit includes the following components:

- Endpoint
- Environmental Sensor Node (Temperature, Humidity, Air Pressure, Light)
- O2 Node
- CO2 Node
- GPS Node
- WLAN Communicator
- Battery Pack
- Charging Connector
- Debug Tool
- Quick Start Guide and Box
- Aegex10 Tablet with Windows 10 IoT Enterprise
- Aegex10 Docking Station
- 6-months free License to Server (in paper form)
- Guide to Power Management
- Desktop Stand / Ground Mount
- Shipping Case

6. User Interface and Analytics

In a typical offshore oil rig with 30,000 sensors for capturing data, only 1% of that captured data is being turned to actionable information used to make decisions. This same percentage holds true for other industries as well.[2] It is an exercise in futility to capture billions of data points and then fail to turn them into a usable form that would allow field workers to make necessary, if not life-saving, adjustments. Effective data visualization tied to machine learning is critical.

Aegex has developed the NexVu IoT Solution on Microsoft Azure and Power BI to ensure security and scalability that enables companies to move to an IoT- or IoE-managed infrastructure. One of several pages of an easy-to-read dashboard that was originally developed for the test facility at Guardian Centers is shown in the graphic above.

In environments where problems can quickly turn into catastrophes, the easy-to-read, real-time and accurate analysis of information can improve operations, protect the environment and save lives.

[2] The Right Moment for Analytics," by Pallav Jain, Gloria Macias-Lizaso and Guido Frisiani, McKinsey &Company 2016

Conclusion

Industrial IoT for Hazardous Locations must consider the special conditions that govern machine learning in highly volatile industrial operations. It must also include specific components that are purpose-built for these environments in order to capture and really utilize big data, whether in oil and gas, chemical or pharmaceutical manufacturing, public safety or other critical operations. With the right intrinsically safe IoT architecture widely deployed throughout hazardous locations, organizations can see the “next view” of their operations. With NexVu, companies can safely connect people, data and machines to optimize processes and improve their overall safety, efficiency and performance.

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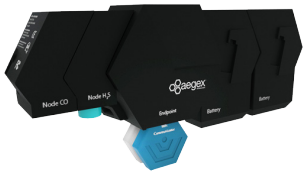

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