Aegex IoT Platform for Hazardous Locations

By: Thomas P. Ventulett, CEO
Aegex Technologies, LLC

www.aegex.com

Aegex IoT Platform for Hazardous Locations

Thomas P. Ventulett, CEO Aegex Technologies LLC

Summary

The **Aegex Internet of Things (IoT) Platform for Hazardous Locations** 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:

1. Aegex10 Intrinsically Safe Tablet
2. Meta-Scale IoT Platform – Aegex Test Facility
3. Architectural Integrity
4. Applications and APIs
5. Intrinsically Safe Sensors
6. Intrinsically Safe Wearables
7. User Interface and Analytics

All of 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.

General Overview: Building an Internet of Everything for Hazardous Locations

Industrial Internet, **Smart Cities**, **Internet of Everything**. All of these terms seem like simple enough concepts, but in real-world practice they are extremely complex and difficult to implement. In environments that are designated as *hazardous locations*, or that could become hazardous in the event of an emergency (think rail-car spill in your town), how can facilities or cities be monitored in a pervasive and cost-effective manner? "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.
How can we make machines in hazardous industrial environments communicate with one another and learn to respond to data to solve large-scale problems?

Based on our award-winning and patent-pending intellectual property design of the Aegex10 Intrinsically Safe Tablet, Aegex Technologies has developed the **world's first fully integrated, cloud-based, *intrinsically safe Internet of Things platform for hazardous and explosive locations***.

Adopting Microsoft's "Cloud-first, Mobile-first" strategy, Aegex has built a comprehensive **IoT Platform** on the **Microsoft Azure Cloud** for the most hazardous locations of some of the largest global industries. The comprehensive platform serves as an **Internet of Everything** (IoE) - the networked connection of people, process, data and things - for hazardous environments.

The current hype around IoT has reduced the concept of an IoT deployment down to a few simple components with some environmental limitations:

- Sensors
- Communications
- Big Data
- Analytics
- Visualization

This simplicity works nicely on a loading dock or in a warehouse. But it is an incomplete plan for IoT when monitoring very large, "**meta-scale**" operations such as refineries, chemical plants, urban landscapes or other facilities.

Meta-Scale IoT Platform

Deploying an IoT solution for hazardous locations is a very different challenge than for other industrial environments. After significant field trials, Aegex developed the IoT Platform for Hazardous Locations around certain key and unique components:

- Intrinsically Safe certified 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 cost 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

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, pharmaceutical plants, and urban environments are all "meta-scale" locations that can cover multiple square kilometers and, therefore, require a unique approach not previously proven.

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 Aegex IoT Platform, 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.

AEGEX IoT PLATFORM COMPONENTS

1. *Aegex10 Intrinsically Safe Tablet*

Aegex believes the first step in connecting everything in a hazardous environment is to connect 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 (UL Class I, II, III Division 1 and ATEX/IECEx Zone 1) industrial environments in oil & gas, chemical and other industries' hazardous locations.

Due to restrictions of 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 using pens and clipboards and toward smart devices empowers the human element of an IoT platform in a hazardous location.

Additionally, the tablet connects Bluetooth data-capture sensors, biometric wearables and other peripherals that have been designed safe for use in hazardous locations utilizing Aegex patent-pending intellectual property. These peripherals connected to the Aegex10 also mimic a gateway architecture by enabling low-power devices to backhaul data via multiple radios.

2. *Meta-Scale IoT Platform – Aegex Test Facility*

Aegex Technologies has learned that to manage a **meta-scale IoT platform**, particularly one where hazardous or explosive materials are present, elements of each of **Gartner's Five Types of IoT Architectures**[1] are necessary and must all be applied. Gartner defines these five key IoT architecture types as:

[1] Build Your Blueprint for the Internet of Things, Based on Five Architecture Styles
Refreshed: 12 May 2016 | **Published:** 24 September 2014 **ID:** G00269736; **Analyst(s):** *Hung LeHong;* © 2014 Gartner, Inc.

- Thing-Centric Architecture (machines/things are "smart" on their own and store their own data; only communicate with Internet for coordination)
- Gateway-Centric Architecture (gateway houses application logic, stores data and communicates with Internet for things that are connected to it; things do not have to be as smart)
- Smartphone-Centric Architecture (a mobile device houses application logic, stores data and communicates with Internet for things that are connected to it; things do not have to be as smart)
- Cloud-Centric Architecture (cloud acts as connection hub, performs analytics and stores data; things do not have to be as smart)
- Enterprise-Centric Architecture (things are behind firewall and located together; little need for external Internet)

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 is collaborating with Intel, Microsoft and 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 more than 80 IS sensors of 30+ 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. Architectural Integrity

Through this realistic testing process, Aegex has perfected the IoT for Hazardous Locations and is providing proof of concept for customers in the oil and gas, chemical manufacturing, utilities, and other global industries with hazardous location environments. Each of Gartner's Architectures have been applied to a holistic solution that is the Aegex IoT Platform. A basic architectural structure includes the following:

- Mobile-Centric Architecture: devices such as intrinsically safe smartphones, tablets or other devices are globally certified to safely operate in hazardous locations. They independently identify anomalies and determine if they warrant an actionable alert, such as digitally capturing a photo of a gauge or independently directing a user to an alternate "route" for tasks such as maintenance jobs. Other mobile-centric uses cases include tasks such as routing an IP session such as Skype for Business based on the location of an individual to intelligently connect a user or situation to the right source for assessment.

- Thing- or Device-Centric Architecture: individual sensors independently analyze a condition inside a refinery, for example, where regular communications, availability of power, or human data capture is unreasonable, yet an alert for any anomaly is necessary. Independently, this is a common solution and is colloquially defined as "in the Fog" rather than "in the Cloud." The key differentiator is this type of monitoring and machine learning must take into account Aegex device architecture and intrinsic safety IP to ensure long-term, reliable and safe connectivity. A simplified example of the importance of device-centric learning is the need for a device to initiate alerts when a deadly gas such as hydrogen sulfide is detected.

- Gateway-Centric Architecture: Much like the device-centric machine learning defined above, gateway-centric architecture is commonplace in IoT planned systems. To build on the example above concerning hydrogen sulfide detection, a gateway-centric architecture in a hazardous location can poll surrounding devices to accurately map air movement, humidity, and air pressure across an immediate area so that actionable information about a complete, localized view of a situation can be directed the correct party for an appropriate response. The differentiating points about the Aegex gateway are:
    - Gateway itself must include an array of multiple sensing devices to maintain a baseline and to add to the capacity of a device-centric system.
    - Gateway devices must also connect some number of "near-by" devices to ensure pervasive connections.
    - Gateway devices must be globally certified as intrinsically safe but also support multiple physical architectures including LAN and/or a variety of WLAN connections.
    - Gateway devices must support performance processors to handle device-specific machine learning as well as analytics of connected devices in order to form a "cluster" of contextual data that monitors anomalous situations. Such anomalies or exceptions are then reported via clustered gateways.

- Cloud-Centric Architecture: This type of architecture takes on a very different level of importance over typical use cases in a hazardous environment. Due to the vast meta-scale of a typical refinery or even a small-scale remote well house, the contextual data gathered by a dispersed array of sensor creates greater precision in holistic system learning. As a simple example, a rise in temperature at one location can be signaled by an alert when a light sensor on the east side of a facility detects the sunrise.

- Enterprise-Centric Architecture: This is the final critical aspect to include in a system for monitoring a hazardous location. It is relevant for small remote locations, specific locations within a large facility, or a meta-scale facility in its entirety. Aegex IP for making devices intrinsically safe for operation in hazardous locations is fundamental to its business. Safe operation of electronic devices in a chemical plant, for example, means that the device has been tested and certified that it will generate neither enough heat nor spark to ignite the ambient environment. Safety of electronic devices, though, should not be limited to this single issue. An Enterprise-Centric Architecture provides for a closed, on-premises communications system that ensures information security and integrity, such as an ethernet system that is not connected to the outside world. In a modern world of hacking and cyber-terrorism, hazardous locations can become the source of a human catastrophe if such information security is undermined. Applying a separate, secure Enterprise-Centric Architecture with its machine-learning capabilities enables organizations to benefit from an additional layer of information while segregating highly sensitive information from other aspects of the IoT platform.

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 and consumption. Armed with the right 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, thermal imaging, the device helps consolidate the number of devices deployed, but ensures that communicating such remote information is on the same secure protocol as other applications deployed on the tablet. Further, using such tools including 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 contributes to a robust IoT platform. These include tools that add to the contextual value of data captured. Users can:

- 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. Intrinsically Safe IoT Sensors

Simply plugging in a gas sensor or anemometer is not feasible in a hazardous area or large cityscape. 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 Aegex IoT Platform is built on these following concepts as derived from the various Architecture defined above:

1) **Hybrid Cloud / On-Premises 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-premises 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 (unlimited numbers of compounds, 14 critical gases that do not rise, dusts, particulates, fibers, etc.) that can exist across industries and even within single facilities, flexibility and customer-specific customization is necessary. The problem to solve is that this mass customization must take into account the requirements of the architectures previously addressed in this document. 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.

To achieve a viable IoT Platform for Hazardous Locations, Aegex has applied its patents-pending intellectual property developed for the Aegex10 IS Tablet to the following array of devices, with the ability to mix and match types of specific sensors, types of devices, radio options and power options to create a sufficient base platform to inexpensively deploy all five IoT Architectures in a remote location or meta-scale complex. A test device demonstrating this platform is installed at the Aegex proving-ground at The Guardian Centers (shown in photo below).

Select up to 8 Sensors Per Gateway and up to 4 per End-Point Device	Communication Options (Select any or All)				Power Options (Select 1 per Device)		
Sensor Options	VLF Radio	Hart Radio	Wi-Fi Radio	LTE Radio	AC with Battery Back-Up	DC Power	Solar Power and Battery
Temperature							
Wind direction							
Wind Speed							
Rain Guage							
Gases (Benzene)							
Gases (Butane)							
Gases (Oxygen)							
Gases (CO2)							
Gases (CO)							
Gases (CH4)							
Gases (Ethanol)							
Gases (LPG)							
Gases (Hexane)							
Gases (Smoke)							
Gases (H2)							
Gases (Ammonia)							
Gas (Ozone)							
Gas (Hydrogen Sulfide)							
Gas (Phosphine)							
Light Intensity							
Nuclear Radiation							
Laser and Trip sensor							
Sound Intensity							
Liquid pipe Pressure							
Fire/Flash							
Proximity (very short Distance sensor)							
Humidity							
Air Pressure							
Air Quality (Dust)							

The Aegex IoT Platform 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 **big data** that improves processes and can help improve overall efficiency, safety and productivity.

6. *Intrinsically Safe Wearables*

Health and safety are priorities in hazardous areas. Monitoring individuals' well-being can help prevent accidents. A worker's vital signs can be critical indicators of a pending problem when contextually combined with ambient information such as a sudden increase in carbon monoxide plus an accelerated heart rate and a look of distress on his/her face as derived from a Cognitive API.

In cooperation with the Microsoft Innovation Center in Atlanta, Aegex is studying the Microsoft Band and other wearable devices to create the very **first intrinsically safe wearables** for "human data" capture in hazardous locations.

The Aegex IS Wearables are:

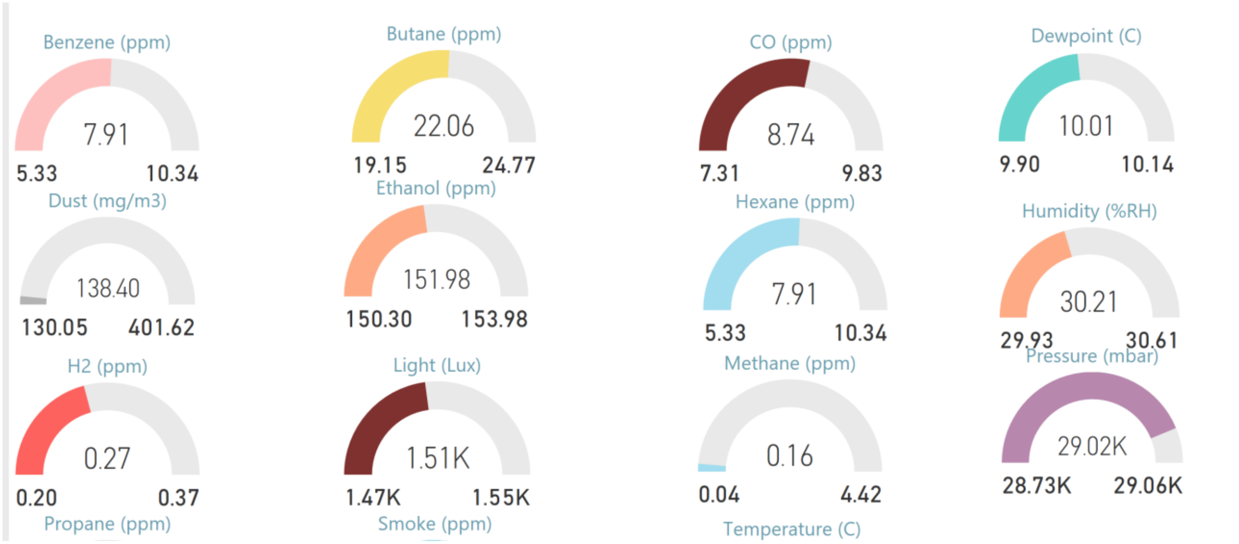
- Biometric devices that monitor human vital signs such as the Microsoft Band. As Aegex applies its patent-pending intellectual property to devices such as this, the human data points become a critical data point on the overall view of the condition of not only the workforce, but the facility. A biometric device + other data inputs (Emotion API, data from surrounding sensors) provide a complete view of a facility and its people.
- Tools that compile collective data can indicate potential health or safety risks currently unidentifiable in today's HazLoc environments.

7. *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.

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

Effective visualization of data is critical, but only if the five Gartner Architectures are applied and related to machine learning.



Aegex has developed the IoT Platform for Hazardous Locations 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 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.

Conclusion

An Internet of Everything 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 utilize big data coming out of these operations.

By connecting people, machines and processes to the cloud in the world's most explosive hazardous locations, Aegex Technologies' IoT Platform can help transform the way hazardous industries operate, thus improving productivity and safety.