How to Bring Differentiated AIoT Solutions to Rugged Industries

Overcoming the dust-proof, water-proof, and explosion-proof design challenges of complex AIoT systems

Companies looking to deliver value in the AIoT marketplace will be faced with extreme design requirements. Many of these systems will be deployed in rugged outdoor conditions, harsh climates, explosive environments, and wet or dusty settings, and therefore need a significant amount of customization. To succeed, these AIoT vendors must carefully consider their entire system design, from hardware to software to integration. Selecting the right end-to-end design partner can help avoid early pitfalls while adding value to end customers.

Paradigm shifting technology trends like artificial intelligence (AI) and the Internet of Things (IoT) have disrupted the electronics marketplace. This disruption has opened the door for countless startups, as well as existing companies looking to enter new application areas.

However, developing a successful AIoT solution is full of challenges that can make or break a product. These challenges go beyond the complex AIoT technology itself, and include the rigorous work of designing to specific functional and environmental requirements of a target application.

Highly regulated industries like healthcare, industrial automation, and transportation demand that most electronic systems conform to a wide variety of standards. But developing to the electronic safety standards of the medical industry, rugged requirements of the automation industry, or harsh environments of the oil & gas and chemical processing industries are neither simple nor inexpensive endeavors.

Below are just a few design requirements an AIoT design team could encounter on their path to productization.

- **Ingress Protection (IP) –** The IEC 60529 standard specifies a variety of IP ratings that signify how resistant a system is to objects, dust, water, and even submersion, while ISO 20653 ratings dictate resiliency against steam jets (Figure 1). These standards are principally a measure of how well a system is packaged. Of course, the more heavily packaged a system is, the more susceptible it becomes to overheating.

- **Explosion-Proof Design –** The possible repercussions of overheating and sparks in explosive settings are obvious, but the ways in which electronic subsystems could contribute to an explosion are not. They range from optical transmission components and fieldbus ports up to the system enclosure itself. IECEx standards, many of which have been converted to IEC standards, define the various levels of explosion prevention a system can achieve (Figure 2).

- **RF Emissions –** EMC regulation too comes in a number of forms. EMC standards regulate RF energy emissions to help prevent interference between systems in "noisy" RF environments and ensure consistent device operation. At the highest level, EMC is split into Class A equipment (systems that operate outside of domestic environments) and Class B equipment (systems that operate within domestic environments). In brief, Class B is more restrictive than Class A by a factor of ~10 dB. Beyond that, systems are also designated as either Group 1 or Group 2 devices, which defines ISM equipment that generates or uses RF for its own internal functioning or ISM equipment that generates or uses electromagnetic radiation for an external function.

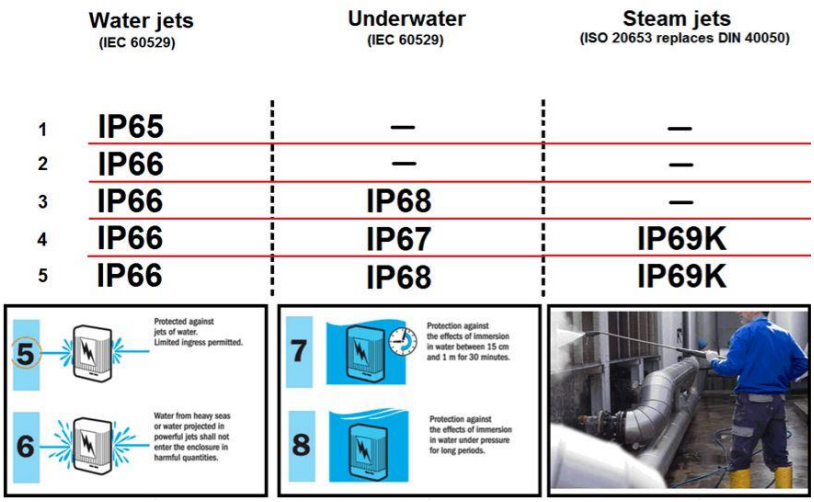

Figure 1. Industrial-grade systems are typically rated from IP66 up to IP69K, the highest ingress protection grade against high-pressure, high-temperature steam and water jets (Source: Phoenix Contact).

AIoT companies must consider these factors and much more before proceeding too far with their AIoT solution development.

Add AIoT Value Through End-to-End Partnerships

Especially for companies with no prior experience developing rugged, reliable, and long-life systems or applications, the most logical path forward is to partner with an electronic design and manufacturing company with extensive knowledge of the technologies, regulations, and environments in which these devices will operate.

Zone	EPL	Cat	Mark	Protection type	IEC Standard
0	Ga	1G	ia	Intrinsically safe 'ia'	60079-0 + 60079-11
			ma	Encapsulation	60079-0 + 60079-18
20	Da	1D		Two independent types of protection, each meeting EPL 'Gb'	60079-0 + 60079-26
				Protection of equipment and transmission systems using optical radiation	60079-0 + 60079-28
1	Gb	2G	d	Flameproof enclosures	60079-0 + 60079-1
			e	Increased safety	60079-0 + 60079-7
21	Db	2D	ib	Intrinsic safety	60079-0 + 60079-11
			mb	Encapsulation / moulded	60079-0 + 60079-18
			o	Oil immersion	60079-0 + 60079-6
			p,px	Pressurized enclosures	60079-0 + 60079-2
			q	Powder filled	60079-0 + 60079-5
				Fieldbus intrinsically safe concept	60079-0 + 60079-27
				Optical radiation protected	60079-0 + 60079-28
2	Gc	3G	ic	Intrinsically safe	60079-0 + 60079-11
			mc	Encapsulation	60079-0 + 60079-18
			nA	Non-sparking	60079-0 + 60079-15
22	Dc	2D	nR	Energy limitation	60079-0 + 60079-15
			nC	Sparking equipment	60079-0 + 60079-15
			pz	Pressurized enclosures	60079-0 + 60079-2

Figure 2. IECEx standards define how resistant an electronic system design is to explosion (Source: Ex-Machinery).

As a leading engineering firm specializing in the design of custom rugged platforms, Wincomm is capable of combining the AIoT expertise of its partners with application-specific deployment requirements. The company's core competencies span hardware

and software development, systems integration, extreme customization, and low- to mid-volume manufacturing that allows AIoT companies to scale from the prototyping phase into production (Figure 3).

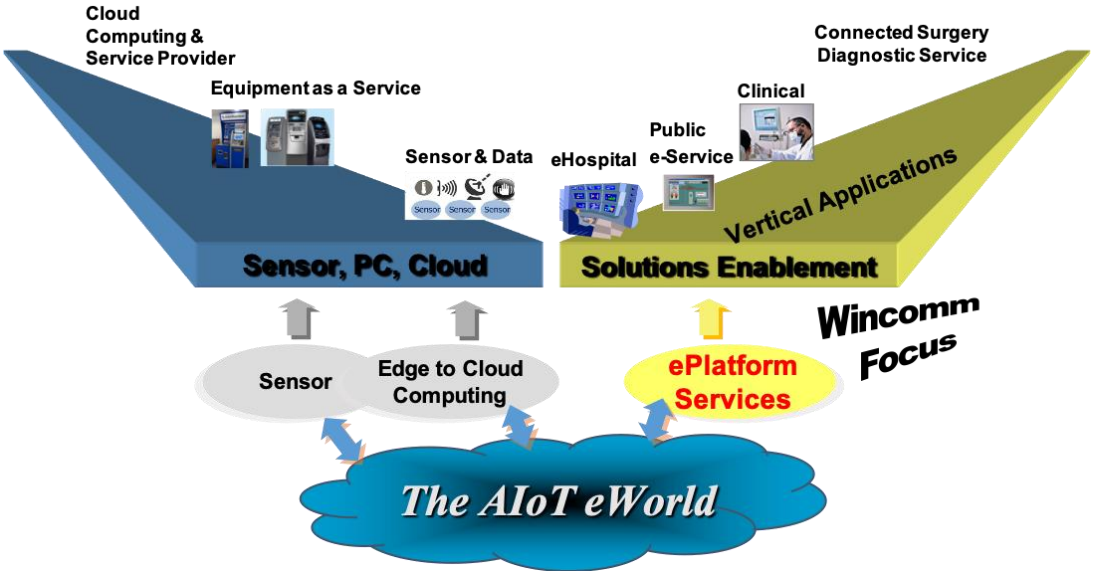

Figure 3. Wincomm is an end-to-end e-Platform services company supporting the emerging AIoT marketplace (Source: Wincomm).

As an ISO14001, ISO9001, and ISO13485-certified company, Wincomm has a heritage of designing waterproof and dust-proof systems rated from IP66 to IP69K – the highest ingress protection ratings for systems exposed to high pressure water and steam. In 2019, Wincomm has been certificated ISO80079-34:2018, which specifies requirements for a quality system that can be used by an organization for the production of equipment and protective systems for an explosive atmosphere.

Let's take a closer look at how Wincomm overcomes the design challenges mentioned earlier across key AIoT markets we've described.

Ingress Protection for Rugged Applications

In almost all of the application areas mentioned, AIoT systems must operate for many years in dirty, wet environments that experience extreme temperatures. Rugged

housings composed of plastic, steel, or aluminum are a baseline requirement in these conditions.

Wincomm leverages a variety of mechanical and thermal design techniques in its custom IP67/IP68/IP69K-certified designs and Full IP series of touch-panel and box PCs. These include:

- **Fully-Sealed, Expertly-Machined Housings –** By utilizing rounded housings, robust connectors and antenna covers, Wincomm engineers are able to deliver fully-sealed, gapless packaging options. Not only does this allow AIoT technologies to be dust-proof and even submerged completely in water. This serves as a baseline for IP69K-rated single- or multi-touch solutions (See Sidebar 1). Downward-facing I/O also minimizes the overall footprint and minimizes installation headaches for machinery deployed into tight spaces (Figure 4).

- **Stainless Steel and Aluminum Packages –** These packaging options are ideal for equipment that requires anti-corrosion and anti-oxidation properties. Apart from being robust against soaps, chemicals, water, and debris, these architectures are low maintenance; produced using green, recyclable materials; and support wide temperature operation.

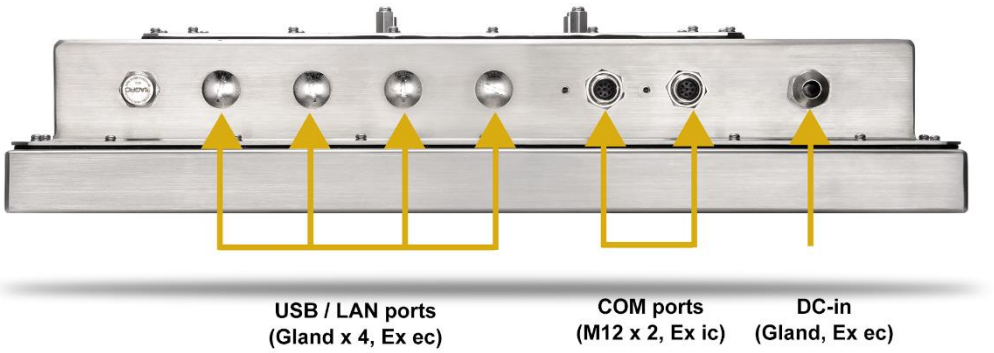

Figure 4. Wincomm provides hot swappable COM interfaces on the underside of designs for easy installation of AIoT systems in space-constrained environments.

To achieve maximum thermal dissipation in sealed, water- and dust-proof systems, Wincomm engineers leverage heatsinks with integrated heat pipes and other innovative tactics. For instance, anti-condensation designs allow systems to “breath” via specially-machined holes that dissipate hot air and prevent the thermal expansion of units.

Beyond mechanical expertise, however, the company also brings its i-Cooling and i-Control intelligent firmware solutions to bear on the thermal management front.

i-Cooling Climate Controls

i-Cooling is an intelligent firmware technology that automatically optimizes processing performance according to system temperature. This is a critical feature for high-performance systems that run continuously, especially if they are packaged in IP-rated, stainless steel enclosures where heat dissipation is a significant challenge.

After breaching a maximum thermal junction, modern processors will automatically reduce their clock speed. In the case of Intel® processors, for example, this can result in performance reductions of as much as 30 percent.

A better alternative would be to keep processors running at higher performance, albeit below the thermal junction, indefinitely. i-Cooling technology enables this, preventing CPUs from reaching the thermal junction trip point, but also not allowing it to drop out of turbo boost frequency ranges.

On the other end of the spectrum, i-Cooling supports low temperature use cases by leveraging a sensor to detect sub-zero conditions and shut down equipment. A companion heating element then draws additional power to heat the system up to 0ºC and restart the device.

These readings can be passed back over the WRDM platform to provide users with advanced operational insights for use cases such as predictive maintenance (See Sidebar 2).

i-Control intelligent Management

i-Control is another IoT technology developed by Wincomm that provides intelligent management of processing performance, power consumption, and heat dissipation for mobile and battery-powered systems.

To prevent power loss in these devices, i-Control monitors and analyzes system operation, tuning it to maximize battery life while maintaining stable performance and thermal operating conditions. This information is then transmitted to administrators, who can intervene by replacing batteries on Wincomm's hot-swappable battery-powered systems at the appropriate time. With i-Control, it is possible to achieve non-stop, 24/7 operation in critical applications.

100% IPxx Guarantee

To ensure quality and compliance various industry standards, Wincomm engineers subject their designs to an extensive battery of tests. These include functional testing, burn-in component testing, LED light-leak testing, high-pressure water jet testing, and high quality testing (Figure 5). As a result, Wincomm backs all of its IP-rated designs with a 100% performance guarantee.

Figure 5. For guaranteed performance in harsh conditions, Wincomm subjects its box and panel PCs to a battery of tests using high-pressure water jets, LED leak lights, and vacuum pressure (Source: Wincomm).

Explosion-Proof Solutions for Extremely Hazardous Environments

Given the variety of ignition sources and varying potential of incendiary sparks in locations ranging from oil & gas facilities to chemical processing plants to pharmaceutical production, AIoT systems may have to be designed to different anti-explosion classifications (Figure 6). These laws and regulations also vary by region, which raises the stakes for universal compliance.

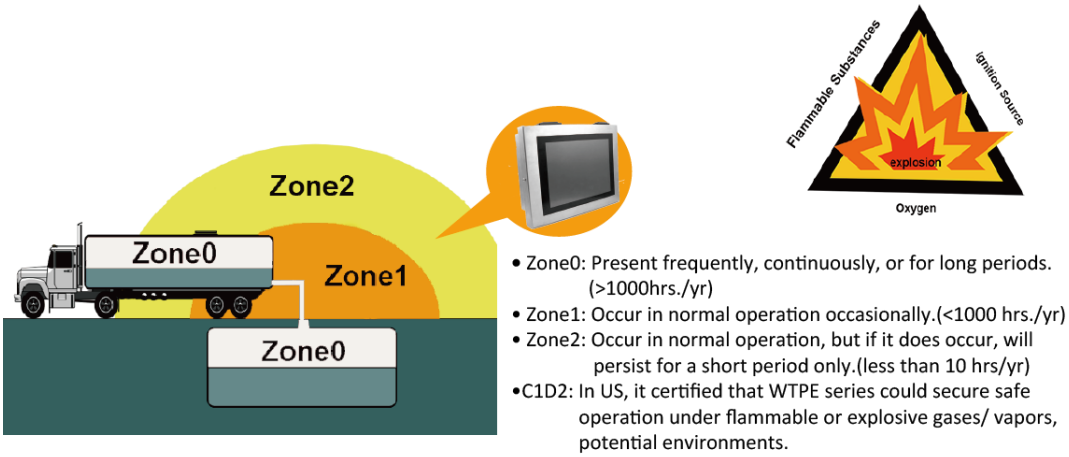

Figure 6. Wincomm's design proficiency has led to 100% explosion-proof designs that are used in environments with incendiary conditions ranging from less than 10 hours per year to more than 1,000 hours per year (Source: Wincomm).

Wincomm's explosion-proof panel PC series has achieved all three of the US/C1D2, EU/ATEX, and international/IECEx certifications (Figure 7). Here, a number of sophisticated engineering tactics were used.

IEC 60079	CENELEC EN 60079	NEC		JIS	CNS 3376
		Article 500 (1)	Article 505		
ZONE 0	ZONE 0	Class I, Divsion 1	Class I, Zone 0	0	0 (Zone 0)
ZONE 1	ZONE 1		Class I, Zone 1	1	1 (Zone 1)
ZONE 2	ZONE 2	Class I, Divsion 2	Class I, Zone 2	2	2 (Zone 2)

Figure 7. Wincomm's explosion-proof product series achieved IEC, EN, NEC, JIS, and CNS certifications to comply with IECex Zone II, EN ATEx Zone II, and US C1D2 (Source: Wincomm).

Intrinsic Safety Design

When designing electronic systems that will be deployed in hazardous, explosive environments, you have to start from the schematics. A seemingly insignificant spike in current or voltage can ignite flammable gasses or dust in these conditions, so protections must be integrated down to the circuit level.

In this case, Wincomm designs in intrinsic safety mechanisms from the ground up that ensure only low voltages are transmitted between components and subsystems. Wincomm's confidential intrinsic safety mechanisms ensure explosion-proof operating conditions, and these are inherent to interfaces and traces on the PCB.

Another requirement in these settings is precision temperature control – even under fault conditions—that prevents the platform from heating to levels that could ignite the ambient environment. The two unique, hot-swappable COM ports depicted in Figure 4 are based on an advanced thermal design that counteract overheating.

Figure 8 below provides a snapshot of the thermal simulation testing performed by Wincomm engineers that ensures surface temperatures of less than 100 ºC, regardless of the system state or operating condition. This guarantees 100-percent explosion-proof operation below that temperature range, placing these platforms in a higher class than most competitive offerings (Figure 9).

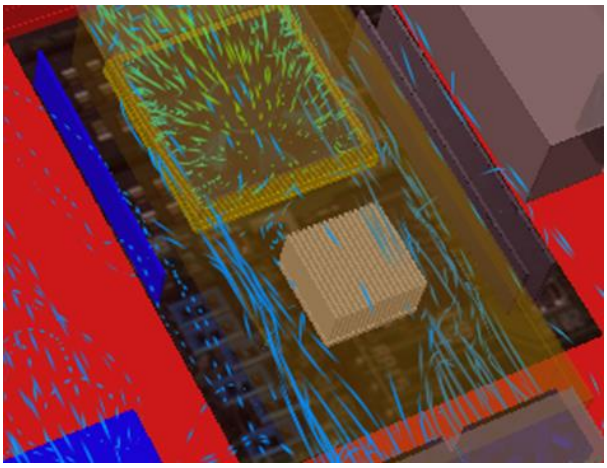

Figure 8. Wincomm performs thermal simulation on their explosion-proof class of products to assure thermally-safe operation in all conditions (Source: Wincomm).

Temperature class of Wincomm explosion proof series is T5, means the maximum surface temperature of is equal to or less than 100ºC, which is much safer than T4 (<=135ºC) grade to competitor

Class	Range of Temp.	JP	US (NEC 500)				EU (IEC)
1	300～450℃	G1	T1 450℃				T1
2	200～300℃	G2	T2	300℃	T2C	230℃	T2
			T2A	280℃	T2D	215℃	
			T2B	260℃			
3	135～200℃	G3	T3	200℃	T3B	165℃	T3
			T3A	180℃	T3C	160℃	
4	100～135℃	G4	T4	135℃	T4A	120℃	T4
5	85～100℃	G5	T5 100℃				T5
6	85℃	G6	T6 85℃				T6

Figure 9. Wincomm's explosion-proof devices are designed to IEC T5 temperature ratings, which specify a maximum surface temperature of 100ºC for explosion-proof systems. This is considerably lower than competitive offerings that classify for category T4 – (<=135ºC; Source: Wincomm).

EMC for Diverse Environments

Electromagnetic emissions are, in fact, another possible source of ignition. But they can also pose serious safety risks to humans.

This can be a tricky design endeavor, especially for devices that are deployed in settings like hospitals that can be deemed both domestic and non-domestic settings. In fact, while most medical equipment is obviously designated to the aforementioned EMC Class A, Group 1, some of the systems that stand to benefit most from AIoT technology are designated EMC Class A, Group 2. These systems include medical imaging equipment, therapy equipment, and high-frequency surgical devices.

To provide better electromagnetic protection for users of AIoT technology, all Wincomm products and designs are, by default, developed to EMC Class B standards.

Partner Wisely

Without all of this knowledge in-house, the only way to achieve AIoT system design goals for rugged industries is by partnering with an experienced engineering services firm. But as we've seen, choosing the wrong partner can lead to downtime, systems re-engineering or retrofits, and unnecessary added costs. It can also present serious safety issues for users.

On the other hand, many OEM/ODMs shy away from this early stage development because it requires application-specific customization, lower volumes, and increased cost and complexity as requirements grow. Instead of general-purpose platforms with different flavors of application software, AIoT designs must be integrated from the ground up at the BIOS and firmware levels then built out into a fully rugged, dust-proof, waterproof, explosion-proof, and/or EMC-certified system.

With more than 25 years of service designing medical, industrial, and energy systems, Wincomm brings the technical proficiency required for today's AIoT design projects. By owning their own manufacturing facilities, submitting sourced components to a rigorous selection process and quality standards, and performing exhaustive system testing, the company is able to guarantee the performance of its designs and support them for the entire lifecycle of most application deployments.

Who will you partner with? Contact sales_support@wincomm.com.tw for more information.

Sidebar 1: Industrial-Strength Enclosures Meet IoT Connectivity & Performance

A food and beverage processing company was looking to add a connected HMI platform to their product inspection system, which demanded significant computing power and an ultra-rugged system design. In addition to widely varying temperature ranges and large amounts of dust and debris, any solution had to withstand cleaning by pressure washers to ensure that foodstuffs did not become contaminated.

To meet these strict application requirements, Wincomm developed the IP69K P-Cap Stainless Steel Panel PC, which functions as a machine controller and operator HMI. Being designed to the IP69K specification, the system is able to withstand high-pressure water flows and corrosive cleaning agents when hosed down by pressure washers.

Figure 1. IP69K design expertise allowed Wincomm to develop a rugged HMI for an automated inspection system to be deployed in a harsh food and beverage factory environment (Source: Wincomm).

While the system's housing is composed of SUS304 stainless steel to prevent the effects of corrosive agents, and features a flush, "true flat" panel/enclosure join that prevents bacteria and particles from amassing between bezels. The design also uses M12 connectors, rounding out the mechanical design characteristics that make the IP69K P-Cap Stainless Steel Panel PC 100 percent dust- and waterproof.

Even with all of those external protection mechanisms, the projected capacitive (PCAP) touch panel PC still doesn't lack for performance. The EMC Class B-compliant system is based on high-performance Intel® Core® i or Atom® processors. Not only do these devices drive the operator interface, they also perform local analytics processing on data stored on two redundant internal HDD bays and drive wireless communications from the system's PCB antenna.

To dissipate sufficient heat from the stainless-steel enclosure, Wincomm developed a custom heatsink that pairs with a condensation-resistant air exhaust system. Despite extreme ingress protections, the platform supports 24/7 operation in high-temperature environments up to 100ºC.

Sidebar 2: WRDM: A Legacy of IoT Technology Development

Wincomm began developing and deploying IoT technologies before embedded devices were being connected to the cloud. For example, the company's Wireless Remote Device Management (WRDM) software was released in 2009, and introduced the ability for customers to control Wincomm embedded systems over the Internet.

The WRDM platform's original capabilities included:

- System power cycling and reboot
- System fan speed and temperature monitoring
- System GPIO status monitoring
- BIOS upgrade
- Operating System upgrade
- Remote KVM for system operation, including control over display brightness, contrast, volume, and input source

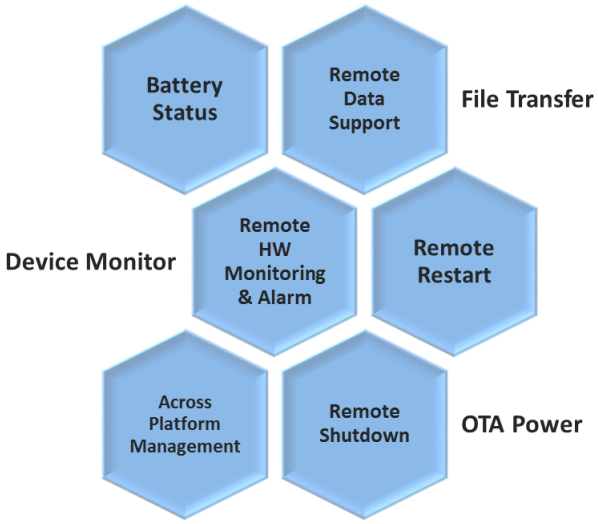

Figure 2. WRDM, wireless remote device management, allowed Wincomm to connect remote system to be managed and save users time to maintain device health. (Source: Wincomm).

More than a decade ago, WRDM allowed users to control a single system or groups of systems via immediate, scheduled, or periodic actions/updates through a graphical web-based dashboard.