SYNAPSE

Designing IoT

DATA COLLECTION IN HARSH ENVIRONMENTS

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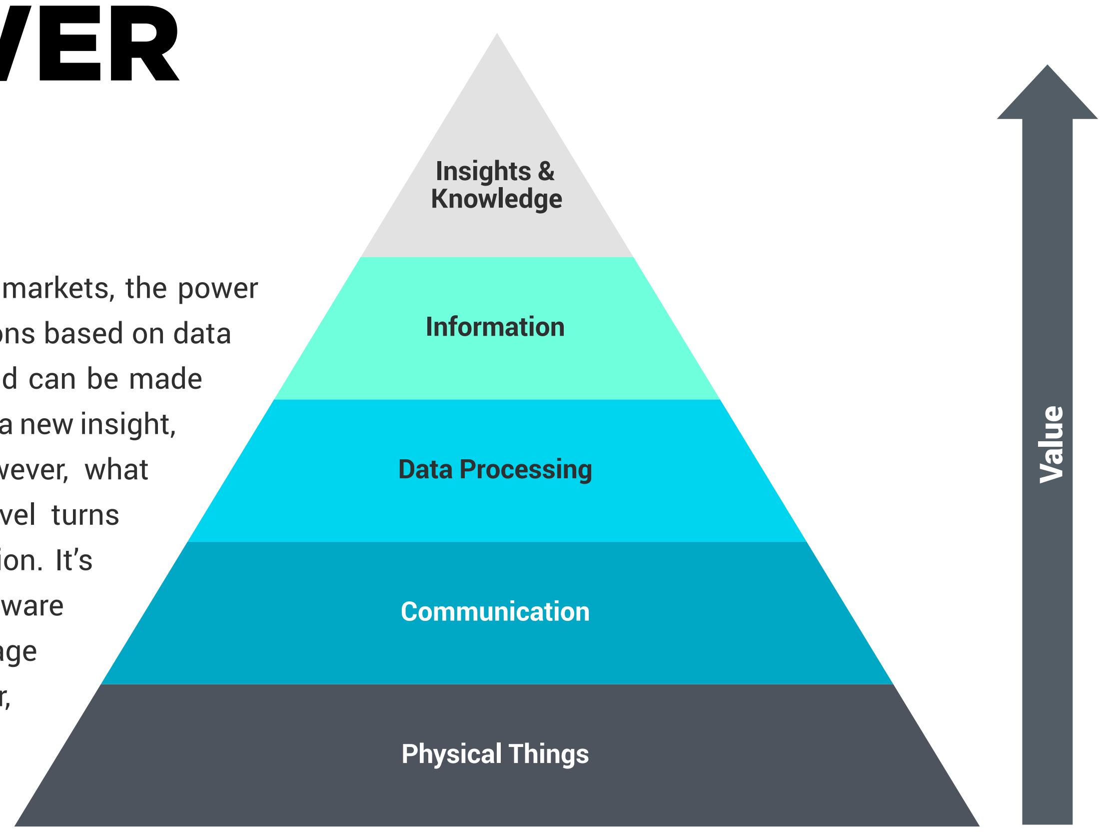
THE POWER OF DATA



In today's rapidly evolving industrial markets, the power of data cannot be overstated. Decisions based on data are more reliable, more impactful, and can be made faster and cheaper. And yes, this isn't a new insight, having been said many times. However, what seems straightforward at a high level turns cloudy as you look into data collection. It's easy to pull information from software systems, but how about an average industrial manufacturing line? Or, how easy is it to pull data during lettuce harvesting, or while it's being stored and prepped in a commercial kitchen?

The value of an industrial grade digital system is realized in the insights that are generated and communicated from the data that is collected. Smart data processing, visualization, and interfaces are required to deliver that value, but they can only be successful when they can get relevant data.

Often simply capturing the data is a significant challenge, with inhospitable environments that are dangerous for employees and difficult for electronics to tolerate. These environments could be anything from a sun-baked field fighting wind, rain, snow, and UV radiation; to a commercial kitchen with high temperatures, grease, smoke, and power washing. With smart engineering and the right approach, data collected in these harsh environments can provide great value, justifying the cost and effort incurred in collecting it.

This white paper discusses some typical industrial environments for valuable data capture and what approaches one can take to design data collection sensors to work in these environments. Each environment is supported by examples of real-world solutions that have resulted in major competitive advantages over the competition.

SYSTEMS ENGINEERING DESIGN APPROACH

As defined by the International Council on Systems Engineering, Systems Engineering is a transdisciplinary and integrative approach to enable the successful realization, use, and retirement of engineered systems, using systems principles and concepts, and scientific, technological, and management methods. With this definition, approaching an industrial IoT system from a systems perspective makes sense in that one needs to understand the balance between the different needs of an industrial organization; there is data to be collected, communicated, analyzed and there are several ways to achieve this. The key is understanding how much effort (in terms of time and money) to put into data collection. Off-the-shelf solutions for data collection sensors are normally the best approach as they are reasonably priced and well supported. The challenge lies when the application calls for something more robust. Considering the mantra that the system is only as good as the data that is put into it, then one can argue getting the right data is critical to success.

Unfortunately, unlimited budgets and timelines are hard to find, and with these constraints, it is imperative to quantify the value of the data for a given part of a process. The more valuable the data, the more important it is to collect, and the more costs can be allocated to getting it done right.

DESIGNING FOR HARSH ENVIRONMENTS

Harsh environments take many forms, each with its unique challenges for data collection. This section discusses the details of how environmental stresses can limit the operation of systems, and how design decisions can be made to support data collection under these conditions, including:

01 **Temperature extremes**

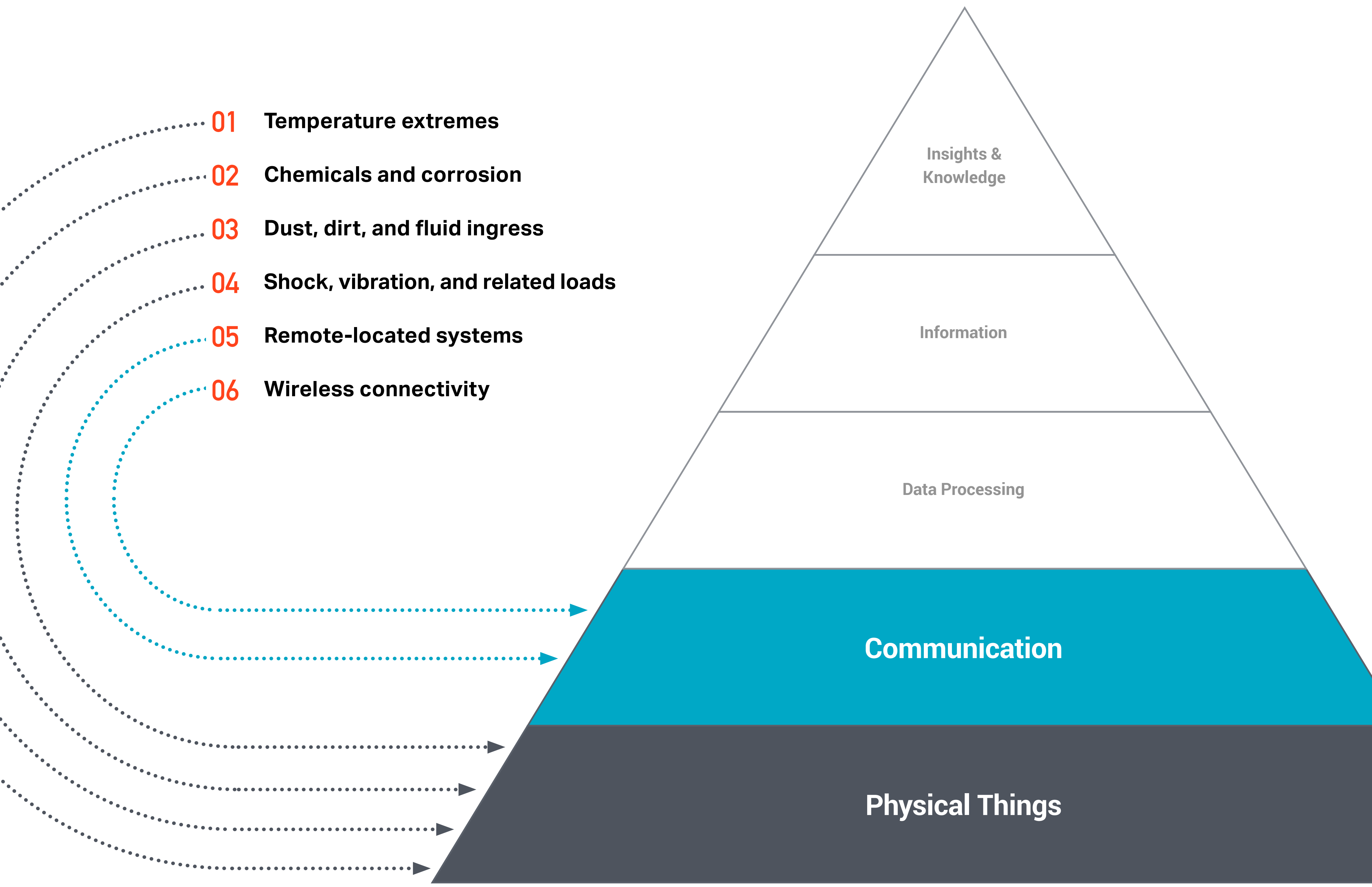
02 **Chemicals and corrosion**

03 **Dust, dirt, and fluid ingress**

04 **Shock, vibration, and related loads**

05 **Remote-located systems**

06 **Wireless connectivity**



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01

TEMPERATURE EXTREMES

CONDITIONS

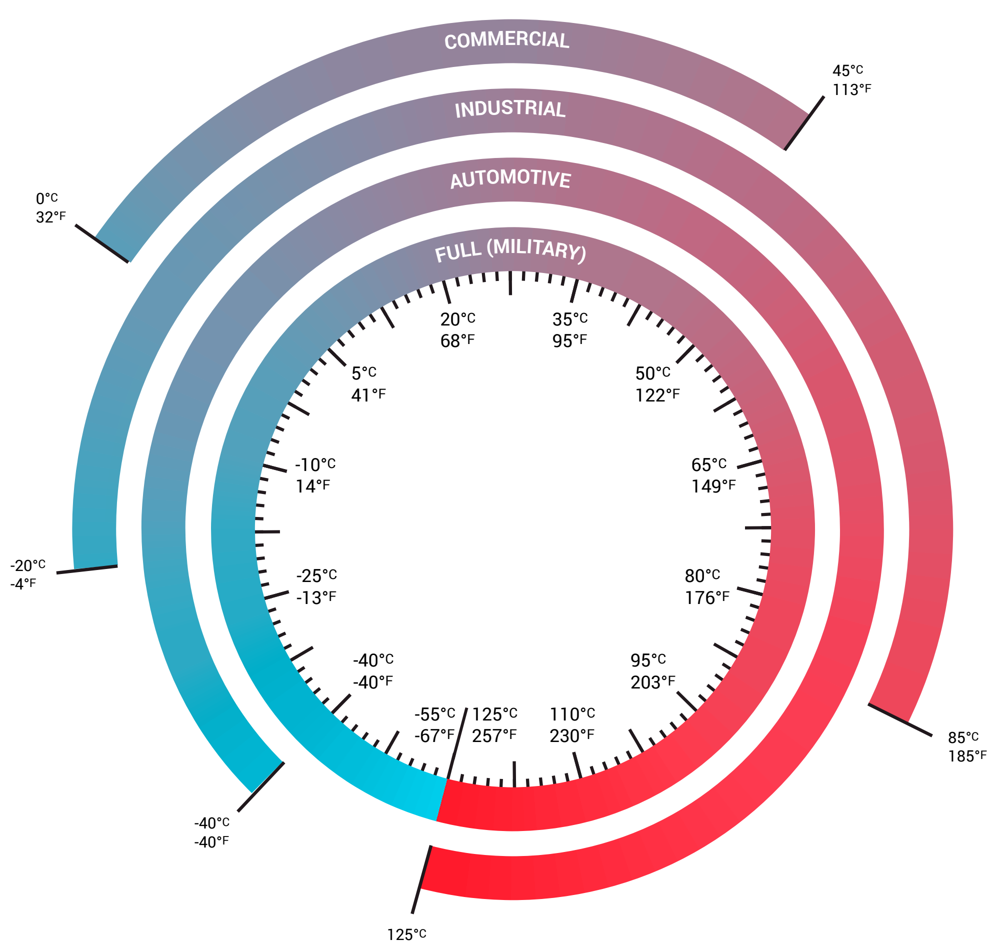
High, low, or rapid changes in temperatures can contribute to a harsh environment. Electronic components are typically those most sensitive to temperature, as mechanical components can usually be selected to have a wider operating temperature range. For electronic components, the typical 'commercial' temperature range they are rated to operate in is 0°C (32°F) to 45°C (113°F), which is fine for most consumer electronics that are kept inside in 'friendly' climate-controlled conditions. However, as soon as systems are required to work in less controlled environments, rated temperature ranges rapidly increase. Typical temperature ratings for automotive components extend to -40°C (-40°F) to 125°C (257°F) to account for the temperature ranges experienced in automotive applications where systems are left unprotected and outside.

Industrial environments are different again, where conditions are often carefully controlled, but may reach temperature extremes that can be more challenging for electronics, resulting in typical specified 'Industrial' operating temperature ranges covering -20°C (-4°F) to 85°C (185°F). This could be everything from metal processing and manufacturing equipment to commercial freezers.

Pushing beyond these temperature ranges is possible, but any components specified for extended temperature ranges that cover the full range of -55°C (-67°F) to 125°C (257°F), or extend beyond this range, are export-controlled, due to the potential for military applications.

Understanding the conditions the system will experience is critical to the design process, and must be done thoroughly to set appropriate requirements. Thermal loads can come from many sources, and the temperatures that products may experience could be more extreme than expected if not carefully characterized. Once these are characterized, and requirements are set, the design process can continue innovating for suitable solutions.

Temperature Ratings for Electrical Component Applications



DESIGNING SENSORS FOR TEMPERATURE EXTREMES

Three principles can be used to design products for temperature extremes, once you have characterized what the conditions are:

1 Select Materials and Components Rated to Appropriate Temperatures

This is an obvious one, but the subtleties come when you consider the appropriate temperature ranges for the individual components. When the system itself is dissipating power there may be local temperature hot spots related to power dissipation that need to be considered. In addition, not all components or parts of the system will be exposed to external environmental conditions and may be able to be specified for a different temperature range. This is discussed further in the next principle.

2 Protect Materials and Components from Temperatures Outside Their Rated Ranges

If components cannot be rated to meet the temperature requirements, the system could be designed to protect these components from temperature extremes outside their limits. Using passive or active cooling systems to reduce temperatures locally is a strategy used in many electronic devices to pull heat away from the most power-hungry components; a strategy that can be extended to keep specific components cooler than the ambient environment if required.

Protecting against lower temperatures is easy when power is not a challenge, simply dumping power into a heater can increase the temperature locally. This can be more of a challenge in low power applications, where more passive solutions such as increased insulation may be the only feasible options.

To develop these designs you can use a combination of simulation and testing to determine the thermal performance, allowing quick iteration through design options to find the most effective solution.

3 Test Components and Materials for Performance Outside Their Specified Ranges

If it isn't possible within the constraints of the system and environment to keep components within their rated temperature ranges, then a last resort is to test the performance of components outside of these ranges (specifically in conditions your system is expected to experience). Component ratings require significant testing by the manufacturer, and it may be that they didn't have the motivation to perform testing to the specific temperatures you are interested in if they are outside normal ranges. Make sure to get information from the vendor and perform your own testing in order to be effective when pushing the limits of the thermal performance of components.

CUTSFORTH
THE POWER OF INNOVATION

Monitoring Power Plant Health with Industrial IoT

Cutsforth's innovative EASYchange® Brush Condition Monitoring system utilizes special sensors to measure and send data about the wear and tear of essential generator parts back to the power plant facility's control room. This is a perfect example of a product facing high-temperature thermal challenges. The sensors needed to be placed close to graphite brushes that were known to operate at elevated temperatures, with reports of brushes glowing red hot in fault conditions.

Due to the high-reliability requirements of this system, it was critical that these sensors wouldn't fail due to thermal issues. If the thermal conditions went out of the expected range in a failure situation, the sensors could not fail in a way that would contribute to an already dangerous situation.

With little reference data to understand temperature limits, the first step was to characterize the required operating condition. This was done using a thermal camera, in conjunction with near form factor data loggers, which were closely monitored during the few hours they were on the system. The data from these gave a good baseline to work from and helped set requirements for the sensors.

During the design process, simulation was used to inform decisions. One of which was to architect the connection of the sensor to the system in such a way as to minimize the high temperatures impacting the electronics within the sensor. Automotive-grade electronic components were also selected to tolerate the significantly elevated temperatures, and high-temperature engineer plastics were used to facilitate radio communication while continuing to be highly temperature tolerant.

Power supply to the sensors was a significant challenge. The temperatures extended well beyond the range normal lithium-ion batteries can tolerate, forcing a move to higher temperature tolerant lithium-metal cells. Careful electronic and firmware design was required to work with these batteries and provide the required product lifetime.

Together, these accomplishments enabled Cutsforth to introduce sensors that monitor generator health and better serve their customers with reliable data to predict maintenance needs.

REAL WORLD
SOLUTIONS

For Temperature Extremes

Optical Sensors in Commercial Kitchens

Whether it's a commercial kitchen at a fast-food restaurant or your kitchen at home, for connected or IoT devices, kitchens can be some of the harshest environments. A connected device for use in a kitchen may need to withstand the temperatures of a commercial oven, steam, grease accumulation, and cleaning with aggressive chemicals.

For example, consider the prospect of adding machine vision to a commercial conveyor-style pizza oven to confirm pizzas have been made correctly per the order. To accomplish this, one would need a method to take a picture of each pizza traveling through the oven, which could be analyzed with a machine vision algorithm. Incorrectly made pizzas could then be rerouted out of the oven before cooking.

Commercial pizza ovens can exceed temperatures of 800°F, which is significantly higher than electronics or cameras are generally rated. Even a highly exotic cooling solution would be no match for these conditions. The best method for protecting the vision system would be to isolate it from the high temperatures. One way to address this is with a feedthrough, where a glass lens with a low emissivity coating protects the camera by allowing it to reflect as much IR (infrared radiation) as possible and could allow it to be physically separated from the high-heat area.

Additionally, an optical solution might allow for mirrors and lenses to be used in combination to add additional distance between the camera and the pizza. However, precision optics such as these are often very costly and need to be positioned correctly to function properly.

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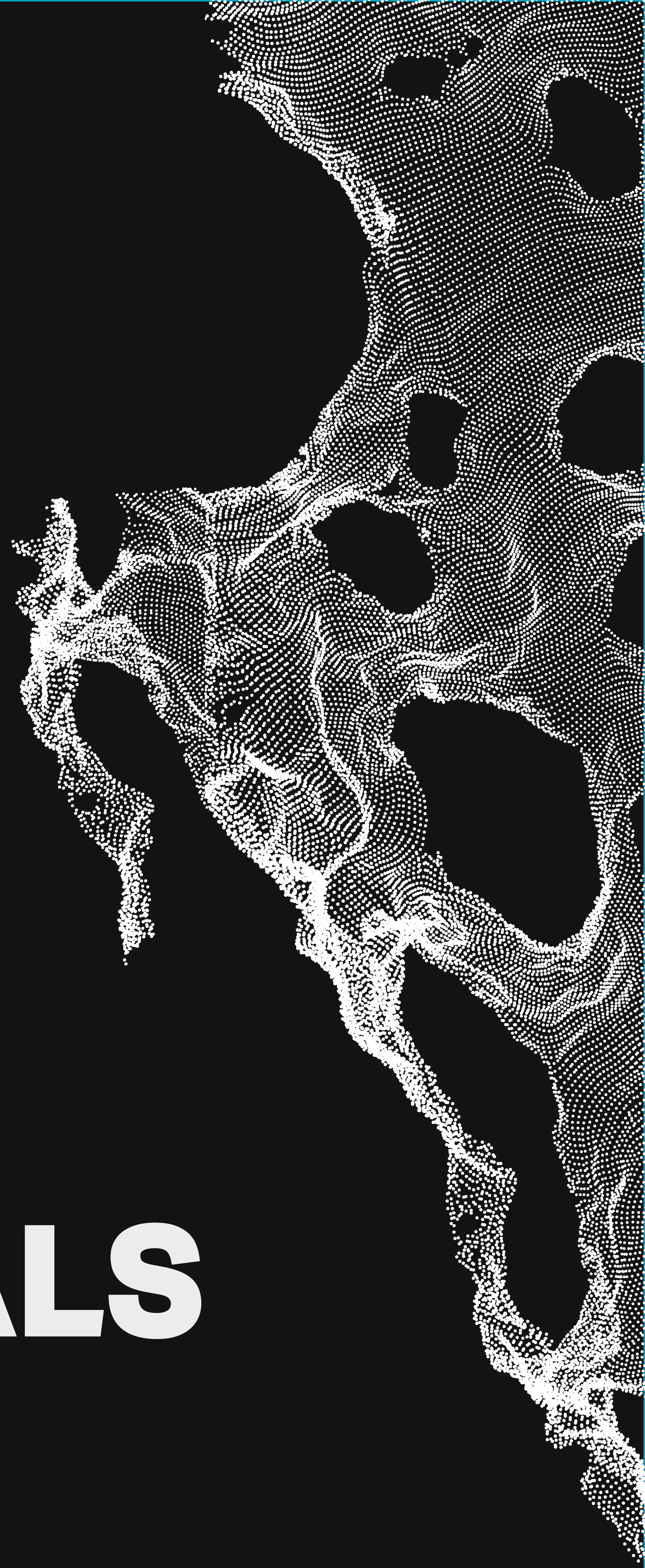


CHEMICALS AND CORROSION

CONDITIONS

All systems are exposed to chemicals of some description, but some chemicals are more challenging to tolerate than others.

Chemical exposure can come from a number of sources: from intentional contact with a chemical process that is being monitored, through repeated exposure to cleaning chemicals, to inadvertent but foreseeable exposure to chemicals that may be on people's hands. Exposure to the atmosphere, for example, the salt air exposure in a seaport, or the caustic dust that surrounds a concrete plant also need to be considered.

Critical to designing for chemical exposure is understanding the time, frequency, and concentration of chemicals that the system is exposed to. There is often a temperature-dependent component to the exposure as well.

Failure from chemical exposure can be observed across a range of time periods, from short-term immediate evidence of incompatibility to the slow growth of Environmental Stress Cracking (ESC) over repeated exposure.

DESIGNING FOR CHEMICAL TOLERANCE

To design for chemical tolerance, it's critical to accurately and thoroughly characterize the chemical exposure of the system overall use cases and the lifecycle of the sensor. This allows for appropriate definition of requirements, and design of verification testing to ensure the product meets the requirements.

With the challenges well defined, appropriate design strategies can be selected and implemented:

1 Prevent Contact with Sensitive Components

Preventing contact with chemicals that can damage components is the first strategy that is implemented in most systems, using a housing or enclosure that is more chemical tolerant to protect the more sensitive components.

Sealing can become a design challenge with this strategy, ensuring that chemicals cannot inadvertently get into contact with the more sensitive components. This particular design focus will be discussed in more detail in the following section on ingress protection.

With IoT systems, there can be particular challenges with designing an enclosure that appropriately protects the more sensitive components but still allows them to effectively measure the conditions of the environment it is in. This could be through having optically clear windows to allow for optical sensors to continue to function, to accommodate for the attenuation of audio or pressure signals by the enclosure.

2 Select Materials Compatible with the Chemicals

Having ensured sensitive components that cannot be redesigned are protected from chemicals they are sensitive to, the enclosure or exposed components need to be designed to be compatible with the chemicals they will encounter. It is very important to consider the system interfaces here, often fasteners, glues, o-rings, and other connection points can lead to material compatibility failures.

Material datasheets and databases are used to select the appropriate materials for the environment. In many cases, this will be sufficient, but not all chemicals of interest are always included in the manufacturer's datasheets, in which case arises the need to move to the following strategy.

3 Test for Chemical Tolerance

The most appropriate materials for an environment can be selected using available databases, but representative testing is required to confirm the performance with specific chemicals and conditions. Success can be found by looking at the most extreme scenarios. This allows for the verification of the design in its tolerance to the chemicals and the incorporation of additional considerations, such as looking at how molded-in or applied stresses to the components can influence chemical compatibility. All potential failure modes should be tested, including environmental stress cracking which can be missed by many test protocols.

Commercial Kitchens

In a previous example, we introduced adding an optical sensor (camera) to a commercial conveyor-style pizza oven to confirm pizzas had been made correctly per the order. Something to consider is that devices located in commercial kitchens would be subjected to a host of harsh chemicals used for cleaning and sterilizing surfaces. For an optical-based system, it would be important to ensure that lens surfaces had been treated with coatings for durability against these chemicals. Additionally, sealing materials would need to be chosen that were rated for use against the chemicals. The effect of elevated temperature and severe temperature cycling would need to be considered in the design of these seals as this could easily accelerate aging or degradation phenomena.

03

DUST, DIRT, AND FLUID INGRESS

CONDITIONS

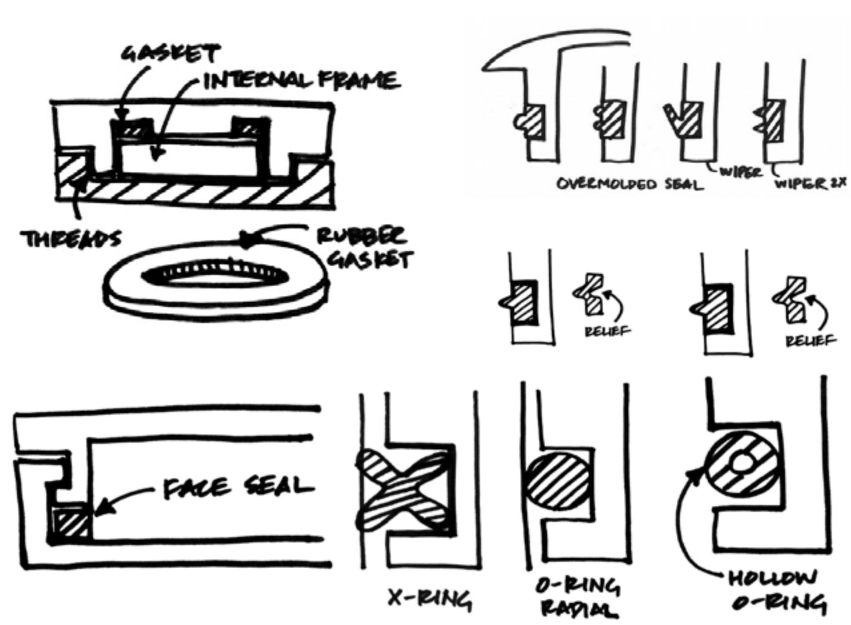
In many situations, dust and water ingress are a particularly difficult challenge to overcome. Sensors still need to be able to measure the environment they are in while protecting sensitive electronics and sensors from the risk of ingress.

The requirements must first be defined, having evaluated the environment the system is going to operate in and identifying appropriate standards. This could be from splash-proof for inadvertent exposure to water, through to being resistant to regular pressure washing.

DESIGN FOR INGRESS PROTECTION

Ingress protection design follows a typical iterative design cycle, designing using best practices, prototyping the designs, testing these to their limits, and iterating the design to address any issues identified in testing.

Sealing strategies are highly dependent upon the application. This could be anything from ultrasonic welding the enclosure closed to provide a seal, to having dynamic seals that can maintain ingress protection in operation with moving parts. Additionally, proper material selection is vital in any sealing strategy. O-rings, for instance, come in many different materials and can be optimized for a specific chemical, operating temperature range, or diffusion characteristics for gases.

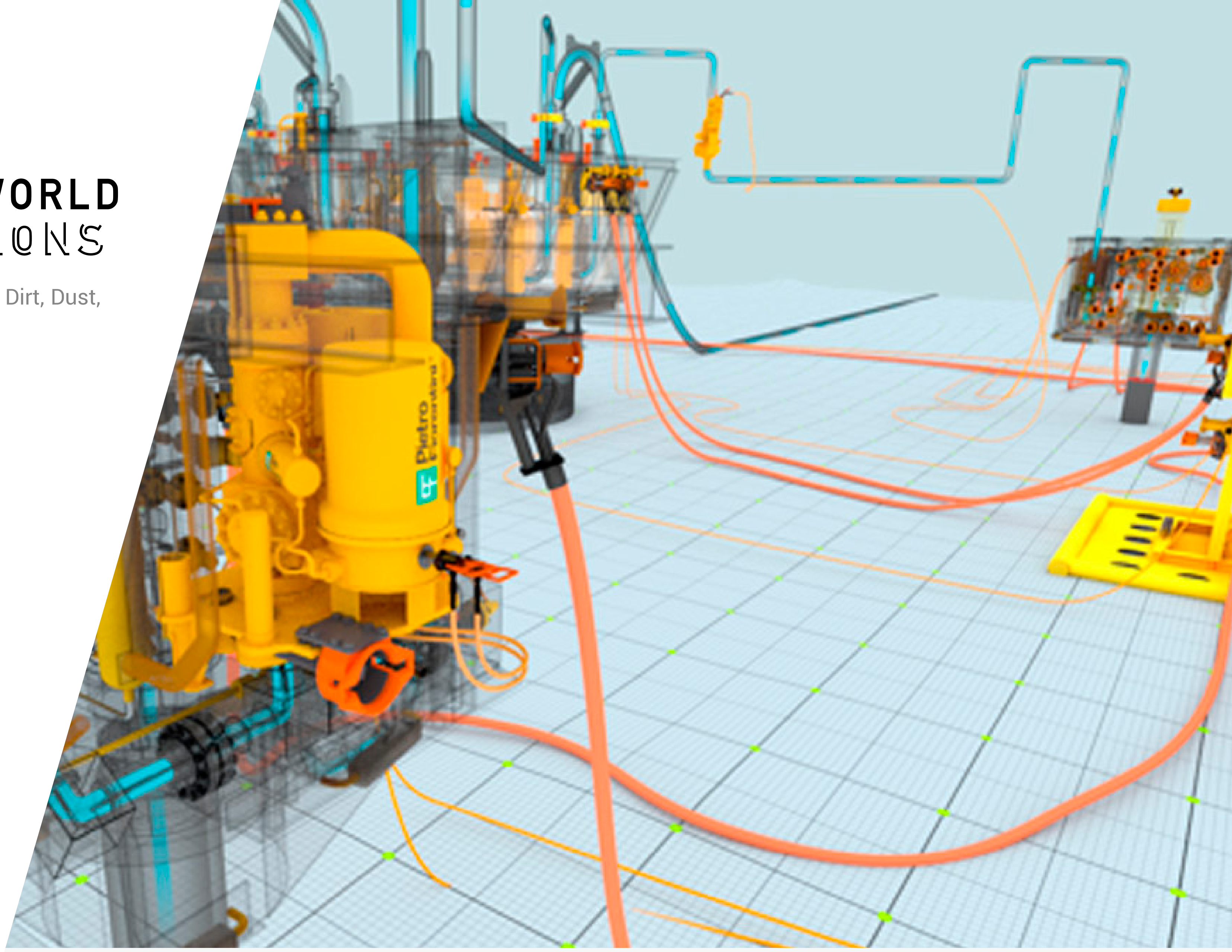


Another significant challenge in ingress protection is designing for higher power IoT devices that require substantial cooling. As more highly complex tasks are performed by IoT devices such as machine vision and learning, their power needs increase. Higher power devices using FPGAs or dedicated GPUs would typically be cooled with forced convection via fans blowing air over the high-temperature components.

However, in dusty or wet environments, cooling via direct airflow may be impossible because it requires exposing sensitive internal electronics to harsh ambient conditions. In this scenario, other more complex cooling solutions would be required. Understanding the thermal loads of IoT devices and developing cooling solutions that are suitable for the environmental constraints is critical to designing durable and reliable products.

REAL WORLD SOLUTIONS

For Keeping Out Dirt, Dust, and Fluids



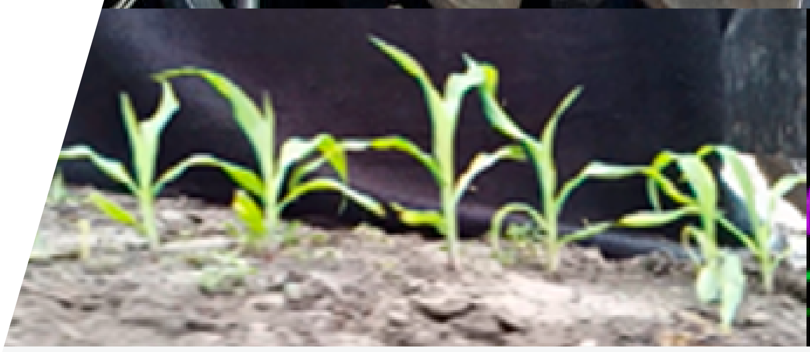
Pietro Fiorentini

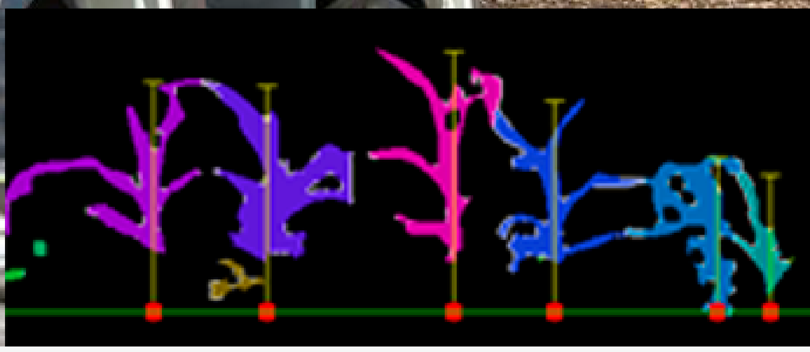
High-performance, Zero-maintenance Subsea Water Cut Sensor

Pietro Florentini has a successful business designing equipment for the oil and gas industry. Water cut sensors measure the amount of water in the flow from an oil well. Operators rely on this data to optimize the use of inhibitors to remove excess water, saving significant expense in the oil-extraction process. This project focused on developing a self-monitoring, fully redundant system which could detect and work around component failures during its 25 year lifetime.

An equipment failure could result in a loss of production worth millions of dollars per day, and replacing a damaged sensor would require chartering a ship and remote-operated subsea vehicle, sailing for 10 days or more to replace a damaged sensor. Not really an option.

The resulting sensor and system are extremely reliable, have multiple fail-safes, and a 25 year lifetime.





Keeping Sensors Clean and Clear ANYWHERE

Back to our commercial conveyor-style pizza oven.....If we enclose the camera to protect the lens and electronics from the environment, the transparent cover will likely get covered in grease and grime, while inside the enclosure, condensation may collect and obscure the camera's view. In either case, pictures taken with the camera are not going to be as clear as they would be with a clean camera enclosure. Similarly, mounting a protected camera on a tractor working in a field will be collecting pictures with dust, dirt and grime collecting on the enclosure over a day's use.

In both scenarios, maintaining proper airflow (to keep condensation at a minimum) and identifying coatings that prevent grime buildup are essential to keeping the cameras collecting clean data.

Machine vision systems rely on images captured from cameras, and are often designed to detect or analyze rare occurrences, such as a poor quality pizza topping or a rare weed in the field. While advanced techniques in artificial intelligence can repair corrupted images (click here for additional information and a video explaining how this works), such approaches cannot reproduce events that occur infrequently. A well-built machine vision system can be trained to detect events of interest even if the camera wasn't cleaned and grease or dust has built up on the lens and the image data is distorted—but not if the data is occluded or otherwise lost. The most effective machine vision systems are trained to handle some level of noise, but also rely on mechanical means to keep the input data relatively clean. Alternatively, a well-designed vision system that can handle noise can also be trained to handle lower-quality images, allowing for the use of a less costly camera, which is especially helpful when operating in an environment that limits a camera's operational life.

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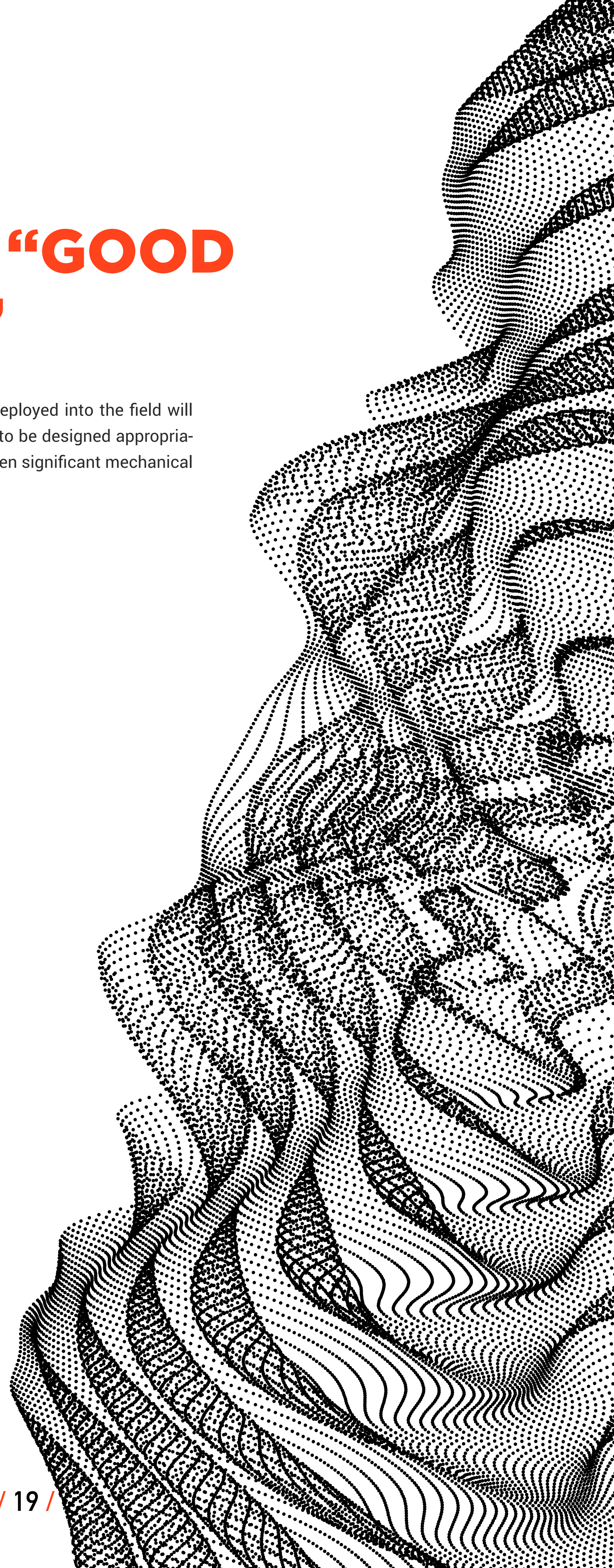
04

SHOCK, VIBRATION & RELATED LOADS

IT'S NOT ALL "GOOD VIBRATIONS"

Movement can create significant loads. Any systems deployed into the field will experience some form of mechanical loading and need to be designed appropriately to ensure data can continue to be captured even when significant mechanical loading is applied.



CONDITIONS

For sensors the most concerning mechanical loading will be vibration and shock. The magnitude of the applied vibration and shock loads should be characterized to allow for effect design. These could originate from the machinery or equipment they are monitoring, or from the expected use case, for example detecting drops or impacts on a system.

Ongoing vibration can not only cause immediate damage, but also fatigue components over time. This can result in failures in the field with no increase in applied load, but simply the duration of the applied vibration being too much for the system.

Static loads also need to be considered, whether they come from external pressure on the system, or from a structural component to the system with loads it needs to support. In some cases, these loads may even be the parameter the system is trying to measure.

DESIGNING FOR MECHANICAL LOADING

Having appropriately set requirements and characterized the loads a system will experience, design efforts will follow a typical path, dependent upon the type of loading.

1

Vibration Loading

Designs will be analyzed for sensitive components and any resonance modes that could be problematic.

Sensitive components can often be isolated, at least partially, from applied vibration with the appropriate addition of compliant connections and components. Damping materials are also particularly effective at ensuring the introduced compliance does not result in just shifting the frequency at which vibrational loads become problematic.

Simulation is used where appropriate to identify potentially problematic modes of resonance, which can then be mitigated by changing the design of the component. This mitigation could shift the resonant frequency out of the range of applied vibration by adjusting the stiffness or mass, which avoids the need to add damping. Damping, which is often the go-to solution, can be added but is not the only solution.

2

Shock Loading

Shock loads often come in the form of drops of the system but can be applied externally in challenging environments. The method and direction of the application of shock loading need to be considered in the design, with the components that require protection identified.

Typically the design will aim to reduce the peak force or acceleration experienced by the sensitive components. This is most often achieved by adding some compliance, spreading the applied impulse over a longer period. Careful consideration needs to be made as to the relative movement of components, however, as excessive movement could result in damage to interconnects or other interface components.

Simulation of drop and shock loads is possible, but much more challenging. Design, prototype, and test iterations are most effective at achieving a robust design.

3

Static Loading

Static loads are typically the most predictable to understand and design for, using simulation and stress calculations to design components appropriately. Particular challenges can come from the time dependence of some material properties, often in combination with temperature. Plastic creep deformation is an example of this and requires particularly careful design to keep the material below its creep limits.

4

Thermal Loading

Temperature cycling can induce loads in components via thermal expansion and contraction. If this thermal cycling is cyclic, it can be concerning over time, especially if it is occurring in combination with other cyclic mechanical loading. This can exacerbate or accelerate fatigue failures in materials.

Additionally, thermal expansion may cause the fit and interactions of multiple parts to malfunction. For example, two parts that have been "press-fit" together may no longer have a tight fit at higher temperatures. Thermal expansion needs to be carefully considered in these types of interactions, especially when the parts interacting have different coefficients of thermal expansion.

Note: material properties of components may change significantly across a wide temperature range. Plastic and metal parts can undergo ductile to brittle transitions that can change how they react under impact or static loading.

compology

Data Collection to Streamline Garbage Collection

Compology's in-dumpster monitoring sensor presented enormous design challenges due to the harshness of the environment. Dumpsters can be nasty places. A camera-based sensing device mounted inside a dumpster will be subject to very high temperatures, weather, chemicals, potentially massive impact loads, and a poor RF environment. Not to mention a dumpster gets filled with water and other fluids, and the device had to be tamper-proof!

Some of the key challenges for this project were designing and mounting the camera in the housing. To protect the camera from impacts, grime, and weather ingress, it had to be mounted facing downward in a rugged plastic housing to ensure it would live up to continued abuse.

Note: In designing the housing, much higher impact loading needed to be considered than would typically be seen by a consumer IoT product. In a situation like this, adding durability to a housing can be accomplished by swapping from plastic to a metal enclosure, or by changing from an unfilled plastic resin to a filled version. Filled resins include glass, mineral, or carbon fibers that substantially increase the stiffness of the material. For a part that will see substantial abuse during use, this can be a low-cost way to add significant strength without adding cost.

A downside of glass-filled resins is that they are often unsightly—the orientation of the fibers is typically very noticeable in the finished part (though this can be mitigated to some extent with texturing). This is often unsuitable for many consumer products, but for a more industrial-focused IoT product, it is often of little concern.

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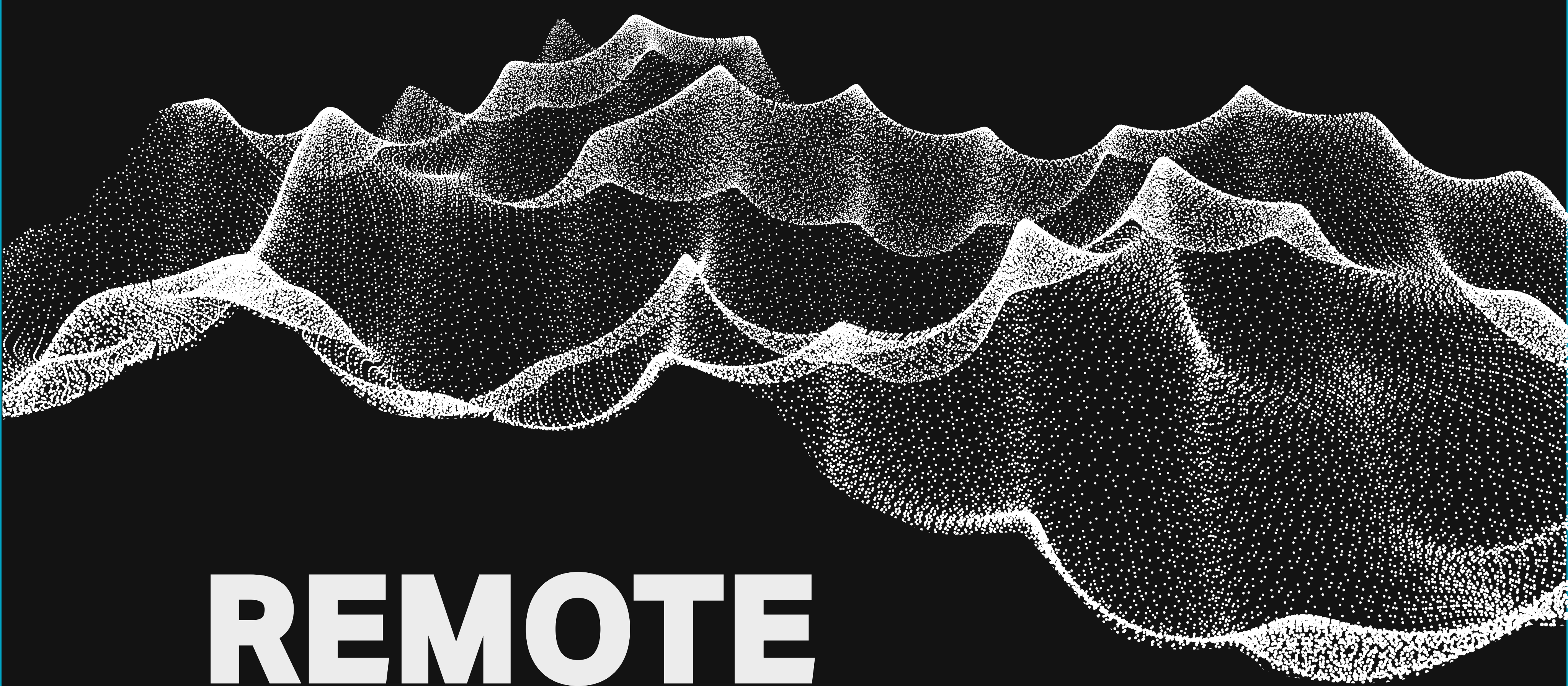

REMOTE LOCATED SYSTEMS

"PLANNING FOR–AND MITIGATING–POTENTIAL FAILURES IS EXTREMELY IMPORTANT FOR REMOTE DEVICES"

IoT devices operating in harsh environments are subject to a host of challenges associated with the potential lack of easy human access to the devices. An IoT monitoring device may be located in a highly remote area that is challenging to get to or may be located in an area of an industrial facility with temperatures or chemicals that render it inhospitable for humans.

Oftentimes, remote devices may need to be engineered for extremely low power consumption or the ability to deal with poor and inconsistent power quality. For example, an IoT device may be mounted on a remote cell tower and powered using a solar panel. In such a case, proper selection of electrical components, efficient firmware, or lower power wireless communication protocols may be required to achieve a long field life under varying power conditions.

For products that cannot be accessed easily, a major design consideration is gracefully dealing with fault conditions if the products are unable to receive human intervention. At Synapse, we recognize that Failure Mode Effects Analysis (FMEA) is extremely important for these types of applications where high availability may be mission-critical. FMEAs conducted early in design can ensure that proper redundancies, autonomous reset, or error correction is built into the hardware from day one.

REAL WORLD SOLUTIONS

For Remote Located Systems

ULTRA-LOW POWER SMART GAS METER

Today's energy providers are constantly searching for ways to get better, more accurate consumption information. Quality data is important to provide accurate billing information for users and monitor the system to identify leaks and prevent theft. However, achieving this in this highly regulated market is difficult. Requirements for smart monitors are stringent; they must be connected through low power radio communications, have a long product life (approaching 30 years) and run off the same battery for up to 10 years.

For one of Europe's largest engineering companies, they had to meet those requirements while updating their smart gas meter offering. A comprehensive hardware and software based approach was used, which relied on low power electronics and specialized data formulation to allow small amounts of power to transmit the correct information at the required intervals.

Leveraging this low power approach allowed the updated smart meter to be installed, calibrated and updated remotely throughout the region, ready for years of use.

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WIRELESS CONNECTIVITY

IoT systems need to be able to communicate the data collected effectively, to allow for processing and insights to be generated. In many cases, this is through wireless communication, which can be challenging in environments that are particularly electromagnetically noisy, or not conducive to wireless communication. Even wired communication of data can be disrupted by very challenging radiative environments.

CONDITIONS

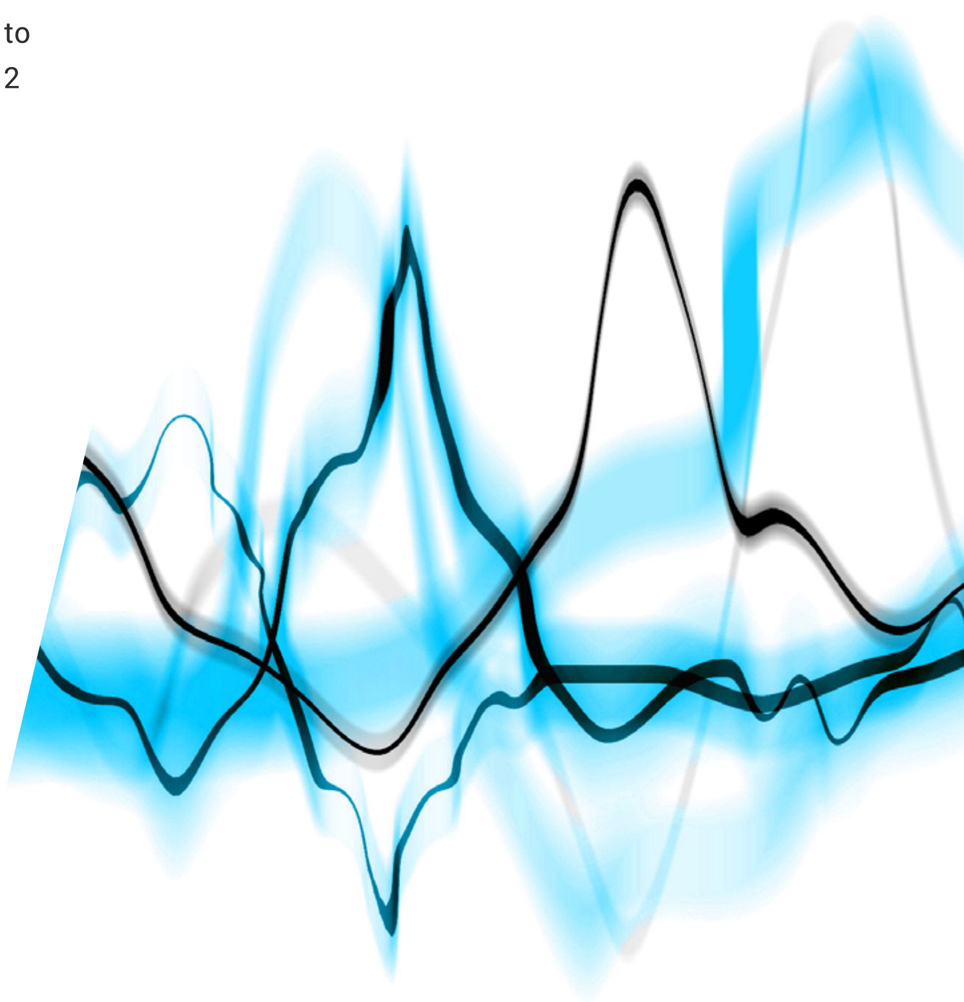
There are a number of different factors that can contribute to challenging radiative environments, but they broadly fall into 2 categories.

Noisy Environments

Electronically noisy environments are challenging to operate in, as the signal can be swamped by electromagnetic noise. This noise can come from several sources, from other electronic components to high voltage power lines, to the radiation present in space.

Radiative Environments

Wireless communication is challenging in environments where the path between the antennae communicating is convoluted, or blocked. This can be found in applications communicating close to the human body, such as a wearable communicating to a mobile phone. Industrial environments, with significant barriers between the sensor location and the receiver, are also challenging, especially when the barriers are electrically conductive.



DESIGNING FOR CHALLENGING COMMUNICATION ENVIRONMENTS

When designing for challenging environments, you can follow a typical process to ensure a successful outcome for the product.

1 Characterize the Environment and the Link Budget

The first step is to characterize the environment, to understand the conditions that the product is required to function in. This could be by using known experimental results or verified simulation models but often requires some testing to get a comprehensive understanding of the environment.

By understanding the environment, and the system architecture, the team can build a link budget, predict the radio frequency link margin, and start to inform design decisions.

2 Simulation and Design Iteration

Simulation is used extensively in design, to allow for many iterations of design options to be considered and to predict the performance of the product. We have extensive simulation capabilities, to allow us to simulate antenna performance, propagation of the electromagnetic waves in the environment, and the impact of different materials in the product.
The main outcome of the simulations is to predict the link margin, which is used to determine if design changes are required, and to predict the reliability of the radio frequency communications.

3 Prototype and Test

Always prototype and test the performance before moving to a production design. This allows us to verify the performance predicted by the simulation and allows the simulation parameters to be adjusted to match the experimental performance of the products.

Specifically, the Received Signal Strength Indicator (RSSI) will be measured in testing, to confirm the radio frequency link margin, by comparing it with the radiosensitivity.

Design iterations often follow the testing of initial prototypes, to fix any identified issues, and to optimize the performance for the final product.

4 Certification and Regulatory Requirements

The final piece to the wireless device puzzle is certification. Often, use cases that involve more challenging environments need to be understood early in the design process as they can create requirements for electrical or mechanical designs and drive certification requirements prior to sale.

These requirements typically center around the safety of the device in the environment where it is operating. For example, certain IoT devices need to operate in environments with flammable dusts or explosive gases and must be designed to ensure that no sparks can be generated.

Additionally, many IoT devices used in industrial environments are required to be UL listed (or equivalent) to ensure the device has been designed so that it will be safe across the full range of operating temperature conditions and under a range of fault conditions. As a design engineer, this can drive a huge range of considerations such as proper fusing, maintaining safe touch temps for plastics or metals, and selecting plastics for enclosures with propper flammability ratings.

Wireless Communication in a Recycling Facility

Plastic, paper, compostables, aluminum, and glass—separating these materials in a commercial recycling facility is difficult at best. Accomplishing this requires a combination of separation process equipment and human operators. Machine vision and artificial intelligence are adding significant capabilities and making the process more efficient. However, a sorting facility is a very challenging environment in which to operate.

Communication in industrial environments depends heavily on the environment, and interference with many wireless protocols is an unfortunate reality. Interfering emissions can come from cabling, power sources, machinery and other in-facility communication systems. Data security needs to be considered as well. Keeping nefarious characters away from shutting a plant down becomes more important as these facilities serve larger parts of the population. Building a robust communication network starts with understanding the system's requirements and exploring trade-offs. Is wired acceptable? Is there an existing system in place that can be used or expanded? What level of data security is required? From here, modeling and simulation are great tools to understand what challenges can be overcome and what investments may be required. Once a model looks promising, building a quick prototype and testing it is the best verification tool.

PUTTING IT ALL TOGETHER

What are the key things to consider when putting industrial IoT systems in place?

A systems approach is best, starting at the high level and defining the information needed to make decisions. Determine the value of the data, and build the business case based on this value. Remember, there are many harsh environments that could impact your ability to gather that data. Explore the trade-offs as to how data is gathered—can off-the-shelf sensors be used? Or is a custom solution warranted?

If a custom solution is needed, be mindful of the tradeoffs that come with developing a very specific solution. Through smart design decisions based on real-world prototyping and experience, input devices like cameras and sensors can gather the data needed to build a valuable industrial-grade digital system.

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