THE **RUGGED COMPUTING** VALUE PROPOSITION

How Ruggedness Best Practice Matters in Concept, Design, Manufacturing, Testing, Certifying, Functionality, and Field Performance

EXECUTIVE SUMMARY

Sensing an opportunity to cash in on the growing need for reliable mobile computing products by government, military, industry, enterprise and public safety agencies, mainstream PC and tablet vendors have been launching slightly modified commercial off-the-shelf products as value-priced alternatives to the purpose-built rugged laptops and tablets from established rugged market vendors. Although using the same mass-produced types of plastic housings as their consumer market products, they claim increased structural integrity due to slight changes in design, rubberized bumpers to match the look of established rugged mobile computing products, and claims to meet certain military testing standards.

Such claims, enhanced by the lower initial cost of some of those products, may carry weight with buyers under budget pressure or less familiar with the standards and capabilities of truly rugged equipment. Unfortunately, they might end up disappointed when the products don't live up to expectations, quickly fail in the field, cause unacceptable downtime, and end up with significantly higher total cost of ownership. What seemed a good way to save money may result in unsustainable failure rates as well as potentially dangerous or even disastrous situations in mission-critical deployments.

How do customers end up in such situations? One problem is that the term "ruggedness" and the various degrees and categories of ruggedness are not well defined. There are no universally accepted ruggedness standards and very few clear-cut, unambiguous ruggedness deliverables. To shed light on these predicaments, this paper provides an overview of ruggedness in modern mobile computers, what types and kinds of rugged computing equipment is available from experienced vendors, why professional-grade ruggedness matters, and why it lowers the overall cost of ownership.

The paper also explains the environmental and operational threats to mobile computers that lead to downtime, repairs, or outright failure. It describes ruggedness testing principles, how established rugged computing market leaders perform ruggedness testing, and the overall value of properly tested and certified ruggedized products to customer operations.

TOTAL COST OF OWNERSHIP AND THE RUGGED COMPUTING VALUE PROPOSITION

Total Cost of Ownership (TCO) is defined as the purchase price of an asset plus all the costs to keep the asset operational over its expected lifespan. For computers used in the field, the TCO is the initial purchase price plus all the costs of repairs, maintenance, downtime and premature replacement over the anticipated life of the device. If the initial purchase price of a consumer or enterprise device is lower than that of a rugged device, but the consumer device quickly fails and must be replaced, the rugged device has a lower TCO. If the consumer device must frequently be repaired, causing downtime, the more reliable rugged device may have a lower TCO.

But, beyond initial purchase price, doesn't anticipated TCO depend on a lot of assumptions? Failures due to accidents are unpredictable, as are failures simply because a device wears out or breaks down. Arriving at an estimated TCO is an inexact science that relies on experience, common sense, warranties, as well as cost of downtime, availability of replacements, repair turn-around, parts availability guarantees and more. A lot of data isn't available and must be estimated. There are, however, a few hard data points that provide a general sense of failure rates. A 2016 report on laptop reliability by PC Magazine showed an 11% annualized failure rate of consumer and enterprise laptops compared to just 2% for the laptops of an established rugged laptop maker. A study by the Pearl Solutions Group suggests

PRE-MATURE REPLACEMENT

MAINTENANCE

DOWNTIME

REPAIRS
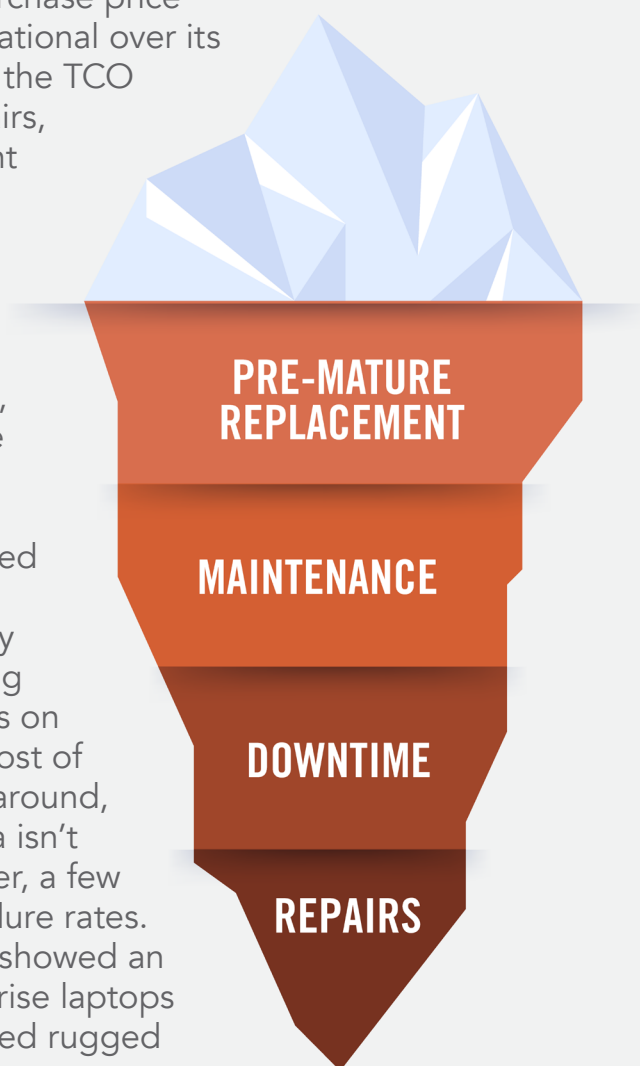
a 16.6% failure rate for non-rugged laptops compared to just 4.6% for rugged laptops. These two data sources therefore suggest the annualized failure rate of non-rugged laptops to be between 3.6 and 5.5 times higher than that of rugged laptops.

3.6x to 5.5x HIGHER ANNUALIZED FAILURE RATE OF NON-RUGGED LAPTOPS THAN RUGGED LAPTOPS

That is a substantial difference that strongly points towards a lower TCO for rugged systems despite their higher initial purchase price. Add to that the peace of mind that comes with knowing that you purchased professional tools for professional jobs, tools that have been extensively tested and certified, and knowing you are dealing with companies that understand your industry's operational and reliability requirements. Add further the guarantee that should repair be required it will be done by expert technicians and with rapid turn-around.

HISTORY OF RUGGED COMPUTERS

How did we come from early mobile PCs to today's robust, powerful and reliable computing tools numerous vertical markets and industries have come to rely on?

The earliest portable computers, such as the Osborn 1 (1981) or the Compaq Portable (1983) weighed 25 to 30 pounds or more and could hardly be considered mobile. Pioneering battery-powered tablet and laptop computers with flat screen displays that were compact enough to be used in the field began arriving in the mid to late 1980s. Notable examples were the 1988 GRIDCASE 1530 laptop and the 1989 GRiDPAD tablet. By the early 1990s, many laptops and tablets had become truly portable, thus making them suitable for a rapidly increasing range of mobile applications.

OSBORNE 1 - 1981
Photo Credit: oldcomputers.net

Not all those applications were indoors-only anymore, and that presented a new set of problems: could those systems handle drops, vibrations, rain, extreme temperatures and other environmental hazards and conditions? Conventional laptops could not, and even tablet computers specifically designed for use in special vertical markets struggled. It wasn't until the mid and late 1990s that truly rugged systems emerged. Those were largely made by pioneering companies that saw a niche for rugged, robust mobile computers built from the ground up for demanding environments and to survive severe punishment. Interestingly, it is these same companies, or their successors, that continue to be the rugged systems market leaders today, over a quarter of a century later.

T3020 MOBILE COMPUTER

Getac's first product in 1989

F110-G1 TABLET

Along the way to today's advanced rugged mobile systems, several obstacles had to be overcome. Among them was battery life, which progressed from just an hour or two on a charge early on to full-shift and longer operation in brand name systems today. There was the gradual migration from impact-prone hard disks to SATA-based solid-state storage, and then to the even faster PCIe NVMe solid state technology. And there was the stunning progress from the dim and barely readable early monochrome LCD screens to the vastly better color display we have today, with rugged systems facing the extra challenge of remaining usable outdoors and even in direct sunlight. The latter saw much experimentation with reflective and transflective technologies until minimization of internal reflectivity via direct bonding, polarizers, and various coatings in conjunction with strong backlights brought the remarkable degree of outdoor viewability available in leading rugged tablets and laptops today.

Today's rugged systems have come a long way. Benefiting from the breathtaking advance in processors, storage, and communication technology on the one side, and by now decades' worth of experience in rugged systems design and manufacturing on the other, today's premium systems offer workstation-level performance in compact, lightweight, fully sealed, and nearly indestructible enclosures.

WHAT IS RUGGEDNESS?

But what is "ruggedness" in the first place? Rugged good looks? Rugged terrain? No, in the computer industry ruggedness refers to devices being of robust construction, engineered to last, and capable of withstanding rough handling. Both "robust construction" and "rough handling" are, of course, relative. In mobile computers, "strongly made" means that the

design, construction, and materials used must be such that they will not break, fail, or otherwise lead to malfunction or destruction when subjected to "rough handling." And that "rough handling" may be physical impact, drops, tumbles, pressure, vibration, temperature, exposure to liquids or solids should the housing be breached, and a whole slew of other accidents and unexpected events.

From this follows that "ruggedness" is that combination of design, materials and manufacturing that keeps a device from costly failure under defined conditions as well as from causing downtime for repair and undue repair and maintenance costs.

This all leads to the need for clear definitions of what constitutes ruggedness overall, and required ruggedness for certain types of uses and deployments. Of course, anything can be destroyed given enough force or brought to failure under extreme conditions. The question is what is appropriate ruggedness – suitable, affordable protection against failure. Appropriate ruggedness means defining the sweet spot, the best balance, between the higher cost and weight of extreme ruggedness, and the lower cost, weight, and acceptable risk of ruggedness tailored to given fields, markets, applications, and jobs.

Customers should identify and document worst case scenario when they use their computers on the job. There is the possibility of accidents and mishandling, but also the hazards inherent in different working locations and conditions. These vary from industry to industry and sometimes from application to application:

- *What kinds of vibration will the system be subjected to?*
- *What temperatures will it encounter?*
- *How often will it be mobile (carried around, used while standing or walking)?*
- *Will it be subjected to rain, salt fog, or even full immersion?*
- *Is pressure an issue, exposure to chemicals, or other factors?*
- *Is intrinsic safety a factor?*
- *Are there antimicrobial materials and special disinfection requirements?*

If each risk factor were assigned a numerical value and those values then weighted and added and averaged, each industry and each application would probably have a different emphasis and different overall requirements.

The rugged systems industry cannot possibly address all those different scenarios all at once. Instead, there are different categories of ruggedness.

RUGGEDNESS AND SAFETY

Professional applications require professional equipment that's specifically built for the job. Every profession has the tools of their trade, high quality gear that's functional, durable, and built to last. Increasingly, these tools include laptops, tablets and handheld computers. Law enforcement, firefighters, field workers, miners, first responders, construction workers, vehicle operators and many others rely on these tools on their jobs. Reliable operation and the ability to hold up in the field, no matter what happens, isn't optional.

What's more, in many of those jobs, safety is at stake. In transportation and logistics, vehicle mounted laptops must endure near constant vibration. In mining, construction and manufacturing, extreme temperatures, exposure to dust and other particulates are the norm. In port and maritime applications, salt water and salt spray are the enemy. In military deployments, rock-solid wireless radio and positioning performance may mean life or death, as can the availability of instant screen and radio blackouts. In many government and public sector applications, the ability to safely remove storage is essential. In oil and gas and many other industries, safe operation in explosive environments is mandatory.

Purpose-built rugged computers can do all this. Consumer and enterprise devices cannot, even if they are placed in protective cases. They are not designed for that. When consumer and enterprise devices fail, help is a text or phone call to the IT department away. In the field and on the job, there's no IT for a quick fix. Consumer and enterprise systems are built to last until next year's models come along. Rugged systems have long life cycles. If lightweight consumer and enterprise devices fail, it's annoying. If a rugged system fails, that can be a matter of life and death. And that is why they are built not to fail. Light ruggedization is no match for that.

RUGGEDNESS CATEGORIES

The most commonly used classifications in the rugged devices industry are "semi-rugged," "fully rugged," and sometimes "ultra rugged." These terms are vague and a bit awkward, and can easily lead to customer confusion and uncertainty.

What do those designations really mean? To use an automotive analogy, a semi-rugged tablet or laptop is to a fully rugged tablet or laptop like a Crossover vehicle is to a Sport Utility Vehicle. The Crossover may have some of the same design elements and rugged features as an SUV or an off-road vehicle, but it isn't that far removed from a sedan or a hatchback. A full SUV is tougher and better equipped to handle off-road. Likewise, while a good semi-rugged is also designed rugged from the ground up and provides better protection than a standard consumer laptop, it isn't designed to handle all the rough handling in the field. For that you choose a fully rugged tablet or laptop.

Unfortunately, even today the term "ruggedness" isn't very clearly defined and there is no universally accepted checklist of what differentiates a semi-rugged from a fully rugged device. There are, however, two commonly used (and measurable) performance criteria that separate semi-rugged from fully rugged devices.

Since semi-rugged tablets and laptops are likely to be used primarily indoors and on desks, they have a "drop spec" of three feet (falling off a tall desk) and an IP52 or IP53 ingress protection rating, which means they are mostly protected against dust, and they can handle the occasional spill or a bit of rain.

SEMI-RUGGED CERTIFICATIONS

Fully rugged devices, on the other hand, generally aim for a four feet drop spec (slipping out of one's hands when using the device standing or walking) or better, and their ingress protection ratings range from IP65 (fully protected against dust and low-pressure water jets from all directions) all the way to IP67 (fully protected against dust and full immersion in water).

FULLY-RUGGED CERTIFICATIONS

While the difference between these two degrees of protection may not appear to be very large, they do require substantially different design, materials, and construction, and they represent most of the significant cost difference between semi and fully rugged. Two devices from the same manufacturer may look almost identical outside, but the complex extra protection and sealing of the fully rugged version may double the purchase price or more.

In addition, established vendors of rugged computing equipment usually have internal lists of all the environmental testing their products are built to meet and subjected to be tested and certified for. Ask for those lists before purchase.

Customers may also come across additional terminology. Devices may be described as business-rugged, enterprise-rugged, value-tier rugged, and more. These are mostly marketing terms without clear ruggedness definitions. You may also come across the term "intrinsically safe." This refers to devices certified for use in potentially flammable environments, and those must meet a variety of very specific requirements.

REAL WORLD CHALLENGES

Why is true ruggedness so important? Because it is the difference between a device reliably working out there in the field and on the job, or not. This makes unsubstantiated ruggedness claims – as are often found in listings or advertisements for bargain-priced "white box" products -- unacceptable. Claims like "MIL-STD tested," "MIL-STD compliant," "IP68" or similar mean nothing unless they are accompanied by a full description of, or reference to, all tests from the manufacturer as well as testing certifications from an independent accredited testing lab.

INGRESS PROTECTION (IP) TEST

This is why customers must compile a list of challenges and environmental conditions that the equipment they intend to purchase may or will encounter in the field:

- *What are the minimum and maximum ambient temperatures the equipment will encounter?*

- *Will the equipment ever freeze and then thaw?*

- *What kind of vibration will the equipment be subjected to? This is imperative for gear mounted in rolling stock.*

- *What heights might the equipment get dropped from, and what kinds of surface might it get dropped on?*

- *Might the equipment get crushed?*

- *Will devices be subjected to extreme altitudes?*

- *Will it encounter salt water, or even saltwater fog?*

- *Must devices be impervious to cleaning agents? If so, what kind?*

- *Is full immersion in water likely?*

- *Can the equipment be hosed down?*

All the above should be part of the procurement process. Reputable rugged equipment vendors will have no problems answering all such questions and present pertaining certified test results.

HOW CAN MOBILE SYSTEMS BE DESIGNED AND BUILT TO MEET THOSE CHALLENGES?

By now it should be clear that true ruggedness is more than skin-deep and that ruggedness claims must be backed up with testing and testing certifications. How do experienced, reputable rugged systems manufacturers anticipate and meet all those challenges and build rugged products that can pass certification testing? It all starts and ends with identifying the challenges, and then addressing them one by one.

DROPS

To survive drops, the housing must be strong enough not to break, there must be no electronics, components or connections that might get damaged or come loose, the design must be such as to protect the display via appropriately designed bumpers, recessed mounting, and break-resisted glass or coatings, scratch-resistant surfaces, and materials. Parts that may break must be repairable and/or replaceable.

DUST AND WATER

In order keep to dust and water out, sealing must completely and reliably meet the specified ingress protection level. Protection against liquids, especially, must be 100% reliable. This means protective port covers that reliably work under all conditions, with fail-safe designs desirable (i.e., ports should not leak even if the port cover fails). It means housing and battery compartment seals that reliably do their job, are easy to visually inspect, are easily replaceable, and do not have weak spots. Fully rugged devices that use fans and antennae must reliably seal those off from the interior of the device and allow for complete drying if immersion occurs.

VIBRATION

In order to stand up to vibration, anything that might come loose must be reliably secured. Anything that is sensitive to vibration must be appropriately shock mounted. If anything comes loose, it must not cause additional damage. In order to stand up to chemicals, scratching, corrosion, pressure, fatigue, heat and cold, all used materials must be tested for suitability. Repair, replacement, and maintenance should be simple and economically feasible.

DURABILITY

If you have ever wondered why rugged systems feel more solid and weigh more than consumer or enterprise devices, that's why. Rugged systems are built strong from the inside out and from the ground up. Depending on the degree of ruggedness required, they have either fully metallic cases, usually magnesium, aluminum, or alloys of those metals, or they use a metallic chassis inside a tough ABS+PC (Acrylonitrile Butadiene Styrene PolyCarbonate) housing. Commercial devices generally use just plastic. And plastic, even with "honeycomb" enforcement cannot provide the structural integrity of metal.
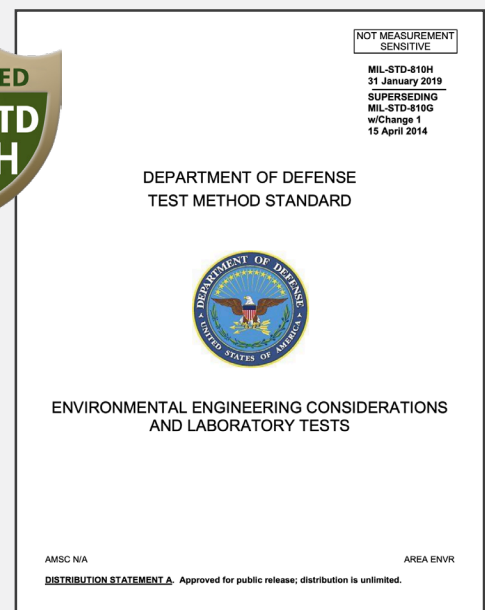
It should be clear that designing and building rugged products is an integrated and highly specialized process. It is far more than skin-deep, and far more than adding a bit of extra protection to commercial off the shelf products. But won't protective cases sufficiently guard consumer devices from damage? To some extent, but inside such cases are still consumer products that were neither designed nor built for rough handling and use in hostile environments.

HOW IS RUGGEDNESS TESTED?

For most disciplines, the gold standard for ruggedness testing is the United States Department of Defense Test Method Standard -- Environmental Engineering Considerations and Laboratory Tests. The current version, the MIL-STD-810H was issued in 2019 and weighs in at 1,089 pages. While created for military applications, it can be used for commercial use as well. The purpose of the standard is to help tailor items' environmental design and test the limits of the conditions the item will experience in its service life.

The authors of the standard stress that the suggested test methods "are to be selected and tailored to generate the most relevant test data possible" and that "tailoring is essential." In essence, it is suggested to apply the "general guidelines for laboratory test methods" listed in the standard. The authors emphasize that "When applied properly, the environmental management and engineering processes described in this Standard can be of enormous value in generating confidence in the environmental worthiness and overall durability of materiel system design."

CERTIFIED
MIL-STD
810H

NOT MEASUREMENT SENSITIVE

MIL-STD-810H
31 January 2019
SUPERSEDING
MIL-STD-810G
w/Change 1
15 April 2014

DEPARTMENT OF DEFENSE
TEST METHOD STANDARD

ENVIRONMENTAL ENGINEERING CONSIDERATIONS
AND LABORATORY TESTS

AMSC N/A   AREA ENVR
DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

What the MIL-STD suggests is what testing is all about:

     a) selecting the tests that make sense for a device
     b) set up a test environment as suggested in the MIL-STD
     c) determine reasonable performance goals
     d) perform the tests
     e) report the results

While the MIL-STD-810H lists laboratory test methods for 29 areas, not all apply to rugged computers. It is up to the manufacturer and the customer to decide which to select, perform, and certify. Understanding this process is imperative. It is an involved, complex, scientific process that builds trust, confidence, and has a direct impact on customer satisfaction and total cost of ownership.

How does this look in practice? Let's take a look at one of the core criteria for rugged laptops and tablets, the "drop test." This is covered in MIL-STD-810H, Method 516.8 -- Shock. The purpose here is to provide a degree of confidence that an item can withstand the shock and protect physical and functional integrity in its intended use and environment. Upon first determining where mechanical shock might occur in the life cycle of the device, proper testing then includes determining what shock can do to a particular item. This could be accelerated fatigue, electronic malfunction, cracks and fractures, breakage, etc. In older standards, testing always assumed a "transit drop," as in something falls off a truck when loading and unloading equipment.

VIBRATION TEST

The DOD realized that and in the latest MIL-STD-810H there is a "tactical transport drop" with five scenarios -- ship, unpackaged, packaged, helicopter, and parachute. The scenario that applies to ruggedness testing of mobile computing gear falls under "unpackaged handling, infantry and man-carried equipment." There, the DOD suggested drop height is

five feet, with drops to flat bottom, left end, right end, bottom right edge at 45 degrees, and top left end corner at 45 degrees, with each item exposed to no more than two drops. Drops are to be to steel over concrete, though the DOD allows for drops onto lesser materials if those are typical for a test item and use environment. While the drop section of the standard consists of a full 75 pages of technical data, statistics, and suggestions, the DOD allows for customization and judgment on how to conduct the tests. This allows rugged equipment manufacturers to design and describe tests that are realistic and make sense for a particular piece of equipment.

Why is all this important? It illustrates that testing is multifaceted, complex and goes far beyond simply proclaiming a device "MIL-STD compliant."

TESTING LAB

ADVANTAGES AND BEST PRACTICES OF STRICT RUGGEDNESS TESTING

It should be clear by now that ruggedness testing is an integral part of the overall design, manufacture, marketing, and life cycle of rugged computing equipment. It is, in fact, part of the overall rugged computing value proposition. These are devices built to provide reliable operation without failure under whatever environmental conditions they may reasonably encounter during their service life. Systematically testing them according to the highest standards is simply part of the process. Doing without it, or even skipping steps, isn't doing anyone a service, not the manufacturer and certainly not the customer.

Rigorous testing and making the results of those tests available to customers is what sets experienced manufacturers of rugged computing equipment apart. It is at the very core of the rugged computing value proposition -- best in overall performance, overall reliability, overall satisfaction, and overall cost of ownership.

IN RUGGEDNESS, EVERY DETAIL MATTERS

When failure is not an option, everything must be designed, engineered and built just right. That's why mobile systems field workers rely on must be built rugged from the ground up. That means selecting materials for housings and structural support that will not crack, fatigue, burn or fail due to other forces the device may be subjected to during its service life. It means that selected electronic components must be able to handle anticipated vibration, heat, cold, pressure, and more. It means that all connectors must lock securely so that they will not come loose under any condition. It means that seals must be 100% reliable, easily examined for damage, and easily replaced. "Fail-safe" must be the guiding design principle; if something goes bad, it must not allow additional harm or damage. Experienced manufacturers of rugged equipment follow all of this; those retrofitting consumer technology generally do not.

RUGGEDNESS DNA

Why is rugged computing equipment an area where it doesn't pay to cut corners and go with low-cost gear from inexperienced vendors? Here's why:

In computer science, the term expert system refers to computers drawing on the accumulated knowledge and experience of human experts to emulate their decision-making process. Such systems contain the wealth of years and decades' worth of professionals' experience, the refinements they created, the exceptions they found, the innovations they came upon, the feedback they received, the obstacles they overcame,

and the improvements and perfections that resulted from lifetimes of work in each field. In essence, expert systems capture the DNA that contain everything that makes a technology, a type of product, a set of solutions work.

Established rugged computer manufacturers are such expert systems. The knowledge they have accumulated during decades in the field represents not only technology as such, but also real-world experience and the feedback from partnerships with thousands of police departments, fire fighters, healthcare professionals, field representatives, maintenance crews, the military, governments, and all the people using rugged computing equipment on the job every day. It is this deep, organic corporate DNA grown over years and decades of work and experience that makes for true, reliable rugged systems and sets them apart from copy-cat efforts long on claims and short on substance.

This, in summary, is the rugged computing value proposition: purpose-built devices designed and manufactured by specialists with decades' worth of experience in building rugged computers. Devices that have been tested and certified to hold up in the operating environment and environmental conditions they will be used in. And a lower total cost of ownership because the devices were designed from the ground up for dealing with all of those challenges without breaking down.

Getac

ABOUT GETAC

Getac Technology Corporation is a global leader in rugged mobile technology, including laptops, tablets, software and video solutions. Getac's solutions and services are designed to enable extraordinary experiences for frontline workers in challenging environments. Today, Getac serves customers in over 100 countries spanning defence, public safety, ambulance, fire & rescue, utilities, automotive, natural resources, manufacturing, transport, and logistics.

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