

**TOP 15
SENSOR
CONSIDERATIONS
WHEN
DESIGNING
MILITARY COMBAT
PLATFORMS**

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INTRODUCTION

Modern military combat systems are extraordinarily complex, requiring teams of trained and experienced engineers to develop solutions that meet stringent requirements for reliability, accuracy, and ruggedness. Designers involved in the process must consider a variety of factors and variables that must contribute to success while minimizing the potential for failure. This document will highlight several of these factors with explanations of why they are important to consider during development.

Sensors are a vital component of military combat systems and serve as the physical entities that enable military operations in various domains, such as land, sea, air, space, and cyberspace.

The importance of sensors in military combat systems cannot be overstated, as they provide the necessary information for making critical decisions in real-time and can mean the difference between mission success and failure.



MILITARY COMBAT PLATFORMS OVERVIEW

1

Military combat platforms are the physical entities that enable military operations in various domains, such as land, sea, air, and space. They can be manned or unmanned, fixed or mobile, kinetic or non-kinetic, offensive or defensive, and modular or integrated. Military combat platforms can perform various functions, such as intelligence, surveillance, reconnaissance, communication, command and control, targeting, strike, countermeasure, protection, logistics, and maintenance. Military combat platforms can also interact with each other, forming networks, systems of systems, or joint forces. Military combat platforms span air, marine, ground, and space environments, and special applications like missile systems.

MANNED AND UNMANNED AIRCRAFT/AERIAL SYSTEM

Manned and unmanned aircraft/aerial system (UAS) combat systems are designed to provide air superiority, air defense, close air support, interdiction, suppression of enemy air defenses, reconnaissance, surveillance, and target acquisition in the contested airspace. Manned aircraft combat systems consist of manned platforms, such as fighters, bombers, attack helicopters, transport aircraft, and special operations aircraft, equipped with various systems, such as avionics, weapons, sensors, electronic warfare, communication, navigation, and identification.

Unmanned aircraft combat systems consist of unmanned platforms, such as drones, remotely piloted vehicles, and autonomous aerial vehicles, equipped with similar systems as manned aircraft, but operated by remote control or onboard computers. Manned and unmanned aircraft combat systems must be able to coordinate and cooperate with each other, as well as with ground and marine combat

systems, through secure and reliable data links, networks, and protocols. Manned and unmanned aircraft combat systems must also be able to operate in different environments, such as day and night, all-weather, high and low altitude, and stealth and non-stealth modes.

A shift from traditional aircraft to smaller, remote piloted aircraft brings new needs for sensors to monitor onboard mechanisms and flight behavior. Smaller size, lighter weight, and a higher number of actuators will be requirements for this new application space. Increased usage of hobby drones with added military equipment calls for less expensive, higher volume add-on components.

MARINE

Marine combat systems operate in a complex and dynamic maritime environment. Marine environments include surface, subsurface, littoral, and amphibious domains. Combat systems and components must be able to reliably perform various missions, such as surveillance, reconnaissance, intelligence, target

acquisition, strike, anti-submarine warfare, anti-air warfare, anti-surface warfare, mine warfare, electronic warfare, and command and control.

To achieve these operational objectives, marine combat systems must integrate multiple components, such as radars, sonars, weapons, decoys, countermeasures, communication systems, navigation systems, data links, displays, and consoles. Marine combat systems must also be interoperable with other platforms, such as naval ships, aircraft, satellites, and shore-based stations. In addition, marine combat systems must be adaptable, resilient, and agile, to cope with the evolving threats, operational requirements, and environmental conditions, while being transparent to acknowledged allies and coalition partners.

GROUND VEHICLES

Combat systems encompass ground vehicles designed to perform over various land terrain. Examples include tanks, fighting vehicles, personnel carriers, mobile rocket launchers, anti-tank missiles, anti-aircraft guns, and remote-controlled or autonomous robots. Ground vehicles, wheeled or tracked, move on land, and are designed to withstand vigorous physical and environmental conditions from combat and geographic location; to facilitate mobility, fire support, and reconnaissance. Harsh environmental conditions include effects from temperature extremes, vibration levels and change, random and high impact shock, moisture and dust exposure, and the presence of electromagnetic interference. Armed and armored combat systems must provide security while in use and function correctly while counteracting the effects of environment and physical exposure.

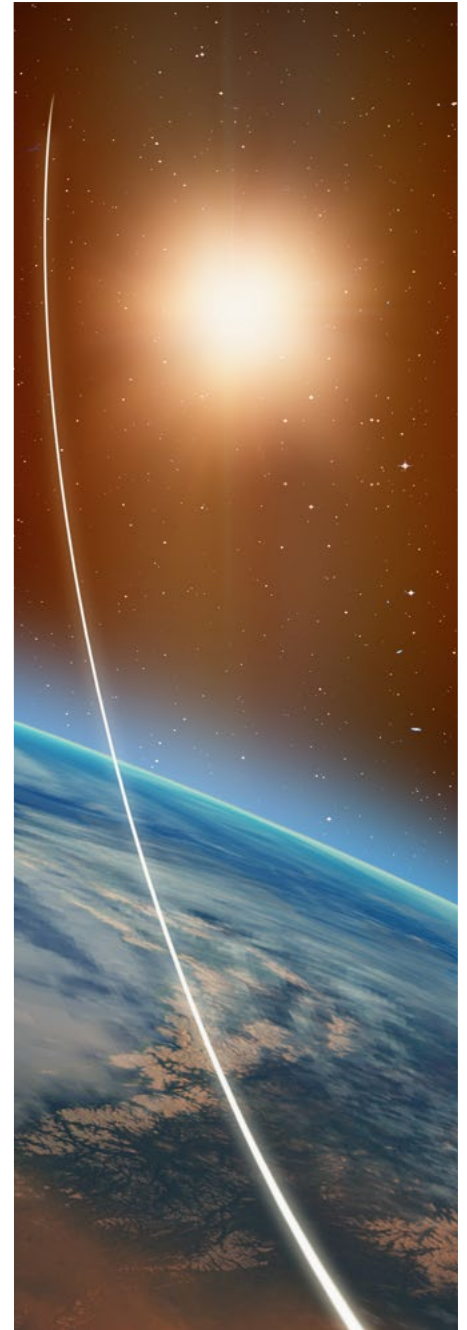
SPACE

Space combat systems are designed to operate in the harsh and hostile space environment, which includes orbital, lunar, planetary, and interplanetary domains. Space combat systems must be able to perform various missions, such as reconnaissance, intelligence, target acquisition, strike, anti-satellite warfare, anti-missile warfare, anti-spacecraft warfare, space control, space situational awareness, and command and control. To achieve these

objectives, space combat systems must integrate multiple components, such as sensors, weapons, propulsion, maneuver, shielding, communication, navigation, data links, displays, and consoles. Space combat systems must also be interoperable with other platforms, such as terrestrial stations, aircraft, satellites, and spacecraft, and with allies and coalition partners. Space combat systems must be adaptable, resilient, and agile to cope with the evolving threats, operational requirements, and environmental conditions.

MISSILES

Missile systems are advanced weapon platforms that use rockets to deliver warheads to their targets. These systems have evolved from their early origins in 10th century China to become a critical component of modern military operations. Missiles can be categorized into several types, including Surface-to-Surface, Air-to-Air, Air-to-Surface, Surface-to-Air, Anti-Ship, Anti-Tank, and Anti-Satellite, and can be deployed from a variety of platforms, including aircraft, submarines, and ground-based launchers. A missile system typically consists of several subsystems, including the warhead, targeting/terminal guidance system, flight control systems, and engine/propulsion systems. These systems must operate with maximum precision to ensure mission success.



SENSOR APPLICATIONS IN MILITARY COMBAT PLATFORMS

2

Sensor technology is a vital component of any military combat platform that enables the detection, identification, tracking, and engagement of targets, as well as the self-protection, survivability, and situational awareness of the platform. Sensors can be classified into distinct types, such as radar, optical, infrared, acoustic, magnetic, chemical, biological, and nuclear, depending on the physical phenomenon they exploit to sense the environment. Sensors can also be categorized by their function, such as surveillance, reconnaissance, fire control, navigation, communication, countermeasure, or warning.

Sensors can be mounted on various platforms, such as vehicles, aircraft, ships, submarines, drones, missiles, rockets, satellites, or spacecraft, depending on the domain and mission they support. Sensors can operate in different modes, characterized as passive or active, cooperative or non-cooperative, single or multiple, and fixed or mobile, depending on the operational scenario and tactics they employ. Sensors can provide diverse levels of information, such as raw data, processed data, or fused data, depending on the degree of analysis and integration they perform. Sensors can interact with other sensors, platforms, systems, networks, or operators, depending on the architecture and protocols they follow.





Honeywell MICRO SWITCH Sealed Limit 1EN1-6

SEALED SWITCHES

Sealed switches are devices that serve as a “component” part of a higher-level subsystem that may be employed to detect a change in physical position, pressure, temperature, or magnetic field. A sealed switch provides a change in electrical state to the governing electrical circuit. The sealed switch provides precise, repeatable performance, via careful installation, rigging, and/or calibration to support different applications and functionality.

Sealed switches commonly used in military combat platforms include thermal sensors, position sensors, and magnetic sensors. These devices are employed for specific purposes at operational and functional levels, such as controlling weapons systems, monitoring engine performance, indicating mechanical position, or detecting physical and environmental hazards.

Physical and environmental conditions impact performance, requiring that sealed switches withstand harsh conditions, including temperature extremes, vibration, shock, moisture, and airborne particulates. Therefore, sealed switch designs require special materials, coatings, and enclosures to protect electrical circuitry from damage and corrosion. In addition, external package design considerations include protections against tampering with the electrical circuits.

Sealed switches are intricate and elaborate and need advanced expertise and abilities to create, set up, and run.

Design performance of sealed switch technologies must provide for reliability and durability to function for prolonged periods without failure or unscheduled maintenance. Design consideration must also include size and weight attributes, including wiring run and interconnect method. Versatility and adaptability allow the sealed switch design to be implemented uniquely to support specific platform and application specifications.



Honeywell 3500 Thermostat Series

THERMAL SENSORS

Thermal sensors measure the temperature of an object or environment and convert readings into a signal that can be used for monitoring, control, or analysis. Thermal sensors are essential for military combat platforms because they can provide information about the thermal state of the platform itself, such as its engine, weapons, or electronics, as well as the thermal signature of potential targets, threats, or environmental conditions.

Thermal sensors offer advantages and limitations depending on their working principles, accuracy, range, response time, and durability. Some of the most common types of thermal sensors are thermocouples, resistance temperature detectors (RTD), thermistors, infrared sensors, and pyrometers. Each of these types has its own characteristics and applications in military combat platforms.

For example, thermocouples are simple and inexpensive sensors that consist of two wires of different metals joined at one end. When the junction is exposed to a temperature change,

a voltage is generated proportional to the temperature difference between the junction and the other end of the wires. Thermocouples can measure a wide range of temperatures, from -200°C to 2300°C, and are suitable for measuring elevated temperatures in engines, exhausts, or rockets. However, thermocouples offer limited accuracy and require calibration and compensation circuits to adjust for the temperature of the reference end.

RTDs (resistance temperature detectors) are sensors that use a metal wire or film that changes resistance with temperature. RTDs can offer high accuracy, stability, and repeatability in temperature measurement and are often used for monitoring critical components or systems in combat platforms, such as hydraulic fluids, fuel tanks, or avionics. However, RTDs have a limited temperature range, from -200°C to 850°C, and are more expensive and fragile than thermocouples. RTDs also require a constant current source to measure the resistance.

Thermistors are sensors that use a ceramic or polymer material that changes resistance with temperature, but in a nonlinear and exponential way. Thermistors can provide high sensitivity, fast response, and low cost in temperature measurement, and are often used for detecting overheat or fire situations in combat platforms, such as batteries, circuit boards, or ammunition. However, thermistors have a narrow temperature range, from -100°C to 300°C, and are prone to self-heating and aging effects that can affect their performance.

Bi-Metal Snap Action Temperature switches are available as a single pole, single throw switch activated by snap action bimetal disc. Temperature calibrations are pre-set at the factory and each unit is 100% thermally and mechanically inspected. Set to open or close based on increasing temperature, the case is laser welded to form a hermetically sealed steel housing with a glass-to-metal seal at the terminal junction. These types of switches are manufactured and tested to meet or exceed critical military and

aerospace specifications for spaceflight use, including temperature stability, shock, vibration, and cleanliness.

With a working range from -60°C to 260°C, these snap action devices can safely handle 5 amps at 28VDC, making them ideal candidates for over-temperature protection, or to be used as simple mechanical on/off control devices to help drive heaters and keep sensitive equipment within working parameters, such as in space and other extreme cold conditions.



Honeywell LVDT4 Dual Parallel Flange Connector

POSITION SENSORS

Position sensors are devices that measure the position, displacement, or motion of an object relative to a reference point or frame. Position sensors can be used for various purposes in military combat platforms, such as tracking the location and orientation of vehicles, weapons, or targets, controlling the movement and stabilization of turrets, cannons, or missiles, and monitoring the deformation or damage of structures or components.

Position sensors can be classified as absolute and relative. Absolute position sensors provide the exact position of an object without requiring any previous information, while relative position sensors provide the change in position of an object from a known initial position.

For manufacturers who need an accurate, reliable, repeatable, and durable rotary and angle absolute position sensor for potential use in defense, aerospace, medical, and industrial applications, resolvers provide 360° noncontact, angular position sensing and enhanced accuracy (± 7 arcmin) for precise motion control.

Resolvers convert mechanical shaft position to an electrical signal which represents the actual shaft angle. They are variable transformers in which the stator has two phase windings mechanically displaced by 90°. The output consists of two sine waves that are phase shifted by 90°

Resolvers are typically chosen over electronic sensors (i.e., optical encoders, potentiometers, magnetic encoders/sensors) because they do not contain electronics, so they are not susceptible to performance fluctuations in harsh environments. Resolvers are inherently radiation hardened and offer durable Electromagnetic Compatibility (EMC) performance.

A precision potentiometer is a mechanical-electrical transducer in which a wiper-contact moves along a resistive element and delivers an output signal that is a precise function of applied voltage and shaft position. Precision potentiometers are available in rotary motion and linear motion configurations. Potentiometers convert rotary motion into a change of resistance, supplying a smooth transition of voltage or current levels. The resulting voltage output may be used to control position transducers in a wide variety of potential applications.

Aerospace proximity sensors are non-contact, hermetically sealed devices designed to sense the presence or absence of a target in harsh duty aircraft applications.

Linear variable differential transformers (LVDTs) use a coil and a movable core to measure the linear displacement of an object. LVDTs are often used for measuring the position and feedback of actuators, valves, or levers, or for measuring the strain or stress of structures or components.

PRESSURE SENSORS

Pressure sensors are devices that measure the pressure of application media such as gases and/or liquids. Pressure is an expression of the force required to stop a media from expanding, and it is defined in terms of force per unit area. All pressure

sensors use a force-summing device to convert the pressure into a stress or a displacement proportional to the pressure. The stress or displacement is then applied to an electrical transduction element that generates an electrical signal that is proportional to the pressure. Typically, signal conditioning electronics is applied to further amplify, process, condition and compensate the signals to achieve the desired characteristics and level of performance necessary in the end application.

Pressure sensors are utilized in a wide variety of monitoring and control applications to directly measure pressure and can also be used in indirect measuring variables such as liquid level, gas flow, liquid flow or even mechanical displacement.

Engineers are frequently challenged with monitoring and/or controlling processes, lines, hoses, and distinct types of application media. Many of these aspects involve hydraulic or pneumatic systems in tactical machinery, heavy duty transportation, land/air defense vehicles, and military equipment & electronics. Real-time pressure measurements in such applications spaces can play important roles in providing user feedback and control in sensitive environments, which make them suitable for design on harsh duty environments, R&D testing, system manufacturing, leak detection, and relevant quality assurance processes.



Honeywell Media Isolated Pressure Sensors MIPS Series

SPEED SENSORS

Magnetic speed sensors can provide non-contacting detection of a rotating ferrous target, which affects a magnetic field, such as a gear, tone wheel, shaft, or similar mechanism. These sensors measure target speed and/or direction. Digital or analog outputs provide a frequency proportional to rotational target speed. Target must have gear tooth pattern of teeth and slots or holes in a plate. Electronic speed and position sensors are designed for enhanced reliability and an extended life.

Multiple technologies are utilized to detect a change in magnetic field and create an electronic signal for control

system interface. These technologies offer the ability to detect speed, direction, or position of a moving ferrous metal or magnetic target. Sensing is accomplished without contacting the target, and there are no moving parts. This eliminates mechanical wear of the sensor or target.

There is a comprehensive line-up of Hall-effect, magneto-resistive, and variable reluctance sensors which provide electrical compatibility to most control system interfaces. Typically, available in a variety of sensor package types designed to enable mounting flexibility and wire harness interface compatibility.



Honeywell VRS Series Speed Sensors



KEY SENSOR CONSIDERATIONS FOR COMBAT SYSTEMS DESIGN

3

Sensors are critical components of combat systems' effectiveness. While design considerations are numerous, certain elements stand out as key decision points that have the potential to reduce failure potential. These include sensor reliability and ruggedness, maintenance, environmental factors, and design standards, to name a few. The following pages detail these crucial factors, along with consideration by sensor type.

RELIABILITY/RUGGEDNESS

Reliability and ruggedness are crucial parameters for sensor considerations for military combat platforms, based on the expectation that sensors must perform reliably in harsh and dynamic environments, where they may be exposed to extreme temperatures, vibrations, shocks, impacts, dust, moisture, electromagnetic interference, or chemical agents. Further, sensors must be sufficiently rugged to withstand long-term storage without degradation, as military platforms may be deployed on short notice or remain in reserve for extended periods.

Designers should consider the following aspects when selecting sensors for military combat applications:

- Use of appropriate materials and components capable of resisting environmental stressors and aging effects
- Application of protective coatings, encapsulations, or housings that can prevent corrosion, abrasion, or contamination
- Implementation of redundancy, fault-tolerance, or self-diagnosis features that can enhance resilience and availability

- Integration of sensors with power sources, communication systems, and data processing units that can optimize performance and efficiency
- Testing and validation of sensors under realistic conditions and scenarios that can verify functionality and durability

By following these best practices, designers can select sensors that improve the reliability and ruggedness of their products, thereby enhancing the operational effectiveness, survivability, and safety of military combat platforms.



MAINTENANCE

Maintenance and repairability are crucial aspects of design considerations for military combat platforms as they affect the performance, availability, and lifecycle costs of the systems. Sensors that are easy to maintain and repair can reduce downtime, spare parts inventory, and logistics support requirements, as well as extend the service life and functionality of the platforms. Some of the factors that influence the maintenance and repairability of sensors include:

- **Modularity:** Modular design allows for the replacement or upgrade of individual components or sub-systems without affecting the

whole sensor system. This can simplify maintenance procedures, reduce repair time, and increase compatibility and interoperability among different platforms.

- **Accessibility:** Accessibility refers to the ease of access to the sensor components, connectors, wiring, and mounting points for inspection, testing, cleaning, or servicing. Accessible sensors can facilitate preventive and corrective maintenance and reduce the risk of damage or contamination during maintenance operations.
- **Diagnostics:** Diagnostics are the means of detecting, identifying, and

locating faults or malfunctions in the sensor system, either remotely or on-site. Sensors with built-in diagnostics or self-test features can enable faster and more accurate troubleshooting and provide feedback on the system's health and status.

- **Redundancy:** Redundancy is the provision of backup or alternative components or subsystems that can perform the same function as primary systems in case of failure. Sensors with redundancy can enhance the system's reliability and availability and allow for graceful degradation or fail-safe modes of operation.



ENVIRONMENTAL FACTORS

Environmental factors are external conditions or influences that affect the performance, durability, and survivability of sensors and their associated systems. Sensors for military combat platforms must be able to withstand and operate in a wide range of environmental factors, such as temperature, humidity, pressure, vibration, shock, electromagnetic interference, corrosion, dust, sand, water, and chemical agents. These factors can degrade the accuracy, sensitivity, response time, stability, and functionality of sensors, as well as cause damage, failure, or malfunction of components or sub-systems.

Therefore, design considerations for military combat platforms account for environmental factors that sensors will

encounter during their intended use, as well as during storage, transportation, installation, maintenance, and disposal. Combat systems designers must also consider the trade-offs between performance, robustness, reliability, cost, and complexity of the sensors and their systems.

Some of the common design considerations for environmental factors include:

- Selection of appropriate materials, coatings, seals, and connectors that can resist environmental effects and protect the sensor elements and electronics from exposure, degradation, or contamination
- Design of robust and resilient mechanical structures and housings that can support

and shield the sensors from physical stresses and shocks

- Implementation of adaptive algorithms and calibration methods that can compensate for environmental variations and drifts in sensor readings
- Incorporation of self-diagnostic, self-healing, and self-reconfiguring capabilities that can detect and correct errors or faults in sensor operation
- Integration of multiple sensors or modalities that can provide complementary or corroborating information and improve the overall system performance and reliability

DESIGN STANDARDS QUALIFICATION

Standards qualification is a crucial step in design considerations for military combat platforms, ensuring that sensors meet the functional and operational requirements of the intended application.

Design standards qualification involves testing and evaluating the sensors under various environmental and performance conditions, such as temperature, humidity, vibration, shock, electromagnetic interference, radiation, and accuracy.

The sensors must also comply with the relevant military standards and specifications, such as MIL-STD-810, MIL-STD-461, and MIL-STD-882, which define the minimum acceptable levels of quality and reliability for the sensor systems.

Specific military standards include:

- Thermistors built and tested in accordance with MIL-PRF-23648
- Thermostats built and tested in accordance with MIL-PRF-24236
- Potentiometer built and tested in accordance with MIL-PRF-39023
- Resolvers built and tested in accordance with MIL-S-81963B
- Validation testing in accordance with MIL-STD-202

Design standards qualification has several benefits for the sensor selection process, such as:

- Enhancing the robustness and durability of the sensors, which can withstand harsh and unpredictable battlefield scenarios and provide consistent and reliable data
- Reducing the risk of failure and malfunction of the sensors, which can compromise the safety and

effectiveness of the combat platforms and the personnel

- Increasing the compatibility and interoperability of the sensors, which can work seamlessly with other components and systems of the combat platforms and enable data fusion and integration
- Improving the efficiency and cost-effectiveness of the sensor design process, which can reduce the need for rework, redesign, and maintenance of the sensors and optimize the use of resources and time

Design standards qualification is an essential aspect of sensor design considerations for military combat platforms, as it ensures that the sensors meet the highest standards of quality and performance and can support the mission objectives and operational capabilities of the combat platforms.



SIZE AND WEIGHT SPECIFICATIONS

Another important aspect of design considerations for military combat platforms is the size and weight specifications of the sensors.

The size and weight of the sensors affect the overall dimensions, weight distribution, aerodynamics, stealth, mobility, and maneuverability of the combat platforms, as well as the power consumption, heat dissipation, and integration with other systems.

Therefore, the sensors must be designed to minimize the size and weight impact on the combat platforms, while maximizing the functionality, reliability, and accuracy of the sensors.

Specific considerations include:

- The type and function of the sensor. Sensors fulfill varying purposes and requirements, such as sensing range, resolution, frequency, bandwidth, signal-to-noise ratio, etc. For example, a radar sensor may require a larger antenna and more power than an infrared sensor while offering better performance in adverse weather conditions.
- The type and configuration of the combat platform. Combat platforms have different constraints and trade-offs, such as payload capacity, fuel efficiency, speed, agility, stealth, survivability, etc. For example, a

fighter jet may have less space and weight allowance for sensors than a tank, though may need more sophisticated sensors for air-to-air and air-to-ground missions.

- The environmental and operational conditions. Environments and scenarios pose different challenges and opportunities for the sensors, such as temperature, humidity, pressure, vibration, shock, electromagnetic interference, jamming, countermeasures, etc. For example, a submarine sensor may need to withstand high pressure and low visibility, though may benefit from the acoustic properties of water.

ABILITY TO CUSTOMIZE

The ability to customize sensors for different combat platforms is a key factor in ensuring optimal performance, reliability, and survivability.

Customization allows the sensors to meet the specific requirements and constraints of each platform, such as size, weight, power, shape, interface, etc. For example, a tank sensor may need to fit into a limited space and have a rugged design, while a drone sensor may need to be lightweight and have low power consumption.

Customization also enables the sensors to provide the best possible data and functionality for each platform's mission and role. For example, a fighter jet sensor may need to have

high resolution and accuracy, while a reconnaissance satellite sensor may need to have wide coverage and stealth features. Customization can enhance the sensors' capabilities in areas such as detection, identification, tracking, targeting, navigation, communication, etc.

To achieve customization, suppliers need to work closely with customers to understand their needs and challenges, and to offer flexible and adaptable solutions. Suppliers need to have a broad portfolio of sensor technologies and products, and the ability to modify and integrate them to suit different platforms and applications. For example, a supplier may need to adjust the sensor's

frequency, range, sensitivity, resolution, or signal processing depending on the customer's specifications.

Engineering support is another crucial aspect of customization. Suppliers need to provide ongoing partnership and collaboration during the design, development, testing, and deployment phases of the sensor systems. Suppliers need to have expertise and experience in working with diverse types of combat platforms, and the ability to provide technical guidance, advice, and feedback. Suppliers also need quality assurance and control measures and must ensure compliance with safety and security standards.



ENGINEERING SUPPORT: PARTNERSHIP DURING DESIGN

Engineering support is not only about providing the right sensor solutions, but also about ensuring their optimal performance and reliability in the field. Suppliers need to offer comprehensive and responsive service and maintenance throughout the lifecycle of the sensor systems. This includes providing regular updates, upgrades, repairs, replacements, calibration, and troubleshooting.

Suppliers need to have a dedicated and accessible team of engineers and technicians who can provide timely and effective support, and who can work

closely with the customers to address any issues or challenges that may arise. Engineering support is essential for enhancing the operational readiness and efficiency of the military combat platforms, and for reducing the risks and costs of downtime and failures.

A related factor in sensor design considerations is the manufacturer partnership. Customers need to look for suppliers who can offer a collaborative and flexible approach to sensor development and integration, and who can tailor their solutions to the specific needs and specifications of the customers.

Suppliers who can provide a full range of sensor products and services, from design and testing to installation and training, can ensure a smooth and seamless transition from concept to reality. Suppliers who can adapt to the changing demands and expectations of the customers, and who can provide continuous feedback and improvement, can ensure a long-term and mutually beneficial relationship.

Manufacturer partnership is a key determinant of the satisfaction and success of the sensor systems, and of the value and impact that they created for combat systems designers.

PEDIGREE: COMBAT SYSTEMS EXPERIENCE

The pedigree of suppliers of components for military combat platforms is important for several reasons.

- Ensuring the quality and reliability of the components is essential for the platforms' performance and safety.
- Reducing the risk of counterfeit or substandard components, which could compromise the functionality or security of the platforms.
- Enhancing the trust and confidence between the military and suppliers, which facilitates cooperation and communication throughout the supply chain.

The quality and reliability of the components depend on the pedigree of the suppliers, who must adhere to the specifications and standards

set by the military. The components must be able to withstand harsh environments, extreme temperatures, shocks, vibrations, and other stress factors. The components must also be compatible and interoperable with other components and systems within the platform. The pedigree of the suppliers ensures that they have the expertise, experience, and reputation to deliver high-quality and reliable components.

The risk of counterfeit or substandard components is a serious threat to military combat platforms, with potential to cause malfunctions, failures, or damage to the platform or its operators. The counterfeit or substandard components could also contain malicious software or hardware that could compromise the security or confidentiality of the platform or its data. The pedigree of the suppliers minimizes this risk, as they have the

verification and validation processes, the traceability and accountability mechanisms, and the ethical and legal obligations to prevent such incidents.

The trust and confidence between the military and suppliers is crucial for the success of military combat platforms, which require the collaboration and coordination of multiple stakeholders across the supply chain. Trust and confidence enable the transparency and efficiency of the information and material flows, the alignment and integration of the requirements and expectations, and the resolution and mitigation of the issues and challenges. The pedigree of the suppliers fosters this trust and confidence, as they demonstrate their competence, credibility, and commitment to the military and the mission.



LONG-TERM SUPPLY AVAILABILITY

Long-term availability of components for military combat platforms is important for several reasons. First, it ensures the platform's readiness and capability to perform the assigned missions and tasks and to respond to the changing operational environment and threats. Long-term availability of components means that they are not obsolete, degraded, or incompatible with the platform and its systems, and that they can be replaced, repaired, or upgraded as needed. This is crucial for maintaining the operational effectiveness and efficiency of the platforms and for

avoiding the costs and consequences of component failures or malfunctions.

Second, it enhances the platforms' sustainability and resilience and supply chain by reducing the risks of disruptions, delays, failures, or shortages of components. Long-term availability of components means that they have a long lifespan, a stable supply, and a consistent quality, and that they can be sourced, stored, transported, and disposed of safely and efficiently. This is vital for ensuring the continuity and reliability of the platforms and for minimizing environmental and economic impacts of component procurement and disposal.

Third, it supports the innovation and improvement of the platforms, as well as the competitiveness and profitability of the suppliers, by encouraging the research, development, testing, and evaluation of new or existing components. Long-term availability of components means that they offer high performance, minimal maintenance, and a potential for integration, adaptation, or modification with the platform and its systems. This is beneficial for enhancing the capabilities and functionalities of the platforms and creating new opportunities and markets for the suppliers.

COST

Cost is one of the crucial factors in sensor design considerations for military combat platforms. Sensors consume power, add weight, increase complexity, and require maintenance and calibration. Therefore, sensor design must balance the performance, reliability, and durability of the sensors with the cost implications for the platform and the mission.

Cost can be defined as the total amount of resources needed to acquire, operate, maintain, and dispose of a sensor system over its life cycle. Cost includes both direct and indirect costs, such as research and development, procurement, installation, integration,

testing, training, logistics, maintenance, repair, replacement, upgrades, disposal, and environmental impacts. Cost can also be influenced by external factors, such as market conditions, supply chain, availability, competition, regulations, standards, and policies. Cost can vary depending on the type, size, quantity, quality, and complexity of the sensors, as well as the platform, mission, and environment they are used in.

Sensor design considerations for military combat platforms must consider the cost-benefit analysis of different sensor options and alternatives. Designers optimize the value and effectiveness of the sensor system for the platform and

the mission, while minimizing the cost and risk of failure or degradation.

Sensor selection should also consider the trade-offs and synergies between different sensors and other subsystems, such as power, communications, computing, weapons, and protection. Design must be flexible and adaptable to changing requirements, threats, and scenarios, as well as interoperable and compatible with other platforms and systems. Sensor selection must also ensure that the sensors comply with relevant standards, regulations, and policies, and that they are safe, secure, and ethical.



SEALED SWITCHES SPECIFICS

Design consideration for a sealed switch, such as a component to an electrical circuit, needs to assess size and available space, actuation means, stroke or travel of the actuation means, and electrical parameters of the circuit. Electrical parameters include amperage, voltage, load type, and duty cycle. Key attributes of the installation for

consideration include environmental parameters of temperature, humidity, vibration, mechanical shock, and any aspect of acceleration.

Design performance of sealed switch technologies must consider reliability and durability, ensuring operation for extended periods without failure or unscheduled maintenance. Design

consideration must also be undertaken for size and weight attributes, including wiring run and interconnect. Versatility and adaptability allow the sealed switch design to be implemented uniquely to support specific platform and application specifications.

More information on sealed switch options may be found [here](#).

THERMAL SENSOR SPECIFICS

Thermistor-based temperature should be built in accordance with MIL-PRF-23648 and tested to specifications detailed in MIL-STD-202. Thermistors are equally effective in sensing temperatures for liquids, gases, or solids. Because of their extremely small size, however, preference is usually given for mounting in special probes or housings that can be specifically designed to position and protect the sensors properly in whatever medium they are to function. Sensors can be readily attached or mounted with screws, threaded into surfaces, or cemented, soldered, and

taped to surfaces. Housings may be made of stainless steel, aluminum, brass, plastic, or other materials.

Thermistor sensors assemblies serve several essential functions:

- Supporting and accurately positioning the thermistor element within the medium to be monitored.
- Protecting the thermistor against damage by handling.
- Helping direct thermal or fluid flow evenly across the thermistor sensor.

Thermostats can provide either temperature control or over-

temperature protection by breaking electrical contact when a specified temperature is reached. Potential options and applications include:

- Precision non-hermetic and hermetically sealed versions designed to serve infotech, transportation, telecom, industrial, aircraft, medical equipment, radar, communications, and electronic control system's needs.
- High reliability military and aerospace versions that meet the unique needs of the military, aerospace, and aviation industries.



POSITION SENSOR SPECIFICS

Position sensors measure the displacement, or angle of a physical object relative to a reference point. They are essential components of military combat systems, such as weapons, vehicles, aircraft, ships, and satellites, that require accurate and reliable feedback on their position and orientation.

When designing position sensors for military combat systems, several factors need to be considered, such as:

- Performance: The position sensor should have high resolution, accuracy,

repeatability, linearity, and stability over the operating range and temperature. It should also offer fast response time, low noise, and low drift. The performance of the position sensor may affect the accuracy, speed, and safety of the combat system.

- Durability: The position sensor should be able to withstand harsh environmental conditions such as extreme temperatures, humidity, vibration, shock, dust, water, and electromagnetic interference. It should also be resistant to wear and tear, corrosion, and fatigue. The

durability of the position sensor may affect the reliability, availability, and maintainability of the combat system.

- Compatibility: The position sensor should be compatible with the interface, power supply, and communication protocols of the combat system. It should also be compatible with the physical dimensions, mounting, and alignment of the system. The compatibility of the position sensor may affect the integration, interoperability, and functionality of the combat system .

PRESSURE SENSOR SPECIFICS

When selecting a pressure transducer, design engineers must consider the operational environment as well as the device's specifications and features. This may include excessive heat, voltage spike potential, and electrical disturbances or unusual shock/vibration in unforeseen conditions. Once these environmental situations are understood, the design engineer can move further toward transducer selection addressing application challenges. Heavy duty pressure applications require precise, accurate,

and dependable solutions that offer longevity.

When selecting pressure sensors for space or military applications, the following considerations are important:

- Provide customer value: Multiple configuration possibilities in electrical connection and port fitting to provide flexibility of use in the application with no upfront development costs or tooling charges
- Accurate & cost-effective: Compact packaging in form factors to reduce

design and manufacturing costs while maintaining performance and reliability

- Durable: Must withstand tough, rigorous environmental specifications, including insulation resistance and dielectric strength, and EMC performance
- Hermetically welded: Supports aggressive media, as heavy duty packaged pressure sensors are designed to be used in harsh environments



SPEED SENSOR SPECIFICS

When measuring the speed of a rotating object in a machine or other equipment is needed, speed sensors may be used. The rotating object will have a gear tooth pattern of teeth and slots. As the gear actuator rotates past the sensor, an analog (frequency sine wave) voltage output signal is generated. The output signal is directly proportional to the speed of the target gear; however, they cannot provide output at zero or extremely low speeds.

Speed sensors may offer passive speed sensing. Self-powered options require no external power source, and may offer advantages such as cost effectiveness, less cabling required, simple installation, and no moving parts.

In addition, utilizing two sensing units enables the possibility of determining direction, offering a unique application of sensor technology as a primary or backup directional readout.

Speed sensors must also meet two conditions for use:

- Provide required peak voltage at the minimum speed of interest.
- Will continue to function properly at the maximum operating frequency of the application.

CONCLUSION

Combat systems design involves many challenges and requirements. Given the complexity of military combat systems, designers must balance multiple considerations that will contribute heavily to the effectiveness and accuracy of these systems.

This document highlighted 15 key factors with explanations of why each is important to consider during development of combat systems and provided an overview of sensor types applicable to these systems.

Because sensors provide essential information for the performance and functionality of various components, selecting sensors for specific applications and environments is critical to achieve optimal results and ensure safety and reliability. Sensor considerations are not only important, but also complex and dynamic, requiring constant innovation and adaptation to the changing needs and demands of combat systems design.



For more information

Honeywell Sensing & Safety Technologies services its customers through a worldwide network of sales offices and distributors. For application assistance, current specifications, pricing or the nearest Authorized Distributor, visit our [website](#) or call:

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