Selecting precision motors for smart defence applications

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Developing the latest smart munitions, today's military contractors rely on specialist manufacturers to provide critical control and actuation. The motion solution is central to ensuring targeting accuracy, and while each specific smart defence application has its own unique challenges that demand an exacting approach, the design will essential attributes common across applications. Whether utilizing a bespoke or customizable off-the-shelf (COTS) approach, this makes motion solution design a critical requirement for smart munitions.

Precise control for missiles and guided bombs, as well as for the seekers that maintain their path, is imperative. In these most critical situations, it is also essential that the motion control solution is reliable, as well as safely integrate with the avionics and electronics within the wider aircraft or launch system.

Actuation control in use

Vital to the position of control surfaces on a missile, a control actuation system makes high speed adjustments to the fins or canards based on the inputs from the missile guidance system. Similarly, the extension of a wing deployment system on a guided bomb is vital to achieve the desired range and targeting.

The priority in motion design for both of these systems is precise control to actuate the flight surfaces with speed and smoothness which is key to determining whether a missile or guided bomb will strike its intended target. This control must be achieved within an extreme temperature profile, ranging from a low of -55°C to an excess of 100°C, and the motion solution must also withstand high levels of shock and

vibration during operation. This reliability must be maintained through a long storage period that could extend to more than 20 years. Working in a compact space and weight envelope, low mass and a small footprint of the motor are also compulsory. The electro-optical or infrared systems in missile and guided bomb seeker heads (also used in vehicles and land-based guided munitions), demand similar characteristics. To achieve target accuracy, the azimuth, elevation, and zoom axis motors must precisely coordinate, and it is imperative that the system performs in the most demanding environmental situations. Here too, footprint, mass, and electromagnetic compatibility (EMC) compliance are imperative. Even if the overall duration of use is short, the limited onboard power budget requires a high-efficiency motor to minimize power draw from the vehicle power system.

Designing the motion solution

Typical motor choices for smart defence applications include brushed DC coreless designs, as well as brushless cylindrical and flat motors. The brushed DC coreless motor includes a coil arrangement rotor, free of iron laminations, and a stator with fixed magnets. Meanwhile, brushless DC (BLDC) cylindrical motors utilise a stationary coil with a rotating permanent magnet and coil windings as part of the stator, and these designs remove the need for brush commutation. In addition to the cylindrical designs, a BLDC slotted flat motor includes coils in lamination slots, but unlike their cylindrical counterparts, they incorporate an outer rotor in a flat architecture.

Selecting the Right Motion Solution

As each design offers varying advantages, the motor selection depends on the prioritisation of parameters, particularly within the required size and weight envelope. Of these parameters, torque density is a typical priority. High-energy magnets that generate high flux density coupled with a coreless coil configuration is an optimal design, and both BLDC slotless and slotted motor technologies can provide high continuous torque without magnetic saturation. In comparison to

cylindrical motors, BLDC flat designs typically offer the highest torque density to form factor.

Maximum motor speed is also a common requirement, and electrically commutated BLDC motors can achieve higher speeds, with cylindrical designs achieving over 40,000 rpm. At these high speeds, motors require specially designed bearing systems, and the package is balanced to minimise vibration. For dynamic speed operation, the BLDC slotted motor is the preferred choice for low rotor inertia due to the relatively small rotor diameter.

Friction counteracts heat and energy efficiency, so combating this factor is also an important design consideration. Low-friction materials can minimise the effect, even in brushed motors, while BLDC designs remove the issue of friction in commutation. For the same reason, BLDC motors also have a longer operational life than their brushed counterparts. Creating a similar impact on heat and energy efficiency, iron core DC motors generate eddy current losses at higher speeds, meaning that coreless designs are favoured for higher-speed applications. However, magnetic design and material selection can minimise loses even for iron core motors.

Meanwhile, cogging torque, which can create uneven motion, is the result of the rotor's preferred magnet position in relation to the stator lamination teeth. Coreless technology eliminates iron laminations, removing the problem. While slotted designs are inherently susceptible to cogging torque, this can be minimised with an adjusted alignment of the core laminations, or by optimising the combination of poles and slots or teeth.

Deployed in any environmental arena, the flexibility to handle harsh conditions is also a key consideration. The BLDC slotted motor is best suited to handle high shock and vibration, as well as high humidity and saline conditions, due to its robust stator and rotor designs. However, BLDC slotless and DC coreless motors can also be used in, and prepared for, applications that must withstand the requirements of MIL-STD-810.

Motion solution customisation

While meeting the STD-MIL-810 environmental specification is essential, to achieve the application's performance requirements, specific design is required. Additionally, meeting the needs of operational deployment, long term storage requirements, such as preventing corrosion and retaining lubrication, might also be necessary.

While a fully bespoke design might be required, a customizable off-the-shelf (COTS) design approach could be used to meet operational needs, while speeding up time to market and reducing development costs. Whichever strategy is used to achieve the motion solution's exacting specification, design experience and expertise for smart defence applications is crucial.

Image captions:

Image 1: Precision motor choice is crucial for critical control and actuation in smart defence applications (Source : AdobeStock_375885621).

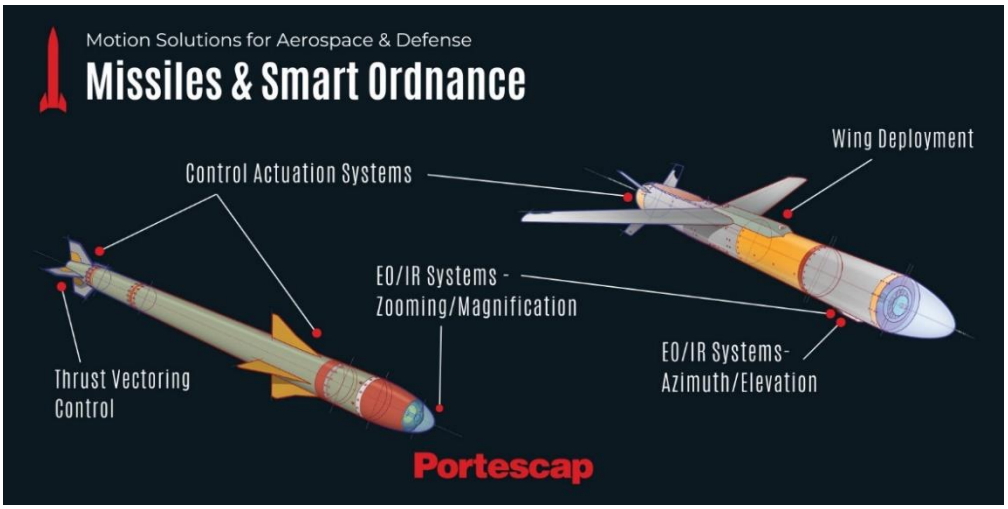

Image 2: Portescap motion solutions have numerous applications in smart munition development.

Image 3 : Portescap's Athlonix and Ultra EC motors.

About Portescap

Portescap offers the broadest miniature and specialty motor products in the industry, encompassing coreless brush DC, brushless DC, stepper can stack, gearheads, digital linear actuators, and disc magnet technologies. Portescap products have been serving diverse motion control needs in wide spectrum of medical and industrial applications, lifescience, instrumentation, automation, aerospace and commercial applications, for more than 70 years.

For more information, visit www.portescap.com

Press contact:
Portescap
Nicole Monaco
Global Marketing Manager
Tel.: +1 404.877.2534
sales.europe@portescap.com

PR agency:
DMA Europa
Brittany Kennan
Progress House, Great Western Avenue, Worcester,
WR5 1AQ, UK
Tel.: +44 (0) 1905 917477
brittany.kennan@dmaeuropa.com
news.dmaeuropa.com