



Technology vs. Topology: Designing Motion for Turrets and Large Azimuth Drive Systems

Defense OEMs are operating in an increasingly demanding and dynamic environment. The global military land vehicle market is growing at a tremendous rate, driven by modernization programs, shifting mission needs and geopolitical realities.

Around the world, military ground vehicles are being reimagined to replace aging platforms and meet more sophisticated threats. Programs are moving fast, and expectations for performance and adaptability are higher than ever.

The battlefield is not a static environment. It's dynamic and unforgiving. Ground combat vehicles must perform reliably under punishing conditions—shock, vibration and a wide range of temperatures—while executing faster, more complex and more automated missions.

At the center of this transformation is one of the most critical design challenges: enabling precise, reliable azimuth motion. For turrets, remote weapon stations (RWS), large-scale radar and SATCOM arrays, the architecture of the motion system can define the platform's performance, reliability and maintainability for years to come. Getting it right isn't just an engineering exercise; it's a strategic advantage.

Changing Landscape of Military Ground Vehicles

As defense programs modernize, they're moving away from traditional hydraulics systems in favor of electrification, where practical. Beyond removing the maintenance burden of hydraulic fluid systems and leaks, electro-mechanical actuation also allows for smoother, more precise control and long-term sustainment in harsh environments. This is essential for turrets, RWS and sensor payloads.

At the same time, ground vehicles are becoming more autonomous, connected and agile. Remote and optionally manned platforms demand motion systems that respond instantly through digital interfaces, while modern tactics require "shoot-and-scoot" capabilities with accurate fire on the move and rapid repositioning. From unmanned turrets to vehicle-integrated unmanned aerial systems (UAS) and counter-UAS, these shifts place new demands on azimuth motion systems to deliver stability, torque and precision under dynamic battlefield conditions.



Motion System Topology vs. Technology: What's the Difference?

When designing motion systems, it's important to distinguish between technology and topology. Technology refers to the components like the motors, drives, controllers, etc. Topology, on the other hand, is the high-level architecture of how those components are arranged and interact within your system. Put simply, technology is what's used and topology is how it's used.

Why Topology Matters

While many engineering teams default to thinking about technology first, topology is the design choice that shapes nearly every other decision. It establishes the system architecture that determines performance, mechanical complexity and long-term reliability.

A well-chosen topology can simplify manufacturing and maintenance while integrating seamlessly into the vehicle's design. On the other hand, a mismatched topology can add unnecessary weight, costs or workarounds that increase risk later in development.

Ultimately, topology influences how motion systems perform under operational conditions. Get it right and you enable mission-critical performance and dependability from day one.

Key Topologies for Ground Vehicles

There are three motion topologies that can be used to drive turrets and large diameter azimuth drive systems on modern ground combat vehicles. Each offers distinct benefits and trade-offs depending on your application. The best choice depends on your specific platform goals, size constraints, performance demands, and design timeline.



Large Single Through-Bore Torque Motor

Also referred to as a “torquer motor,” this topology uses a large-diameter, direct-drive ring motor with a hollow center. The load mounts directly to the stator, eliminating the need for gear trains or couplings. Because the motor is direct-drive, there’s minimal mechanical compliance, which results in smoother, more accurate azimuth motion.

For platforms prioritizing high-end targeting or sensor capabilities—especially in unmanned turrets—this topology offers unmatched performance and responsiveness.



Servo Load Sharing Design

This architecture uses two or more conventional servo motors—each in a housed configuration—driving a ring gear in tandem. Software algorithms balance torque output between the motors, preventing overloading and limiting backlash. This topology is especially valuable when designing for higher loads without needing massive individual motors.

It’s an excellent option for platforms that need a balance of torque, cost and serviceability, especially in programs with budget or timeline constraints.



Segmented Motor Design

Segmented motors use multiple curved rotor and stator elements joined together to form a large-diameter, ring-style motor. The modular design gives engineering teams the flexibility to create large azimuth motion systems sized to their needs, without being limited by what can be manufactured, shipped or installed as a single oversized motor. In some cases, the smaller segments can even be serviced or replaced individually versus removing the entire motor assembly.

With their smooth rotation, scalable design and field serviceability, segmented motors are an ideal solution for the most demanding defense environments.

Kollmorgen is one of the few motion partners that can deliver and support segmented motor systems for defense applications. Our designs can exceed 1.4 meters in outer diameter and 1 meter of clear bore while producing over 5000 Nm of continuous torque.

Evaluating Topologies

Topology	Large Single Through-Bore Torque Motor	Servo Load Sharing Design	Segmented Motor Design
<p>Use Cases</p>	<p>Ideal for high-precision systems that need smooth, direct motion like stabilized weapon turrets, radar stations or heavy caliber weapons.</p>	<p>Suited for large systems requiring high torque but not necessarily ultra-smooth motion, such as heavy weapons or up-armored turrets. Scales across a range of automation levels, from basic point-and-shoot to fully integrated fire control.</p>	<p>Best for systems that require smooth rotation and are challenging to ship or integrate as a single unit like large radar systems, satellites communications (SATCOM) dishes or heavy turret.</p>
<p>Advantages</p>	<ul style="list-style-type: none"> • Direct-drive architecture eliminates mechanical backlash • Delivers smooth, high-precision motion control • Enables compact, space-efficient integration 	<ul style="list-style-type: none"> • High torque per weight for reduced size and mass • Cost-effective option for performance-critical systems • Easier sourcing and replacement of standard motors 	<ul style="list-style-type: none"> • Scalable for flexible system design • Modular components enable faster production and integration • Designed for maintainability
<p>Challenges</p>	<ul style="list-style-type: none"> • Cost and complexity increase with diameter • Larger motors are heavier and require more support during integration • Less flexibility in field serviceability 	<ul style="list-style-type: none"> • Mechanical backlash if not carefully designed • More mechanical interfaces to maintain • Requires well-coordinated control to ensure even torque distribution 	<ul style="list-style-type: none"> • Costs rise with diameter and system scale • Segmented design requires precise alignment and integration • Less common in the market, expertise and support are essential

Considerations for Motion Design

Choosing the right motion system for a ground vehicle is a complex design decision shaped by mission requirements, mechanical architecture, vehicle topology and environmental realities. Engineers must weigh multiple, sometimes competing, factors to arrive at a system that performs reliably in combat scenarios while fitting within the broader program scope.

Application and Power Requirements

Every motion system starts with a clear understanding of the application. What needs to move and how? Whether it's rotating a turret, aiming an RWS or actuating a commander's view, the torque and inertia demands will define the size and performance of your motor system. Available onboard power also plays a critical role: some vehicles have robust electrical capacity, while others (like retrofitted platforms) may be limited. Continuous operation profiles, duty cycles, and required stability during high-speed movement or vibration further impact motor sizing and control architecture.

Mechanical and Integration Constraints

No motion system exists in isolation—it has to fit within a defined mechanical envelope. Engineers need to consider available space, mounting locations, structural reinforcements, and even motor orientation (horizontal vs. vertical) based on vehicle layout. For example, crewless turrets or armored hatches with limited footprints can benefit from torquer or segmented motors, which allow optical systems or cabling to pass through their center—saving space and simplifying integration.

Environmental and Operational Needs

Ground vehicle systems must perform under the harshest conditions: shock loads from weapon fire, long-term vibration during transit, temperature swings, dust, moisture, and even electromagnetic interference. Motion systems must be ruggedized accordingly—sealed housings, reinforced connectors, and vibration-dampening designs are all critical. At the same time, ensuring systems can be maintained in the field or returned to service quickly is as critical as performance when vehicles are expected to operate for decades.

Required Speed and Responsiveness

Rotational speed and acceleration are often overlooked in early design stages, but they can make or break a system in operation. Whether it's rotating a turret quickly to track a moving target or repositioning a sensor array to maintain line of sight, speed requirements must be clearly defined. Motion systems must not only achieve the required degrees-per-second performance—they must also do so with minimal overshoot and maximum stability, even when the vehicle is in motion or under fire.

Tradeoffs and External Constraints

Every design decision comes with tradeoffs. Direct-drive ring motors may offer the smoothest azimuth motion but could add weight and cost. Load-sharing servo configurations may simplify sourcing and servicing, but also introduces mechanical backlash if not tightly controlled. Integration complexity, lead times, supply chain stability, and export compliance (ITAR, RoHS, ECF, etc.) can all influence what's feasible within program timelines. Engineers need to balance what's ideal with what's practical, especially when speed to prototype or regional sourcing is a requirement.



Checklist for Engineers: Selecting the Right Motion Topology

- ✓ **Required motion performance**
Precision, speed, smoothness and responsiveness of motion
- ✓ **Engineering integration support**
Availability of co-engineering, tuning support, and documentation
- ✓ **Load characteristics**
Size, weight and inertia of the payload to be moved or stabilized
- ✓ **Environmental exposure**
Resistance to shock, vibration, temperature extremes, EMI, dust and moisture
- ✓ **Available power**
Voltage and current available for use in driving the load
- ✓ **Space and weight constraints**
Integration limits within the vehicle or platform envelope
- ✓ **Backlash and compliance tolerance**
Sensitivity to play or deflection in geared or coupled systems
- ✓ **Program timeline**
Timeframe to prototype, iterate, test and deploy into the field
- ✓ **Through-bore requirements**
Need for cable routing, optical paths or mechanical pass-throughs
- ✓ **Compliance and localization needs**
ITAR restrictions, in-region export controls, sourcing or manufacturing
- ✓ **Range of motion**
Full 360° continuous rotation vs. limited or oscillating motion or manufacturing
- ✓ **Engineering integration support**
Availability of co-engineering, tuning support, and documentation

Strategic Partner for a Strategic Advantage

Building a modern ground vehicle requires the right motion partner, one with the expertise to help you design for performance, integrate with precision and deliver long-term success. Kollmorgen brings 70 years of aerospace and defense experience, helping OEMs around the world turn motion into mission success.

Proven Combat Performance

Kollmorgen motors and drives deliver the precision, torque and dynamic control required for targeting, stabilization and advanced maneuver systems. Our solutions are field-proven on iconic platforms, including the Abrams, Bradley, Stryker and LAV-25.

Built for the Mission

Designed to operate in the harsh and real-world battlefield conditions, our ruggedized options deliver stable, accurate and reliable performance across turrets, hatches and remote weapon stations.

Co-Engineered

Our engineer-to-engineer collaboration model accelerates development, reduces integration risk, and adapts quickly to compressed program timelines with expert support and digital tools.

Designed to Scale

From design to deployment, we support your full lifecycle with lean manufacturing processes and a robust supply chain. Our commitment to quality is reflected in full compliance with AS9100, ITAR, and key European defense regulations.

Meeting Local Demands

As military needs expand, so do our resources. Kollmorgen's in-region, for-region production aligns with regional regulatory, security and logistics requirements — including ITAR, RoHS, and the EU Defense Fund. One example of how we are investing in strengthening local industrial bases and enhancing program agility is the plan for our Brno, Czech Republic, facility to become military-qualified.

Make Topology Your New Tech Advantage

Designing the right motion topology is just as critical as selecting the right motor technology. With increasing system complexity, compressed timelines and rising mission expectations, topology becomes a lever for performance, reliability and survivability.

Kollmorgen brings unmatched motion experience, a deep understanding of military applications, and a full spectrum of topology and technology solutions. Whether you need precision actuation, stabilized turrets or ruggedized, scalable architectures, we help you design with confidence so your platforms perform with certainty.

Ready to move forward?

[Contact Kollmorgen](#) to discuss your needs and goals with a Kollmorgen expert for defense applications.

About Kollmorgen

Kollmorgen, a Regal Rexnord Brand, has more than 100 years of motion experience, proven in the industry's highest-performing, most reliable motors, drives, AGV control solutions and automation platforms. We deliver breakthrough solutions that are unmatched in performance, reliability and ease of use, giving machine builders an irrefutable marketplace advantage.