TECHNOLOGY WHITEPAPER

Reducing Risk and Accelerating Time to Market With Turret Aiming and Stabilization

The Value of Integrated Stabilization Systems

CURTISS-WRIGHT

DEFENSE SOLUTIONS

Read About

Electromechanical drive systems

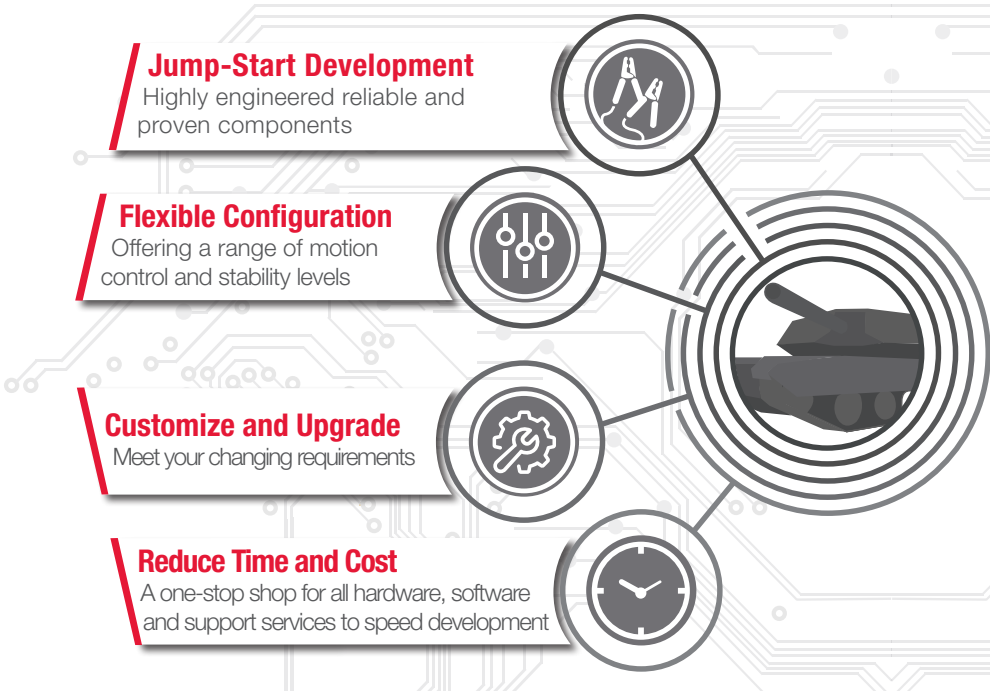
Turret aiming and stabilization

Turret drive servo systems

Turret Aiming and Stabilization Systems Are Complex

Tanks and infantry fighting vehicles are often moving across very rough terrain at high speeds while engaging an enemy. For the safety of the personnel on board and the accuracy of the weapon systems on board, the turret aiming and stabilization systems on these platforms must enable steady and precise control in all conditions.

Designing a robust, reliable, and high-performance turret drive system from the ground up is an extremely ambitious undertaking. It requires very specific engineering expertise in each of the key components — rotary gear drives, linear drives, gyroscopes, motor controllers, and hand controllers — and how they interoperate. Getting the design right and ensuring the system undergoes adequate field testing adds significant time, cost, and risks to programs.



Simplify Turret Aiming and Stabilization

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The challenges associated with designing a turret aiming and stabilization system are many and varied. For example, to operate reliably and accurately at any speed on almost any terrain, the system must deliver extremely high performance in a rugged and reliable form factor. But the very stringent size, weight, power, and cost (SWaP-C) requirements on highly space-constrained weapon platforms often make that combination difficult to achieve. A precise understanding of the trade-offs that can be made to ensure the system meets the required performance metrics within SWaP-C limitations and at an acceptable price is the key to meeting program requirements. Typically, this knowledge is gained through years of experience with the performance properties and complex technical relationships among all of the electrical components and physical materials in the weapons system.

The significant time, cost, and expertise required to design an effective turret aiming and stabilization drive system can place program specifications, budgets, and schedules at risk. But a prequalified and customized system that is based on proven modular components reduces program risks and accelerates time to market. An integrated turret drive system that is tailored for program requirements minimizes customization tasks for tanks, infantry fighting vehicles, and remote weapons stations, while reducing program cost and risk.

Curtiss-Wright Custom Aiming and Stabilization Systems:

Are designed and built with renowned Swiss precision, quality, and attention to detail to ensure they ***deliver unmatched turret stabilization and target location accuracy***

Can be prototyped in six to 12 months to accelerate ***time to market***

Include integrated logistics support, full documentation, and training for the ***full life cycle of the drive system***

Considerations for Effective Turret Aiming and Stabilization

There are a number of interrelated and complex factors that make designing and building a robust, reliable, and high-performance turret drive system from the ground up time-consuming and difficult.

High Dynamic Range Enables Accurate Target Tracking at Any Speed

A system with high dynamic range is needed to ensure the turret is completely stable and under the operator's full control when it is moving at extremely low speeds and throughout acceleration to the highest speeds at which the turret or weapon can move. This capability is needed so that gunners can consistently and accurately track targets no matter how slowly or quickly the line of fire needs to be adjusted or how suddenly and rapidly the turret or weapon needs to move.

Designing a drive system with a high dynamic range requires specialized knowledge in control loop technology, as well as the mechanical and electrical interactions that must take place among all of the components that comprise the system. It also requires extensive testing of different control loop scenarios.

Vehicle Profiling Avoids Obstacles Onboard

Obstacles on the vehicle, such as hatch doors and exhaust outlets, restrict the possible elevation levels and moving range of the weapon. To avoid interference or collisions with these obstacles, the elevation of the weapon relative to the vehicle's surface and the obstacles on board must be dynamically adjusted.

Precise vehicle profiling is needed to automatically adjust the position of the weapon to avoid collisions. Engineering these kinds of automated and dynamic turret movements requires in-depth expertise in electrical power systems and the control loops that automatically adjust system responses based on measured inputs. The challenge is to appropriately prioritize the control loops that reference turret position versus the control loops that reference ground conditions for stabilization.

TDSS Building Blocks

Stabilization Quality and Dynamic Performance Depend on Interrelated Technologies

To ensure overall stabilization quality and consistent, accurate weapons performance, the drive system must be fully integrated into the turret's overall subsystem and control loop architecture.

For example, when the operator locates a target, the drive system must correctly align and stabilize the line of fire to the line of sight, even as the vehicle accelerates rapidly over rough terrain.

To achieve this accuracy, motion control systems must be extremely steady, line of sight tracking must be extremely fast, and communications with the fire control computer and sight systems must be almost instantaneous. And all of these subsystems must be able to communicate and interoperate seamlessly.

Designing these integrated capabilities requires a deep understanding of communication protocols, digital control loop timing, and physical layers. However, it is not enough to understand typical communication standards, such as Controller Area Network (CAN), MilCAN, proprietary RS485, Ethernet, and MIL-STD-1553. The appropriate timing, mapping, addressing, or scaling of transmitted data must be customized for the unique requirements and turret system architectures of each vehicle and drive system.

A Rugged and Reliable Design Is Mandatory

Turret drive systems must be designed to withstand severe vibration and shock as well as the extreme environmental stresses — heat, cold, temperature shock, blowing rain, sandstorms, and ice — to which combat vehicle platforms are regularly subjected.

The design must also comply with military standards for electromagnetic interference (EMI) and electromagnetic compatibility (EMC).

Engineers require extensive knowledge of mechanical and electrical responses to physical and environmental stresses to design a drive system that will remain reliable over the long term. Even with this knowledge, the design and development process also requires an enormous amount of time to test, integrate iterative improvements, retest, and verify that turret drive systems are designed with the quality levels required to ensure continuous high performance in a wide range of conditions.

SWaP-C Constraints Limit Design Options

Addressing all of the design challenges described above becomes significantly more difficult when the extreme SWaP-C constraints of tanks, infantry fighting vehicles, and remote weapons stations are added to the mix.

Electrical components and physical materials must be carefully selected to ensure they meet SWaP-C limitations, but are also within budget. Making the right trade-offs requires extensive knowledge of the physical properties, availability, performance levels, and costs of every component and type of material used in the system.

For example, titanium is extremely lightweight, strong, and corrosion-resistant, but extremely expensive. Aluminum is also extremely lightweight, but its strength decreases at high temperatures and its linear expansion is higher than that of other metals. Steel is available in different grades, each of which must be evaluated for properties such as strength, weight, weldability, and durability.

Integrated, Modular Turret Drive Systems Save Time, Effort, and Money

System integrators that incorporate an integrated turret drive system that is based on proven, modular components can avoid the major challenges associated with new turret builds. As a result, they are in a far better position to reduce program risk, accelerate time to market, and cuts costs.

An Expert-Designed, Purpose-Built System Reduces Risk

When each component in the drive system is purpose-built for aiming and stabilization, integrated by experienced engineers, and proven in numerous field applications, system integrators can rest easy knowing they have the **key properties** built in that are needed to meet performance requirements:

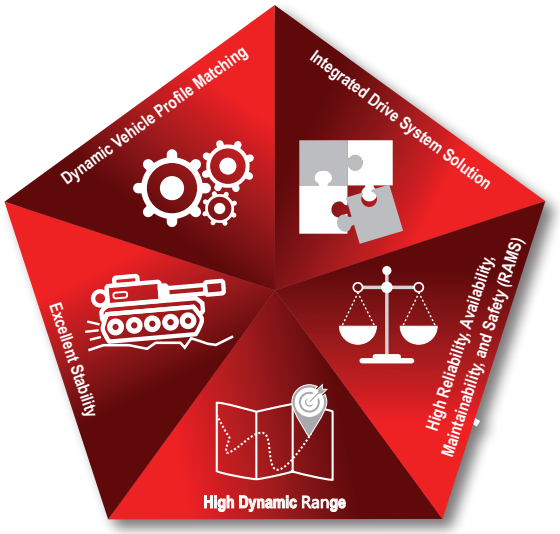
- **High dynamic range** to accurately track targets on all types of terrain and at all speeds
- **Excellent stability** to ensure best possible target tracking and hit probability, even when moving across rough terrain
- **Dynamic vehicle profile matching** for automatic and dynamic movement of the weapon to avoid interference with obstacles onboard at any speed
- **An integrated drive system solution approach**, which allows perfect fit into the overall turret architecture, ensuring fast, accurate, and consistent interactions with other turret subsystems
- **High reliability, availability, maintainability, and safety (RAMS)**, balancing perfect functionality, performance, durability, as well as SWaP with the lifetime expectations

The most complete, integrated drive system offerings include supporting detailed documentation about reliability calculations, maintenance requirements, and safety considerations for the system over its lifetime. This information gives system integrators important insights into the frequency at which parts need to be replaced based on mission profiles, environmental conditions, and length of time in the field. The complete system will also include detailed instructions that clearly outline the physical facilities, tools, and steps required to replace parts in the drive system when the time comes.

Together, these drive system properties and value-added services help system integrators ensure that the drive system provides safe, long-term operation in the field.

Proven, Prequalified Drive Systems Save Time

The most sophisticated drive system is built on information about the vehicle and turret type, physical constraints, expected operating environment in various terrains under challenging climatic conditions, and other factors. With this information, it can take many years to design and integrate all of the drive-system components needed to deliver a fully stabilized turret drive system.



Drive System Key Properties

However, an integrated turret drive system that is tailored to meet program requirements, built with prequalified and proven components, and thoroughly tested to military standards will help system integrators get their offerings to market faster. Typically, a fully customized, tested, and prequalified drive system can be delivered in less than one year. And because integrated systems include prequalified components, the time required to certify the complete system is reduced significantly.

Speed and Quantities of Scale Save Money

There are two main ways that incorporating an integrated turret drive system helps system integrators save money:

- **Lower program costs.** The old adage “time is money” applies here. Getting new turret builds to market significantly faster with far less engineering effort and far faster certification reduces program costs dramatically.

  Fully integrated drive systems are purpose-built for the toughest military applications. All the modular components have been thoroughly proven in a variety of field applications.

As a result, the integrated system typically needs only about 20 percent of its capabilities to be customized to meet the requirements of even the most challenging turret build programs. In some cases, customizations can be achieved by simply choosing the appropriate gearbox or the best applicable controller from the available modules.

- **Quantities of scale.** Purchasing an integrated drive system enables system integrators to take advantage of industrialized production processes. It is very expensive to source and purchase parts for a one-off drive system. However, a system built on field-proven, modular components integrates parts and materials that have been purchased in larger quantities. The manufacturer has probably received preferred pricing from its suppliers because of the volume of materials purchased and can pass those savings on to system integrators.

The Right Partner Keeps New Turret Builds On-Spec, On-Time, and On-Budget

Curtiss-Wright Defense Solutions is a trusted, proven leader in comprehensive, rugged, and secure mission-critical solutions. We use our deep experience and expertise in custom drive systems to help system integrators keep new turret build programs on-spec, on-time, and on-budget to reduce risk and accelerate time to market.

The DriveTech division of Curtiss-Wright Defense Solutions offers fully customizable, integrated turret drive systems in a flexible, upgradable, modular building block model, to meet program requirements today and in the future. System integrators can jump-start their programs with predefined system configurations based on an expandable drive system solution. They can then take advantage of the building block approach to evolve the performance and functionality of the system to higher levels over time.

All drive-system components — rotary gear drives, linear drives, gyroscopes, motor controllers, and hand controllers — are designed to be easily adapted to meet specific functionality and performance requirements and to be upgraded as new requirements emerge. For example, motor controllers include the electrical interfaces required to upgrade from an electromechanical drive to a fully stabilized system.

In addition, system components are built with materials of the lowest possible weight while still optimizing performance and cost. For example, smaller, lighter gear drives can be used to meet the size and weight constraints of smaller turrets. And gear ratios can be easily changed to accommodate the gears according to the ring gear sizes and the required torques.

System integrators who partner with Curtiss-Wright also benefit from the economies of scale we are able to achieve when purchasing components and materials, as well as our ability to reuse modules across projects to help keep costs down.

Leading Military Organizations Count on Curtiss-Wright

Curtiss-Wright aiming and stabilization solutions have been successfully incorporated into military programs and platforms for more than 30 years. They are field-proven in deployments around the world and qualified against key military standards.

Author

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Learn More

- Aiming and Stabilization Systems
- Turret Control
- Case Study: Stabilized, Modular, Turret Drive System for Modern Infantry Fighting Vehicles