

# The Role of Precision Linear Stages in Metrology and Inspection Systems

## Enabling Accurate Measurement Through Controlled Motion

### Executive Summary

Metrology and inspection systems rely on accurate, repeatable, and stable motion to deliver meaningful measurement results. As manufacturing tolerances tighten and product complexity increases, the demand for precision motion solutions has never been greater. Linear stages play a critical role in enabling these systems by providing controlled, predictable movement of sensors, probes, and workpieces.

This whitepaper explores the fundamentals of metrology and inspection, explains why linear stages are essential to these processes, and outlines how Novanta Precision Motion supports metrology-driven applications through the design, verification, and integration of high-precision linear motion systems.

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### Introduction to Metrology and Inspection

Metrology is the science of measurement. In manufacturing and advanced engineering, metrology ensures that components conform to design specifications for size, shape, geometry, and surface characteristics. Inspection applies metrology tools and techniques to verify these characteristics during or after production.

Together, metrology and inspection are essential for:

- Quality assurance
- Process control (I'd like all the bullets together and graphic to the side)
- Compliance with industry standards
- Reduction of scrap and rework
- Validation of product performance

Modern inspection systems often operate at micron or sub-micron levels, making precision motion a fundamental requirement.



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## Why Motion Accuracy Is Critical to Measurement Accuracy

In any inspection system, the accuracy of a measurement is directly linked to the accuracy of motion. Errors in positioning, straightness, vibration, or repeatability introduce uncertainty into measurement data, regardless of sensor resolution.

Common motion-related measurement challenges include:

- Positioning error
- Backlash and hysteresis
- Structural deflection under load
- Thermal drift
- Vibration and dynamic instability

Linear stages address these challenges by providing controlled, predictable movement along a single axis, forming the foundation of reliable metrology systems.

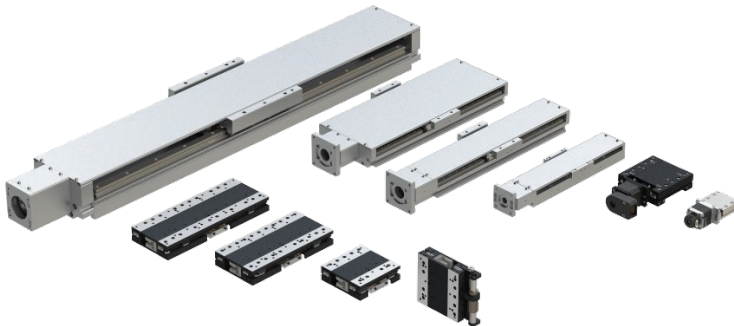
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## Linear Stages in Metrology and Inspection Applications

### What Is a Linear Stage?

A linear stage is a mechanical system designed to move an object or sensor in a straight line with high precision. It typically consists of:

- A rigid base and moving carriage
- A guidance system (mechanical bearings or air bearings)
- A drive mechanism (lead screw, ball screw, linear motor, etc.)
- Feedback devices (encoders, interferometers)



### Novanta's Linear Stages

# Common Metrology Applications Using Linear Stages

Linear stages are widely used in:

- Coordinate Measuring Machines (CMMs)
- Optical and vision inspection systems
- Laser scanning and interferometry
- Semiconductor wafer inspection
- Medical device inspection
- Automated test and measurement platforms

In these systems, linear stages position measurement probes, cameras, or scanning heads with high repeatability and minimal disturbance.

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## Key Performance Characteristics for Metrology Linear Stages

When selecting or designing linear stages for inspection systems, several performance parameters are critical:

- **Accuracy and Repeatability**  
High positioning accuracy ensures the stage reaches the intended location, while repeatability ensures it returns to the same position consistently over time.
- **Straightness and Flatness**  
Straight-line motion must remain true across the entire travel range to prevent geometric measurement errors.
- **Structural Rigidity**  
A rigid stage minimizes deflection caused by payloads, acceleration, or external forces.
- **Smooth Motion and Low Vibration**  
Inspection systems require smooth velocity profiles and minimal vibration to avoid measurement noise.
- **Thermal Stability**  
Thermal expansion can affect both motion and measurement accuracy, making material selection and system design critical.



Coordinate Measuring Machines (CMM)

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## How Novanta Precision Medicine Supports Metrology and Inspection

### Precision Engineering of Linear Stages

Novanta Precision Medicine designs and manufactures high-precision linear stages engineered to meet the demanding requirements of metrology and inspection applications. Emphasis is placed on:

- Rigid mechanical structures
- Precision guidance systems
- Low-friction, low-backlash motion
- Compatibility with high-resolution feedback devices

### Metrology-Driven Verification and Testing

Novanta Precision Medicine integrates metrology directly into its quality and verification processes. Linear stages are inspected and characterized using advanced measurement tools such as:

- Laser interferometers
- Coordinate Measuring Machines (CMMs)
- Straightness and flatness measurement systems

This ensures each stage meets its specified performance before deployment.



Laser Interferometer test station

### Supporting OEM and System Integrators

While Novanta Precision Medicine does not market standalone metrology machines, its linear stages are commonly integrated by OEMs into inspection and measurement equipment. These stages serve as the motion backbone for systems that require:

- High measurement confidence
- Long-term repeatability
- Consistent performance in demanding environments

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## Enabling Advanced Inspection Technologies

As inspection systems evolve toward higher speeds, greater resolution, and increased automation, the role of precision motion becomes even more critical. Novanta Precision Medicine linear stages help enable:

- Automated, high-throughput inspection
  - Multi-axis measurement platforms
  - Integration with vision, laser, and probe-based sensors
  - Scalable systems for future performance upgrades
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## Conclusion

Metrology and inspection systems demand motion solutions that are as precise and reliable as the measurements they enable. Linear stages form the foundation of these systems by providing accurate, repeatable, and stable motion.

Through precision engineering, rigorous metrology-based verification, and close collaboration with OEMs, Novanta Precision Medicine plays a vital role in supporting inspection and measurement applications across industries including automation, robotics, semiconductor manufacturing, medical devices, and advanced manufacturing.

By ensuring motion accuracy, Novanta Precision Medicine helps customers achieve measurement confidence.

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Let's connect today and discuss how we can partner on your next project. Call **1.949.586.7442** or email us at [moso-sales@novanta.com](mailto:moso-sales@novanta.com). For specific locations, please use the contact information below.

To explore our company and solutions further, including case studies, webinars and other research material, please visit our website at [www.motionsolutions.com](http://www.motionsolutions.com).



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