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subassemblies and components

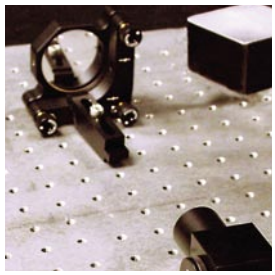
# Absolute Cartesian Sensor Technologies

A dual-axis optical encoder and autocollimator with near-perfect orthogonality, stability, and high accuracy

NASA Goddard Space Flight Center invites companies to license new absolute Cartesian technologies. The absolute Cartesian optical encoder relies on a combination of mature technologies to measure the X-Y planar motion of an object in a true Cartesian coordinate frame with high accuracy and near-perfect orthogonality and is suitable for inspection, manufacturing, and assembly.

Relying on the orthogonal, two-dimensional technology provided by the encoder, Goddard's new Cartesian electronic absolute autocollimator solves the instability problems associated with conventional autocollimators. The technology provides higher sensitivity and a larger field of regard—making it ideal for high-accuracy metrology and aerospace applications.






## Absolute Cartesian Optical Encoder

### Benefits

- **Based on mature technologies**: Uses a highly accurate microlithographic scale, electronic image sensor, and simple image processing
- **Long travel reading**: Can read travel lengths as long as the scale
- **Ultra-fine resolution**: Demonstrates 50 nm coarse-scale resolution and below 10 nm using a finer scale
- **Accurate**: Obtains accurate X-Y readings regardless of orthogonality or straightness
- **Damage tolerant**: Is less susceptible to damage or contamination than conventional optical encoders
- **Small**: Features a very compact design for the level of resolution provided
- **Scalable**: Can easily be upgraded with additional software

## Cartesian Electronic Absolute Autocollimator

### Benefits

- **Sensitive**: Features unsurpassed sensitivity and stability for its size
- **Large field of view**: Offers an exceptional field of view compared to conventional autocollimators
- **Stable linear output**: Assures unambiguous position readout
- **High accuracy**: Provides a high degree of orthogonality or azimuth and elevation readouts over the field of view
- **High-quality images**: Discourages image-sensor drift and offers high brightness

## *Absolute Cartesian Optical Encoder*

### Applications

- Industrial applications
  - Inspection
  - Manufacturing
  - Assembly
- R&D
  - Metrology
  - Astronomy
  - Cryogenic environments

### The Technology

NASA Goddard's patented (U.S. #6,765,195) absolute Cartesian encoder offers an extremely flexible design for measuring the position of objects moving on a Cartesian (X-Y) coordinate frame, including scale features and optical magnification that can be chosen to accommodate virtually any application. A backlit, microlithographically patterned scale is attached to a moving object and carries X-Y information identifying the horizontal and vertical location of the scale image. This enables determination of the absolute Cartesian position of the object.

Traditional X-Y positioning systems use two, usually stacked, linear translation stages, which increases cost and complexity. Linear encoders offer accurate coordinate determination but may demonstrate imperfect alignment and do not account for lack of straightness of travel of the mechanical axes and the lack of orthogonality of the directions of travel. Laser interferometers with plane mirrors offer high accuracy and resolution but are very expensive. In contrast, Goddard's design serves both axes with one encoder, reducing cost and complexity. Nonstraightness of travel and lack of orthogonal mounting of stages are accounted for, and accuracy is limited only by that tied to the scale lithography.

## *Cartesian Electronic Absolute Autocollimator*

### Applications

- Cryogenic environments
  - Infrared and X-ray mission applications
- Machine making
- Optical metrology
- Surveying
- Aerospace and defense
  - Instrument building
  - Spacecraft construction
  - Aircraft assembly
- Other
  - Augment theodolite capabilities

### The Technology

Goddard's technology replaces a conventional autocollimator target with a Cartesian encoder scale. An area array image sensor replaces the typical position-sensitive detector (PSD), and analog signal-processing circuitry is usurped by computational image processing. A captured image is surveyed to find row and column indices of the intersections of the gridlines, and binary coded identities are derived by examining the code bits for each gridline. The two-dimensional angular relationship of the flat mirror is computed by determining how far off the center row and column of the image sensor each gridline is with respect to an arbitrary reference angle with extreme sensitivity.

Goddard's design eradicates many of the problems faced by conventional electronic autocollimators. Notably, traditional designs suffer from readout instability due to drifts in their analog circuit elements and to temperature effects on the PSD. Goddard's autocollimator processes digital images from its area array image sensor rather than from a conglomeration of drift-prone analog amplifiers. Therefore, the technology provides highly stable linear output that does not change due to the temperature of the detector or its processing electronics. Goddard's design also yields higher angular sensitivity, a larger field of view, and unambiguous position readout compared with conventional designs.

### Licensing and Partnering Opportunities

These technologies are part of NASA's Innovative Partnerships Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing the absolute Cartesian encoder (GSC-14330-1) technology and/or the Cartesian electronic absolute autocollimator (GSC-14718-1) technology for commercial applications.

### For More Information

If you are interested in more information or want to pursue transfer of the absolute Cartesian encoder (GSC-14330-1) and/or the Cartesian electronic absolute autocollimator (GSC-14718-1) technology, please contact:

**Office of Technology Transfer**
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More information about working with NASA Goddard's Office of Technology Transfer is available online: **http://techtransfer.gsfc.nasa.gov**

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