

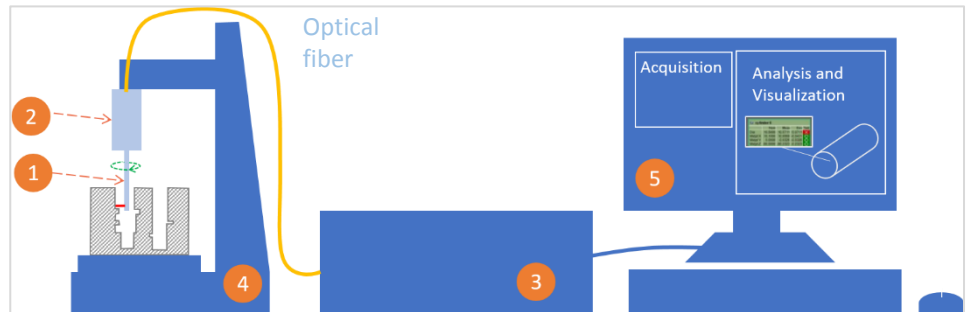
System Benefits

- ✓ **3D measurements of diameter, circularity, cylindricity, parallelism, taper, runout, straightness, cone angle, roughness, etc.**
- ✓ **Measures high-aspect-ratio features such as undercuts, cross-holes, chamfers, rifling, threads, O-ring grooves, and edges**
- ✓ **Reduced inspection cycle time:** up to 100,000 measurements per second, each representing a 3D topographic point
- ✓ **Flexible options for evaluating inspected parts:** measured features can be compared to CAD or to user-defined set of locations, nominals, and tolerances
- ✓ **Simple scan definition and execution:** The scanning sequence defined once by teaching the system with a joystick
- ✓ **Time-saving automated reporting:** Following a scan, go-no-go reports can be produced automatically, and results logged in a manner compatible with industry-standard mechanisms
- ✓ **Adaptable to hostile environments:** radioactive, very hot, cryogenic, vacuum, etc.
- ✓ **No need for expensive consumables:** Optical probes do not wear out like contact probes.

System components

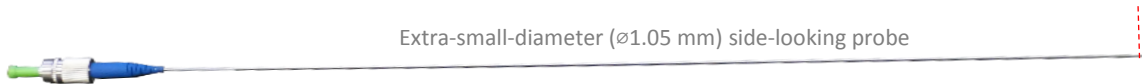
NOVACAM™ BOREINSPECT™ system is a fiber-based modular system comprising:

- (1) Optical side-looking probe
- (2) Rotational scanner (RS)
- (3) MICROCAM™ interferometer
- (4) Inspection station
- (5) PC
- (6) Motion controller(s) for probe rotation and for other required motion components (not shown), and, optionally, (7) Multiplexing hardware (not shown).

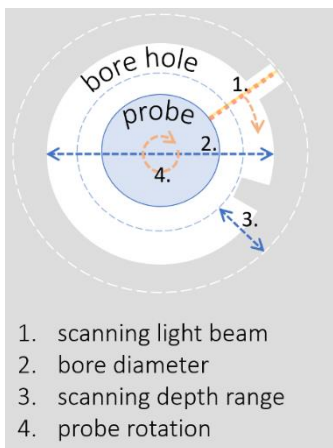


1 Optical probe

The side-looking optical probe is rotated while being advanced inside the tight space to measure its complete inside geometry in a spiral pattern.



Top view of scanning setup



Probe characteristics

Bore diameter range (mm)	Probe diameter (mm)	Probe standoff options**	Typical spot size (µm)	Probe length*** (mm)
1 – 4.5	0.55*	Fixed	15 - 35	50-250
2 – 6	1.05	Fixed		
4 – 14	3.05	Fixed/Adjustable		
6 – 30	4.6	Fixed/Adjustable		
19 – 131	17.8	Fixed/Adjustable		
32 – 260	30.5*	Fixed/Adjustable		

* These are non-standard-diameter probes. Other custom probes with non-standard diameters, lengths, light spot sizes, and light beam angles (different from the standard 90°) are built upon request. Custom probes for extreme temperatures, high pressures, or other hostile environments are also built upon request.

** Standoff is the distance from the probe outside diameter (OD) to the focal point. There are 2 probe standoff options:
 - With **fixed-standoff probes**, standoff is fixed at manufacture time. With this type of probe, clients must choose a subset of the bore diameter range equivalent to twice the scanning depth range of the selected MICROCAM interferometer.
 - With **adjustable-standoff probes**, clients gain precise focus control over a wider (extended) subset of the bore diameter range (up to a limit of 50 mm) for **standard adjustable-standoff probes** or wider for **custom adjustable-standoff probes**. Within the chosen range, the standoff may be adjusted programmatically between scans of various sections of the bore.

*** Maximum probe length may be limited by mechanical constraints. Custom probes as long as 2 m have been built.

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Rotational scanner (RS)

The rotational scanner advances and spins the side-looking optical probe selected to suit the application. The RS housing enclosure is robust and shop-floor ready.

RS models

	RS0	RS1	RS2
			
Range of bores inspected	1 – 6 mm	6 – 260 mm	4 – 131 mm
Distinguishing aspect	Ideal for applications involving extra-small bores, where user-exchangeable probes are required	Ideal for extra-wide bores	Lightest model, with the fastest rotational speed and the most popular for a wide variety of applications
Motion and displacement capability	Rotation + linear (Z-axis) + optional X/Y axis		
User-replaceable probes	Yes	No	No
Extended range option available with adjustable-standoff probes	No	Yes	Yes
Rotational speed	Up to 10 rotations/second (600 RPM)	Up to 2 rotations/second (120 RPM)	Up to 30 rotations/second (1,800 RPM)
Approx. size of rotational probe enclosure box (depth x width x height)	120 x 115 x 90 mm 4.7" x 4.5" x 3.5"	140 x 130 x 180 mm 5.5" x 5" x 7"	170 x 64 x 76 mm 7" x 2.5" x 3"
Approximate weight	1.9 kg (4.2 lb) without probe	3.8 kg (8.5 lb) including standard \varnothing 4.6 mm probe	1.2 kg (2.5 lb) including standard \varnothing 4.6 mm probe



The rotational scanner (RS) is mountable on a variety of precision stages, gantries, and robot arms

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MICROCAM™ interferometer

The interferometer provides the light source to the RS probe and processes the optical signal received back from it. The RS and the interferometer are connected with an optical fiber.



MICROCAM interferometer models

	MICROCAM-3D		MICROCAM-4D
General characteristics			
Technology	low-coherence interferometry		
Light wavelength	1310 nm, infrared		
Size of interferometer enclosure box (depth x width x height)	4U rackable enclosure 445 x 445 x 178 mm		
Non-contact measurements			
Scanning depth range options*	3.5 mm	7 mm	5 mm
Acquisition (A-scan) rate	2.10 kHz	1.05 kHz	100 kHz
Axial (Z-axis) resolution	< 0.5 μ m		
Light spot size (Lateral [XY-axis] resolution)	4.1 - 146 μ m, typically 15 - 35 μ m		
Standoff distance	0.5 - 100 mm for standard probes, up to 1 m for non-standard probes		
Repeatability**	< 1 μ m		
Thickness measurements			
Thickness measurement range (optical in air)	10 μ m - 3.5 mm	10 μ m - 7 mm	20 μ m - 5 mm
Typical materials for thickness measurements	glass, polymers, multi-layer films, coatings, plastics, silicone, liquids, specular or non-specular		
Sample reflectivity	0.1 - 100%		

* To further increase maximum scanning depth, a mechanical displacement axis is available.

**The stated repeatability pertains to a system where the optical sensor is not moving with respect to the measured surface. The repeatability of the motion mechanism is usually bigger; this can be effectively addressed by the use of a glass reference plate.

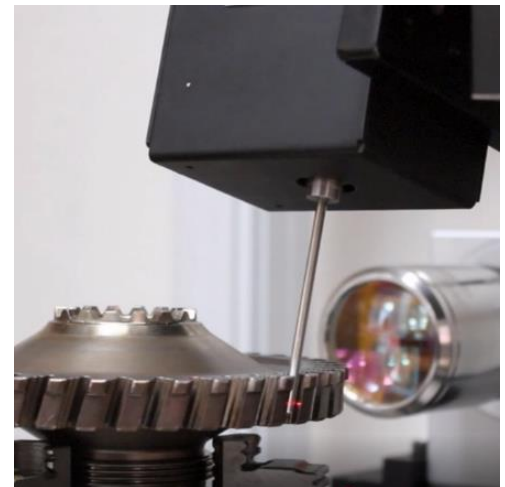
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Inspection station

Inspection station configurations are application-dependent and can be supplied by Novacam. Fixturing for the part is not included.

For lab and shop floor inspection, BOREINSPECT system setups in labs and shops typically include an inspection station with scanner displacement in 2, 3, or 4 axes. Granite tables are optionally available and recommended for some applications.

For automated inline industrial inspection, BOREINSPECT system rotational scanners may be integrated with precision stages or robots (as a robot end-effector) to support high-volume continuous flow manufacturing. The BOREINSPECT system scanners can also be integrated with third-party CMMs (coordinate-measuring machines) and CNC (computer numerical control) machines.



The BOREINSPECT system small-diameter (\varnothing 3.05 mm) rotational probe automatically acquires interiors of fir tree slots on a small jet engine turbine disk.

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PC, monitor and joystick

The BOREINSPECT system comes with a PC, monitor, mouse, and joystick.

6

Motion controller(s)

Motion controllers are included. Depending on the number of additional motion axis required, the motion controller(s) are housed in a 2U, 3U, or 4U rackable enclosure.

7 Hardware for multiplexing support (optional)

Optical switches are available for multiplexing up to 8 probes to a single MICROCAM interferometer. Multiplexed probes may be used one at a time. This option brings additional return on investment (ROI) to many installations.

System software

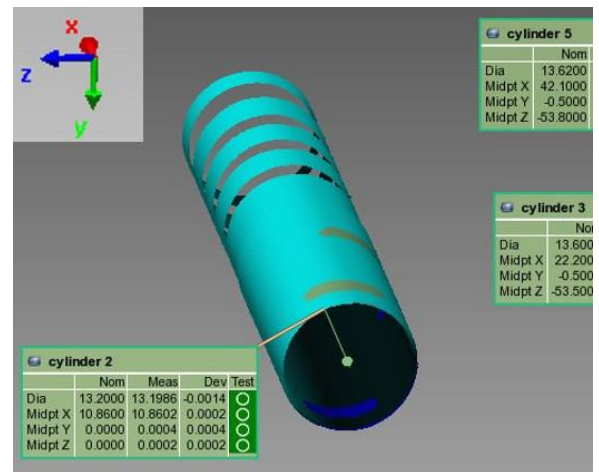
The BOREINSPECT system comes with NOVACAM high-performance data acquisition software, which is PC, Windows®-based, and user-friendly for scan programming. The system simultaneously generates 3 data sets from the same scan: 3D point cloud, light intensity image, and height image. The height and light intensity images facilitate defect detection. STL file format is also available.

An application programming interface (API) is available for system integrators and OEMs to accommodate a wide variety of online and offline applications. Exported results may be integrated with data loggers and SPC software.

A turnkey solution for full GD&T analysis of measured parts is available with InnovMetric PolyWorks® Inspector metrology software that may be purchased with the system. Go-no-go reporting is easily programmed and automated. Operators benefit from capabilities such as a quick visual comparison (deviation map) of the acquired part measurements to pre-specified tolerances or to the CAD of the part.

Visualizing the scan data may be accomplished by importing the data into third party visualization and numerical analysis software such as PolyWorks Inspector, Geomagic, ImageJ, SolidWorks, Octave, MatLab, Mathematica, IDL, or IGOR Pro.

Deriving application-specific measurements from the 3D point cloud is available through a selection of in-house and third-party software. Novacam supports the following options:



Automatic data analysis and go-no-go reporting with PolyWorks® Inspector

Data processing options

	Novacam in-house software	3 rd party software, such as
Dimensional measurements (GD&T parameters)		PolyWorks Inspector (turnkey solution), Geomagic
Roughness and surface analysis	✓	TrueSurf, MountainsMap
Thickness	✓	
Chatter (vibration)	✓	
Volume loss	✓	
Defects	Custom-developed*	

* Novacam offers the option of custom data processing, reporting, and defect detection programs that can be written based on client requirements.

Standard system configuration

- RS2 rotational scanner with a standard 4.6 mm-diameter side-looking probe (for inspection of bores up to 200 mm (8") deep)
- MICROCAM-4D interferometer
- 3-axis inspection station and 3-axis motion controller
- PC with NOVACAM acquisition software
- 1-year warranty

Instrument safety

NOVACAM BOREINSPECT systems feature an in-probe red laser pointer (650 nm wavelength) for alignment purposes. They are Class 1M Laser products, with < 20 mW of infrared and < 5 mW of in-probe laser pointer.

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