LK 三坐标测量机技术介绍

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会议章程

一、LK 公司情况简介

二、LK三坐标测量机各机型的特点

三、LK最新的测量解决方案

四、提问和答疑

LK公司情况简介

LK：三坐标测量技术发展的先驱者，

LK介绍

英国LK有限公司公司历史悠久，1959年由劳斯莱斯工程师 Norman Key成立，从此世界上第一台三坐标测量机诞生。1963年，总部设在英国德比郡的 LK有限公司(LK Limited)开始制造三坐标测量机，是现存历史最悠久的三坐标测量机品牌，也是现代测量机的奠基人 。

专业制造

具有精密制造或计量经验等，并不代表具有测量机的制造经验。LK自成立起55年的时间里，产品仅有一种，即三坐标测量机。他的专业经验不是泛泛的精密计量或精密制造，而是完全三坐标测量机的专业经验。

现代三坐标测量机技术的奠基人

1971年,LK制造出全球第一台CNC测量机。在这台测量机上， LK首先采用了全花岗岩材料和当时非常先进的工业控制系统，用石头造机器，在当时不可思议。LK在全球首家采IBM用的许多技术，都被同行业模仿或采用，有些一直沿用到现代测量机。例如:花岗岩材料、工业陶瓷材料、碳纤维复合材料、气浮导轨、电测头、PC控制系统、DIMS程序内核软件等。

LK介绍

LK是技术型的企业：

设计产品主要针对中高端客户群，这些客户中不乏特殊应用的要求。例如:液体中零件的几何量测量，超大零件、异型零件的测量，亚微米级测量等。LK的年产值仍高达4千万英镑，折合6亿多人民币。

LK在中国的发展

尽管LK进入中国市场较晚，但他在所有测量机制造商中首家荣获中华人民共和国进口计量器具型式批准，首家在中国推广工业陶瓷及测量机，向国内客户提供了开放环境下的在线、共线测量机群，并成功应用至今。历史上，LK以军工和航空航天为主要目标市场，定位于工业陶瓷的中高端产品和差异化产品及服务，随着汽车、模具等行业对测量要求的不断提高，LK的产品得以广泛应用，尤其在通用汽车、福特汽车、波音飞机、空中客车等全球大公司中广泛应用。

LK変迁

1963~

2005~2009

2010~2018

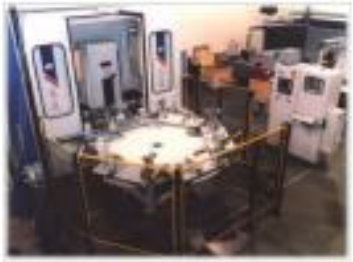
2018~

庞大的客户群体

JAGUAR

CHRYSLER

Cummins



VOLVO

SHANGHAI GM

LAND ROVER

庞大的客户群体


Boeing 747 installation in 1975


陕西飞机工业(集团)有限公司

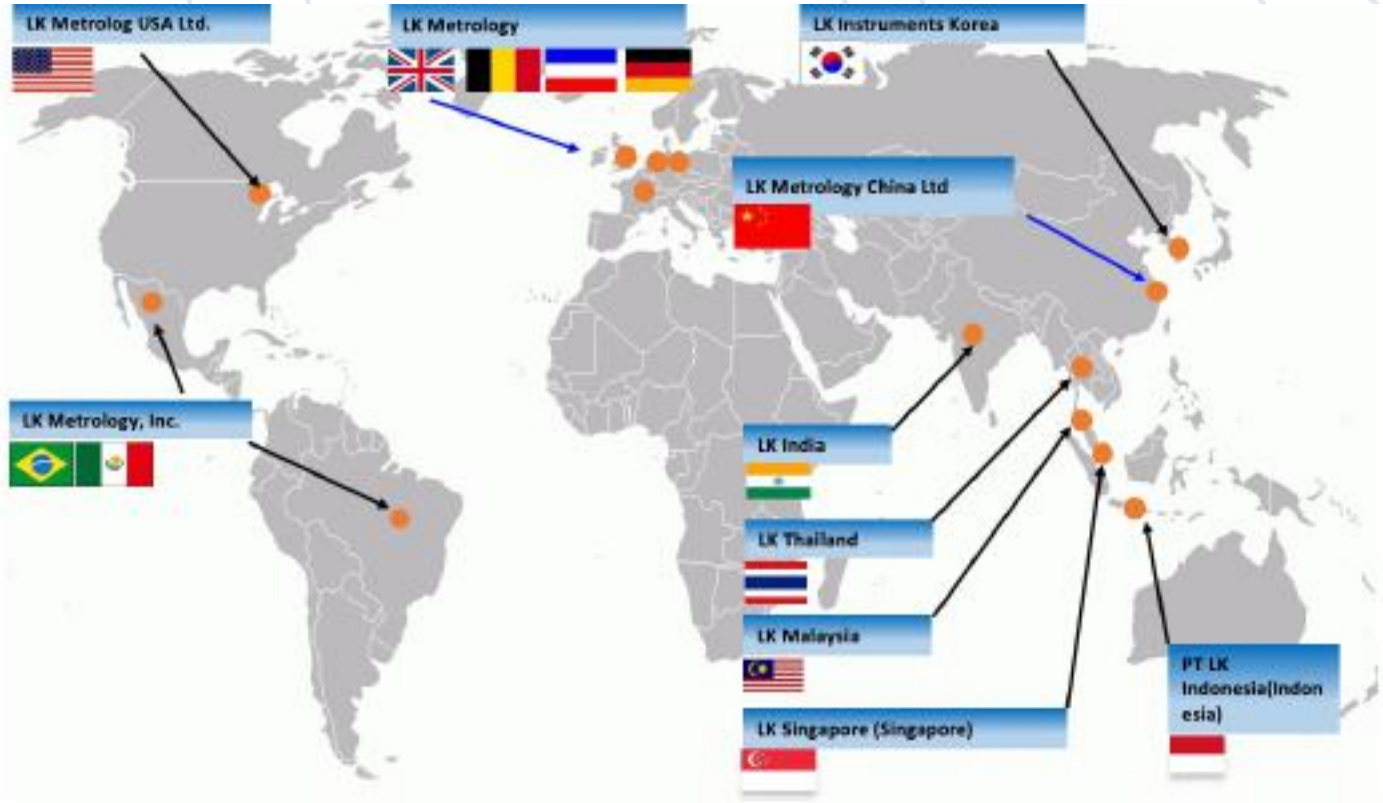

CETC 中国电子科技集团公司第十四研究所

Slavin – Land Systems
Product Range
Installation
Application


Aerospace Division
Williams International
Product Range
Installation
Application


BAE Systems - Typhoon
Eurofighter Typhoon

全球销售网络


LK Metrolog USA Ltd.
LK Metrology
LK Instruments Korea
LK Metrology China Ltd
LK Metrology, Inc.
LK India
LK Thailand
LK Malaysia
LK Singapore (Singapore)
PT LK Indonesia(Indonesia)

第一届欧洲代理商会议2018

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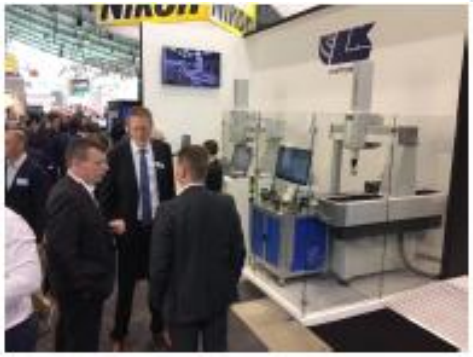
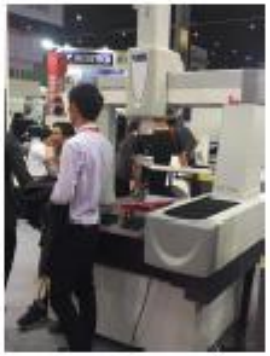
参加展会

英国 MACH展



德国 Control展



泰国曼谷

葡萄牙

意大利

参加展会

越南QES

土耳其

德国FMB展

英国

越南

LK工厂

LK工厂

LK工厂

参加展会

越南QES

土耳其

德国FMB展

英国

越南

LK三坐标机型

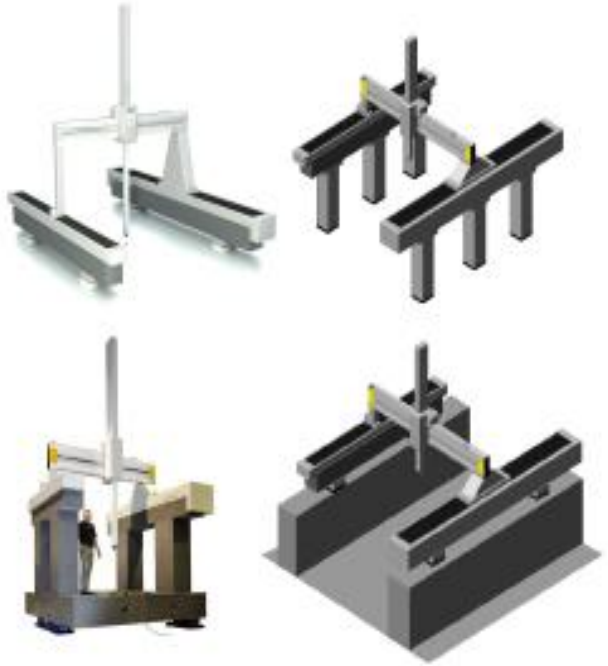
More comprehensive size and variety

LK可以提供市场最全面三坐标尺寸和种类，来满足不同大小复杂零件的检测

标准机器

长：0.7～7m
宽：0.5～2m
高：0.5～1.5m

或 更大定制机型



长：3～20m以上
宽：2～7m
高：1.2～4m

或 更大定制机型

长：4～20m以上
宽：0.8～4.2m
高：0.6～3m

或 更大定制机型

世界领先的测量技术

强大的测头技术，多样化的测量解决方案

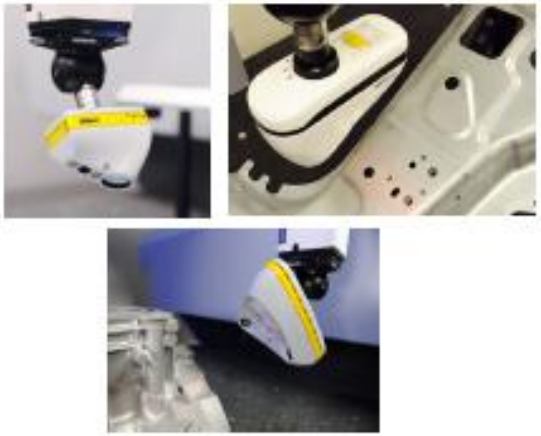
Different with other competitors

柔性测头即可实现计量级超高精度

世界最宽范围的柔性测头应用能力

最佳的便利性

最低成本的选择



世界最强的线激光扫描技术

最佳的精度

最佳的扫描能力效果

真正意义上可以用于精密零件测量的激光

超高效率的解决方案

动力总成的高效解决方案

航空发动机零部件检测的

高效解决方案

最佳的REVO CMM精度

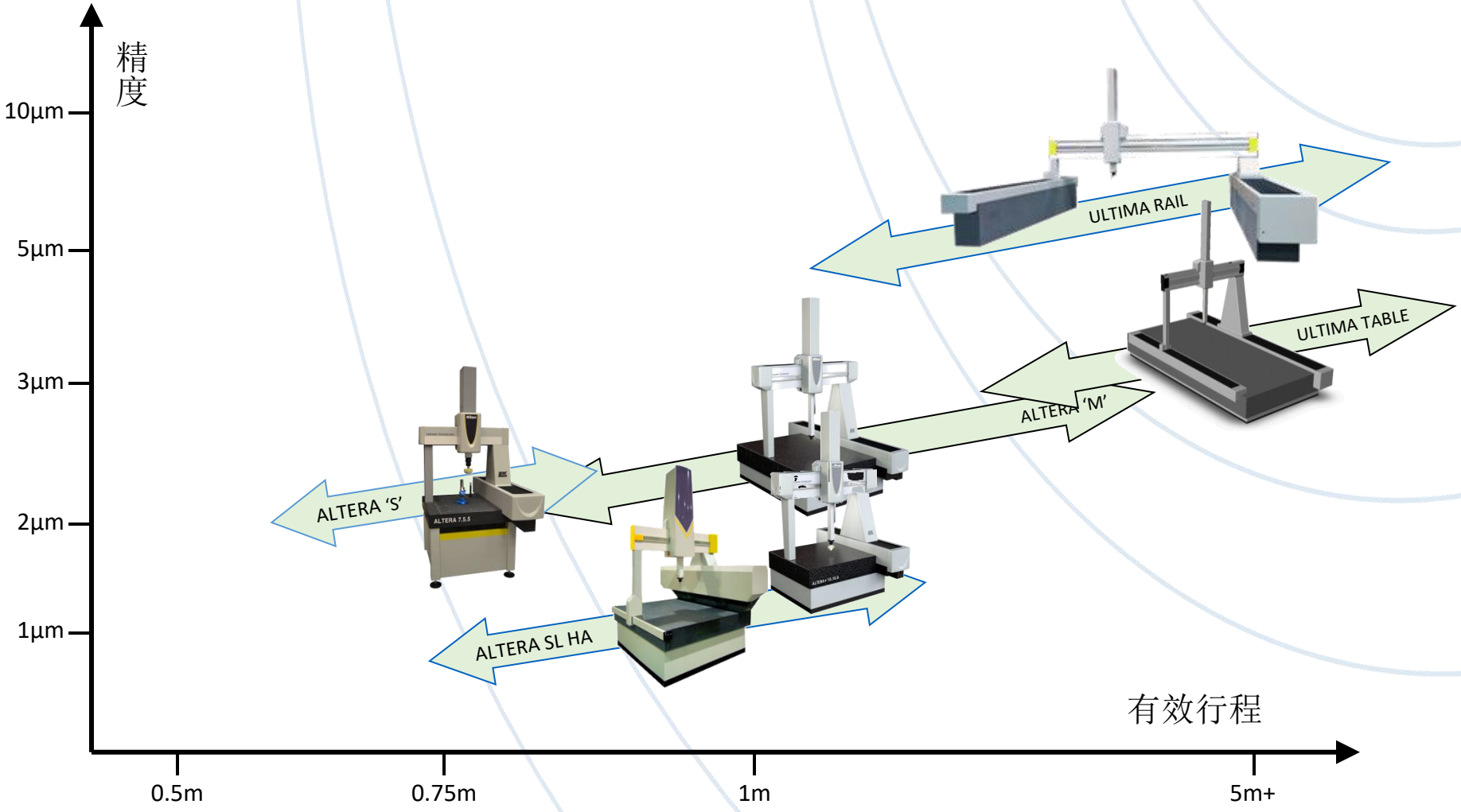
超高精度要求

深孔测量

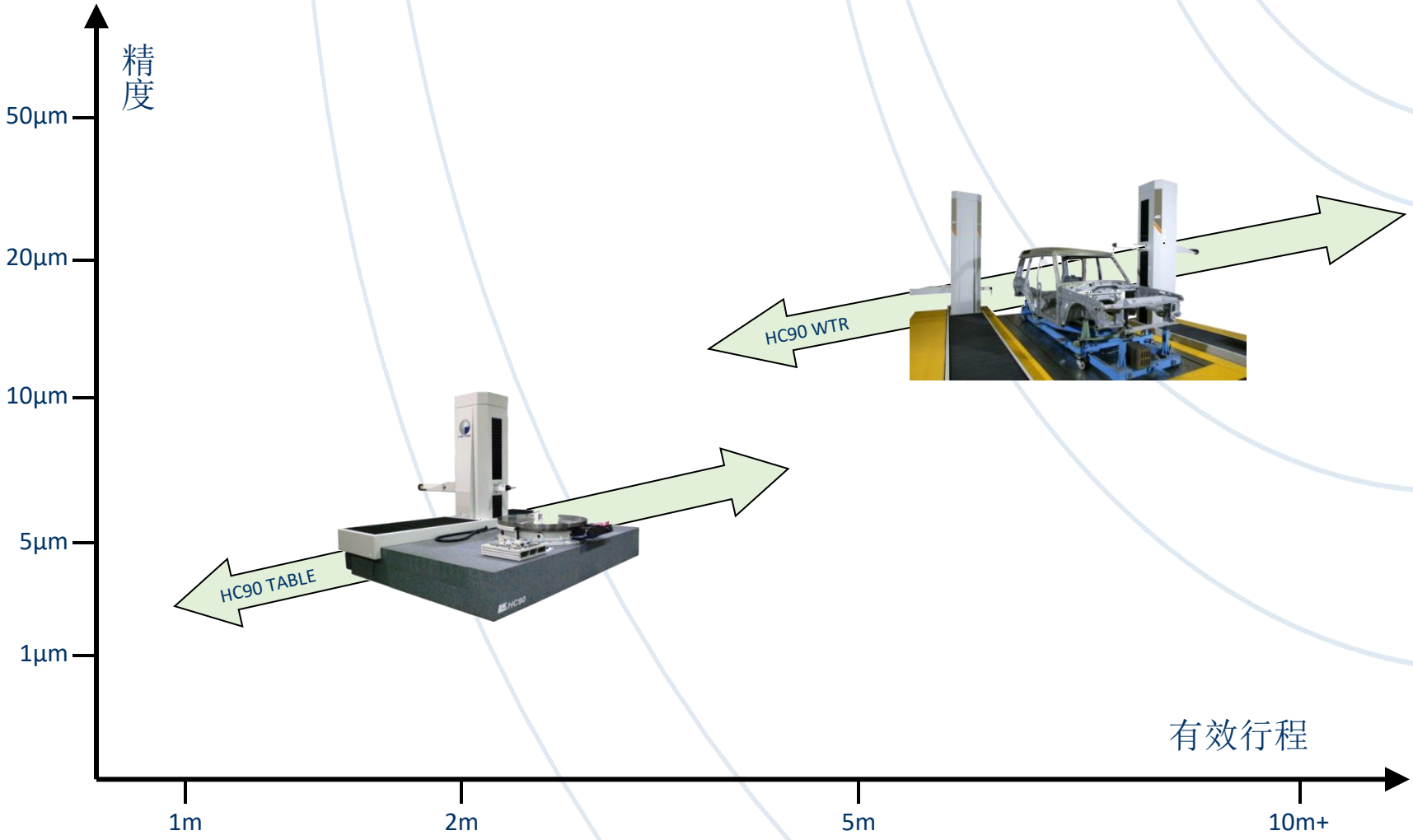
最长可接1000mm

LK可定制1500mm测针

桥式及龙门机型范围


精度
10µm
5µm
3µm
2µm
1µm
0.5m
0.75m
1m
5m+
有效行程
ULTIMA RAIL
ULTIMA TABLE
ALTERA 'M'
ALTERA 'S'
ALTERA SL HA

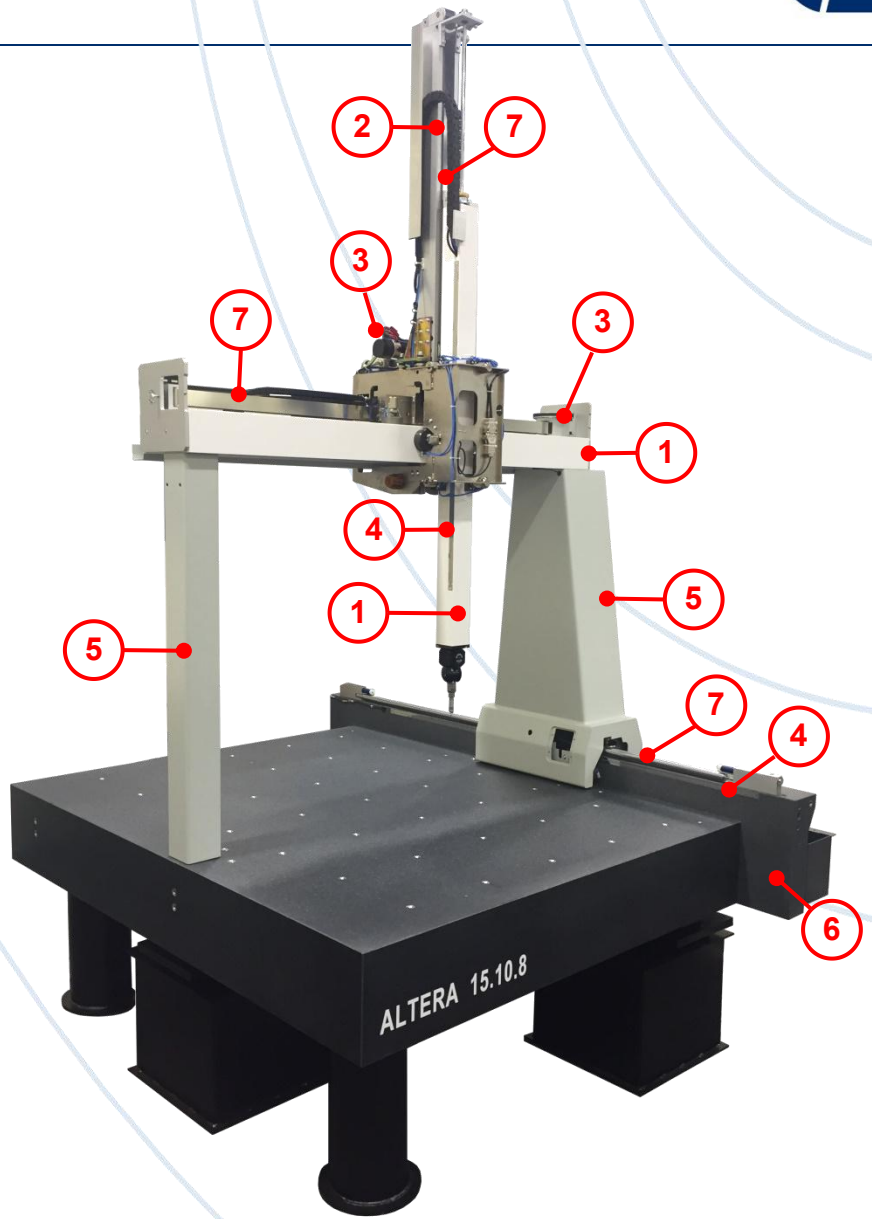
水平臂型三坐标范围



内部结构

气浮轴承结构（所有轴）
采用特殊涂层设计，实现最佳的气垫间隙

1. **陶瓷导轨**
   重量轻，刚性高，温度变形小
2. **平衡气缸防止Z轴滑落**
3. **直流伺服电机驱动（所有轴）**
4. **50nm 雷尼绍光栅 （所有轴）**
   可随温度变化自动伸缩
5. **合金钢立柱**
6. **花岗岩平台及导轨**
   稳定性好，温度变形小
7. **零滞后摩擦传动（所有轴）**
   表面硬化处理的光杆和大截面钢带（周周及横梁）传动



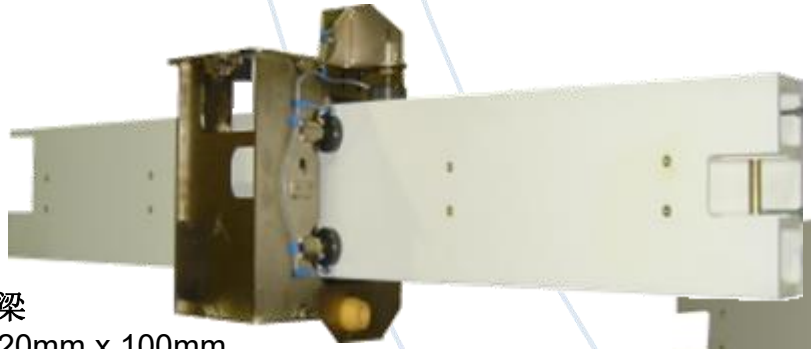
陶瓷导轨的优势

为什么采用陶瓷材料?

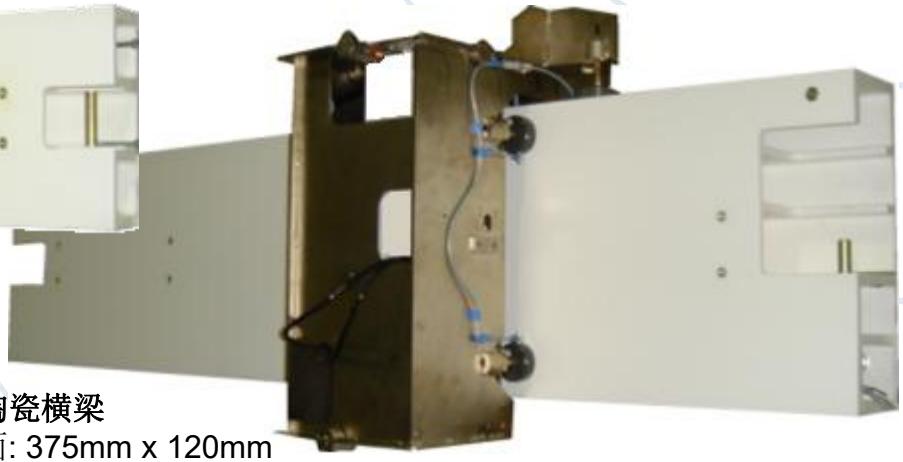
刚性超过铝合金330%
刚性超过花岗岩470%
刚性超过钢50%
热稳定性超过铝合金4倍
热稳定性超过钢2倍
同等体积下，重量比花岗岩轻50%
同等体积下，重量仅为铝合金的32%

为什么采用大截面陶瓷横梁?

- 增加了 Y & Z 轴的气垫接触面积
- 增加了刚性
- 增加了稳定性



标准陶瓷横梁
横梁截面: 220mm x 100mm
Z轴截面: 63mm x 63mm



高精度陶瓷横梁
横梁截面: 375mm x 120mm
Z轴截面: 80mm x 90mm

不同材料导轨的特性对比

材料	杨氏模量 *10^9 Pa	重量密度比 Kg/m^3	刚性重量比 *10^7 m^2/s^2
Epoxy Resin	10	1200	0.83
White Granite	25	2800	0.89
Invar	140	8130	1.72
Grey Granite	63	3200	1.97
Unidirectional Glass in Epoxy Resin	50	2070	2.4
Aluminium	70	2780	2.52
Steel	200	7800	2.56
Bi-directional XAS-HP Carbon Fibre in Epoxy Resin	55	1520	3.6
Uni-directional Kevlar in Epoxy Resin	82	1360	6.0
Uni-directional High Tensile Carbon Fibre in Epoxy Resin	105	1580	6.65
96% Alumina Ceramic	303	3700	8.18
Uni-directional High Modulus Carbon Fibre in Epoxy Resin	150	1580	9.50
Reaction Bonded Silicon Carbide	365	3100	11.8

- 表中的刚性/重量比，可以充分体现陶瓷材料对铝合金，钢和花岗岩的全面超越。
- 刚性重量比对于现代化的设计至关重要。例如F1赛车，其所有设计均围绕着采用最轻的材料，实现最大的刚性。

10 年结构精度保证

自用户采购之日起，LK公司承诺保证其三坐标尺寸精度十年稳定.
10年内，如因LK公司自身部件†原因，导致三坐标无法调至出厂精度，LK公司将免费为客户更换部件，直至将机器恢复出厂精度。

详见下述条款及约定.

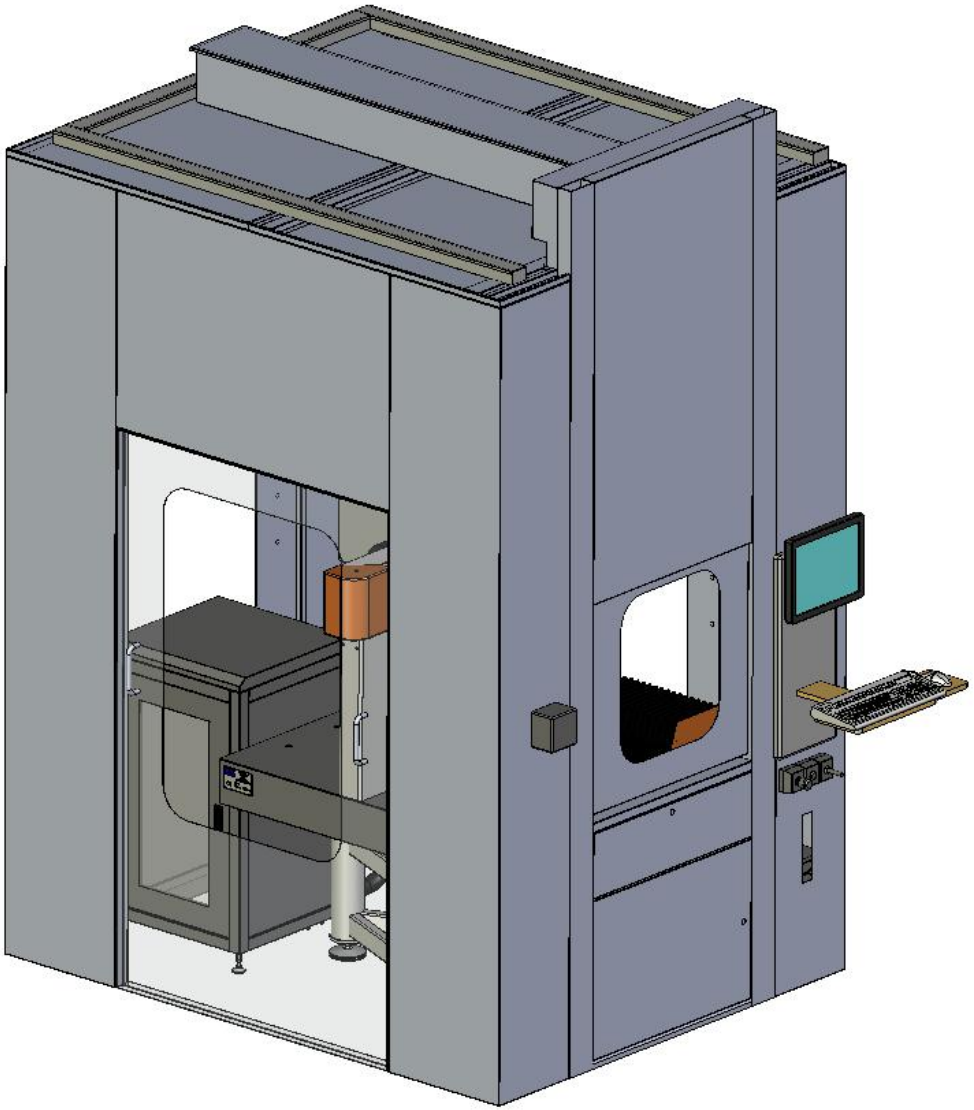
10年精度保证的条款及约定

- 设备需按LK公司规定进行操作。
- 设备按照LK公司的规定连接合适的气源和电源。
- 所有对设备进行校准或维护保养的工程师，必须持有LK公司颁发的资质证书。
- 除LK计量公司授权服务人员外，没有证据表明任何人因误操作对设备造成损害。

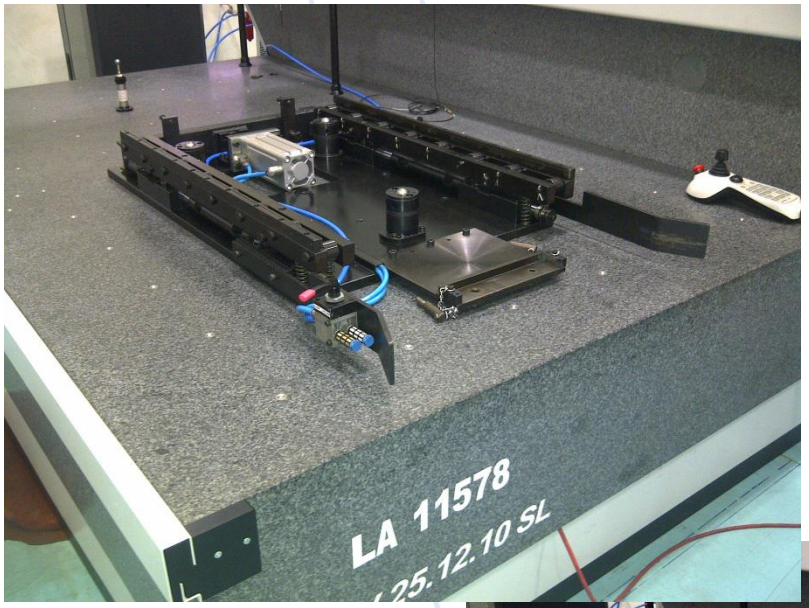
†部件定义：花岗岩工作台，陶瓷横梁，陶瓷Z轴，内外立柱及结构支架（不包含：控制器，光栅尺，传动部件，气浮轴承，电机等）

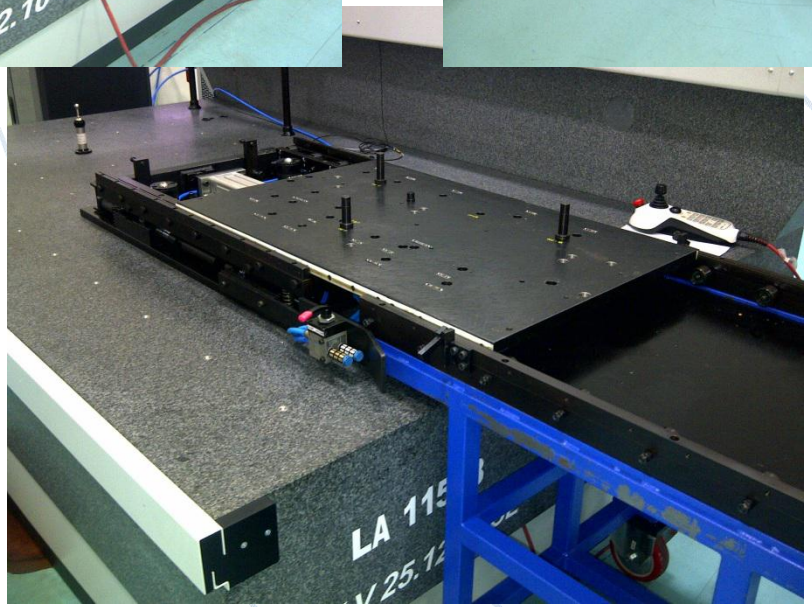
对于因客户原因导致的设备问题，或与该问题有关的任何直接或间接的损失或损害，本公司不承担任何其它或进一步的责任。

CMM 交钥匙工程



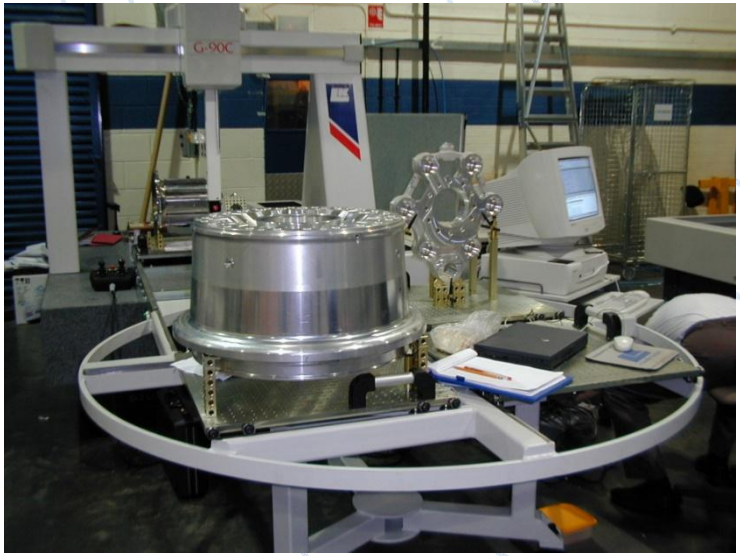
自动上下料系统



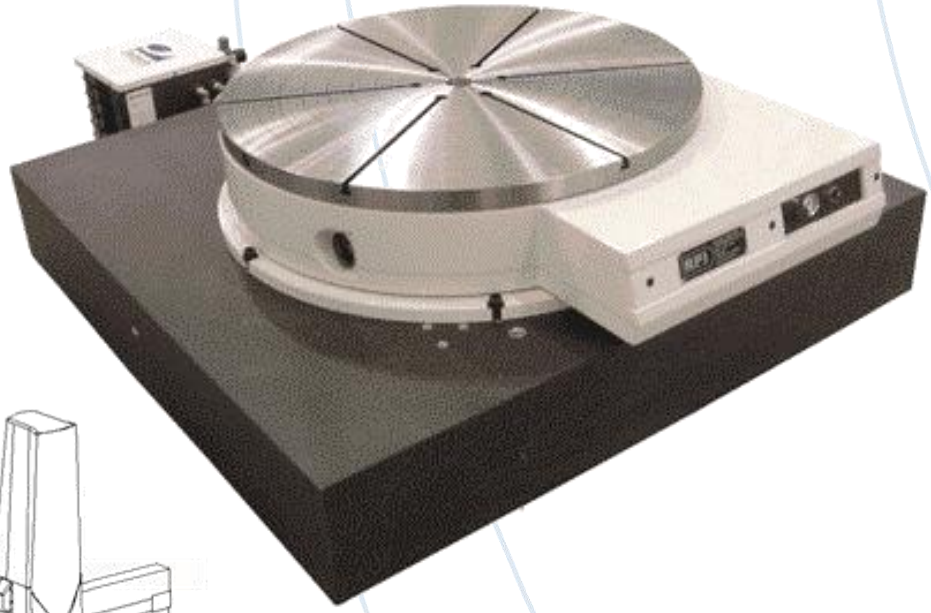


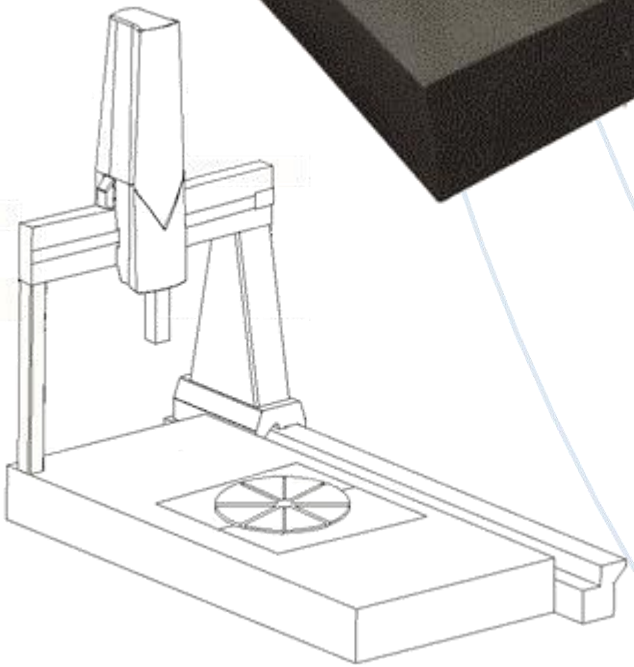
自动上下料-交钥匙工程（Turnkey）

自动上下料系统 – 更多应用



转台 – 六轴





转台

- 需WIQ 5.12申请
- 推荐使用RPI 转台
- 需专用接口连接转台和三坐标
- 可以将转台嵌入工作台内-选项（需定制工作台）
- 转台精度可以满足 DIN EN ISO10360-3等多种标准
- 特殊机型、精度也可申请定制

Altera S 系列

ALTERA ‘M’ 系列

LK V SL / SL HA 计量型

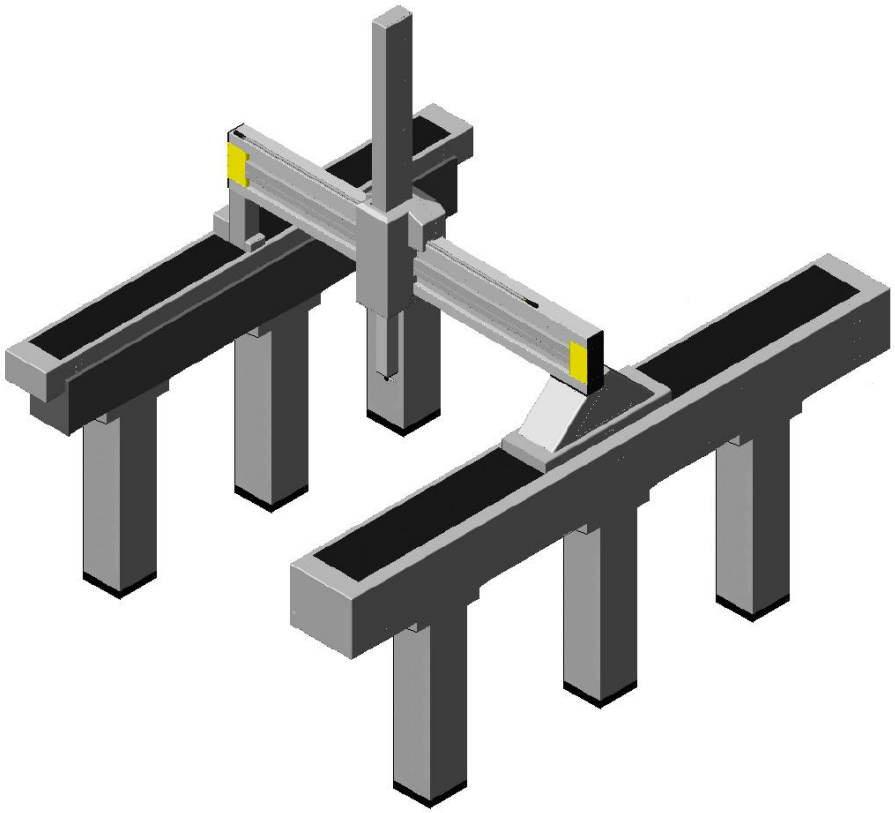
LK V 20.20.25 GP 定制系列

LK HC90 水平臂系列

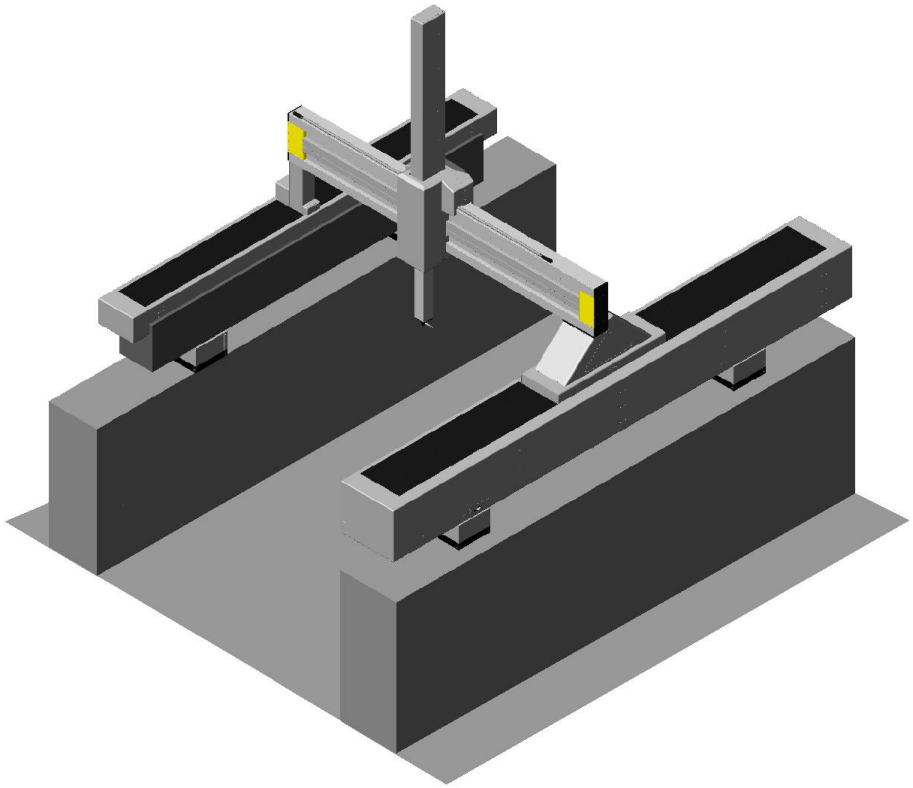

RENSCAN5
Ford
Revo 5轴在美国福特

LK V 103.43.30 GP 生产现场

CMM 高架龙门



Steel pillars



‘U-form’ reinforced concrete foundation

LK CMM 世界上唯一的陶瓷龙门三坐标测量机

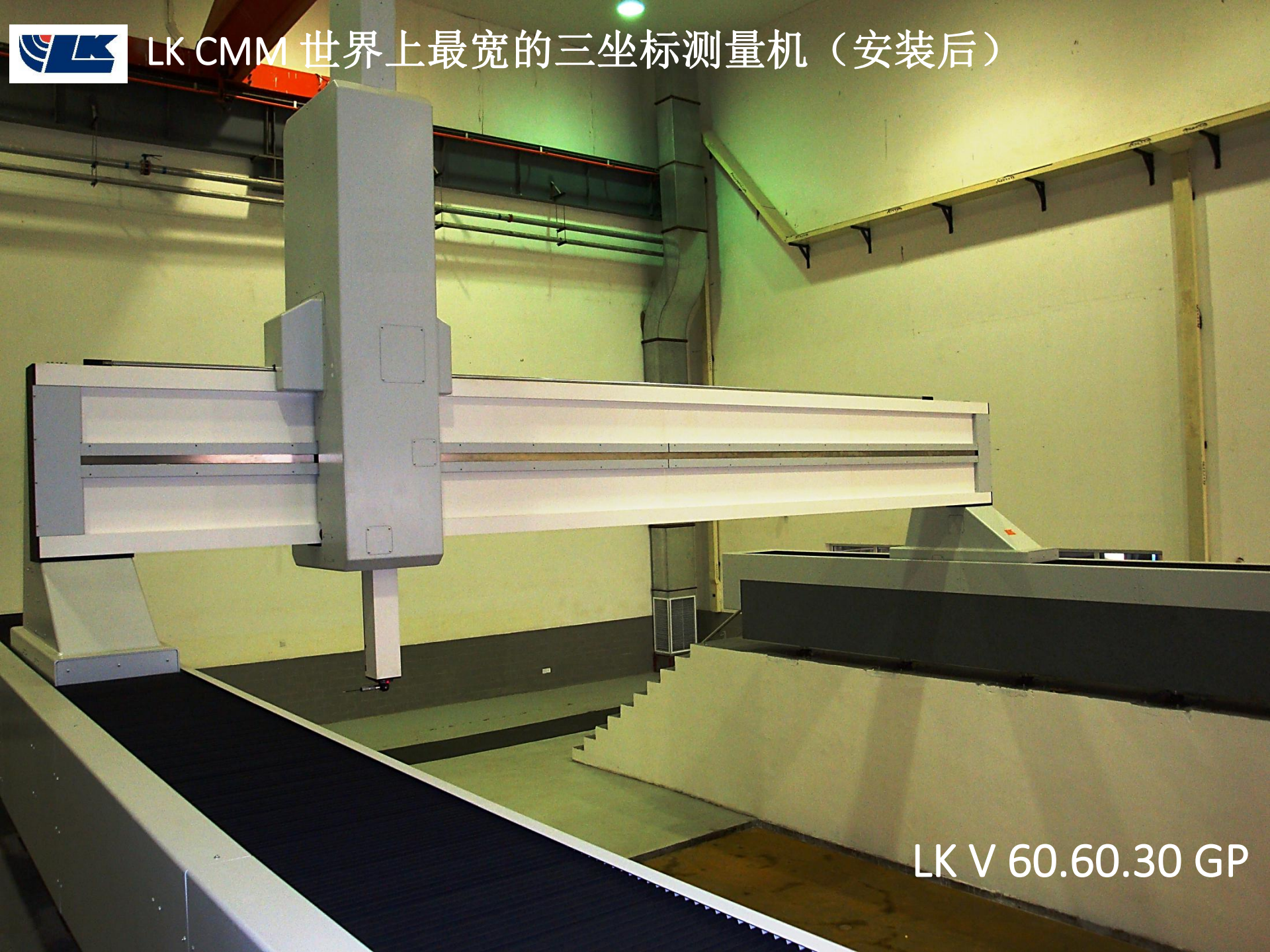
LK V 40.40.25 GP

LK CMM 世界上唯一的陶瓷龙门三坐标测量机

LK V 50.40.12 R

LK CMM 世界上最宽的三坐标测量机（生产现场）

LK V 60.60.30 GP

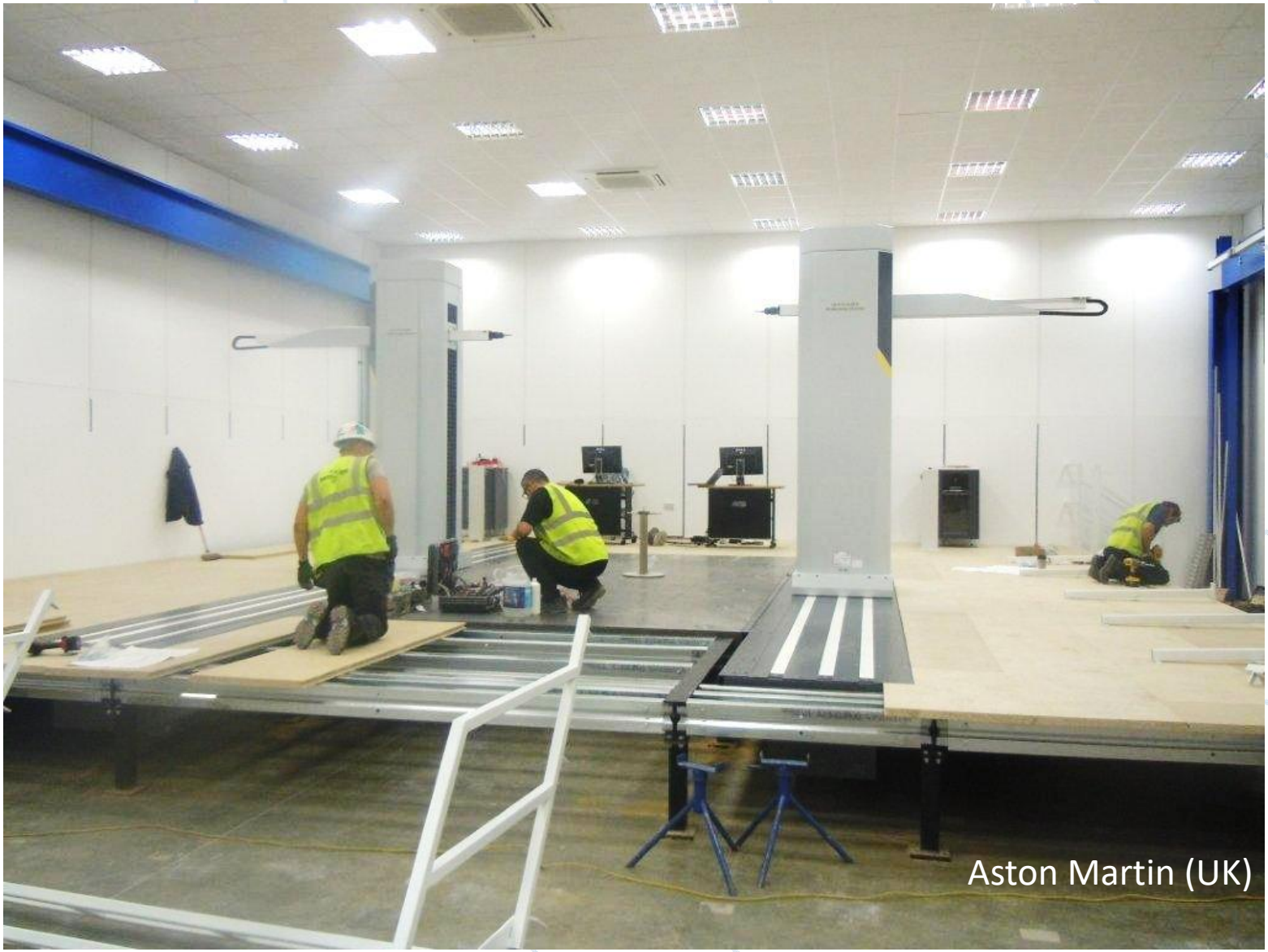

LK CMM 世界上最宽的三坐标测量机（安装后）
LK V 60.60.30 GP

LK CMM 世界上精度最高的双水平臂三坐标测量机

LK HC90 63.16.20 WTR

LK HC90 双水平臂地基

LK HC90 安装



世界上最宽三坐标测量机的相关报道（中国211）

BIGGEST METRIS GANTRY CMM IN HISTORY BRINGS TOP ACCURACY FOR AEROSPACE APPLICATION

A leading aerospace manufacturer recently took delivery of probably the widest bridge style co-ordinate measuring machine ever manufactured in the world. Building on the 40 year heritage of the LK brand, Metris developed the gantry CMM with a measurement volume of 6m x 6m x 3m, to run geometry verification on large aerospace components and assemblies.

UNMATCHED IN TERMS OF DIMENSIONAL STABILITY

While the length of the measuring volume was well within the capability of many CMM manufacturers, the requirement for the super-wide width meant that only Metris LK was able to provide a solution to meet the customer's accuracy specifications.

The gantry style CMM performs with an accuracy of 5 microns, which could only be achieved by the use of ceramic guide ways for the beam and spindle components. Ceramic is an ideal material for metrology because it offers the ultimate in stiffness combined with low weight and excellent thermal properties. Used in combination with double air bearings that prevent torsion, this ceramic LK gantry CMM provides high and long-lasting measurement accuracy. In its final location, the granite rails will be positioned on a purpose built "U" shaped concrete foundation in order to provide the 3m vertical measurement range.

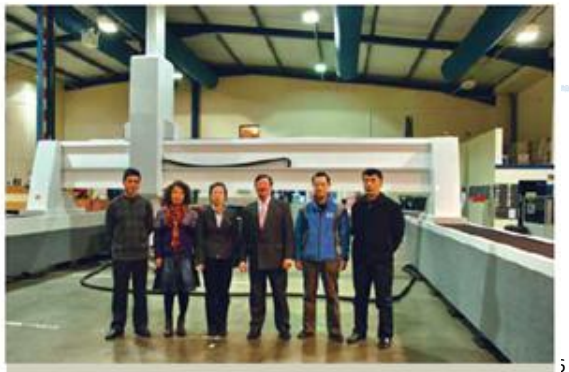
LONG TIME EXPERIENCE WITH SUPER-SIZE CMMS

Metris' long time experience with engineering and manufacturing super-size CMMs was the customer's prime reason to choose the Metris solution. On several visits to Metris LK installations, the customer was impressed with the CMM accuracy and reliability that are second to none. Intensive collaboration with the customer enabled Metris to determine the final configuration and build the LK V 60.60.30 GP to perfectly match the customer's application needs. A growing number of leading global companies such as Caterpillar, BAE Systems, Buhler and many others, rely on Metris LK to efficiently tackle their large-scale co-ordinate measurement metrology challenges in this way.

Metris offers a large portfolio of standard super-sized CMM products, which can be customized and shaped into specific solutions to solve customers' specific measurement problems.

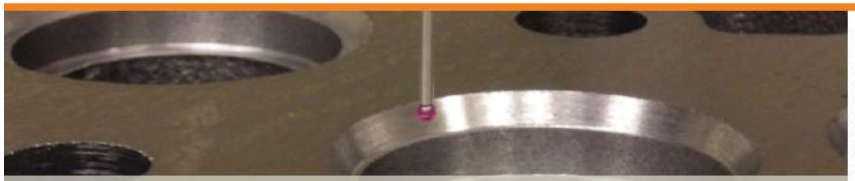
TIGHTLY INTEGRATED MULTI-SENSOR CAPABILITY

Multi-sensor capability is another key driver for world-class manufacturing companies to choose Metris. Next to touch trigger and continuous contact scanning, Metris CMMs fully support non-contact laser scanning with plug-and-play operation of Metris' innovative scanners. As a one-stop-metrology-shop, Metris offers complete CMM solutions with tightly integrated multi-sensor capability and software that drives the entire system and processes all inspection data.



On several visits to Metris LK installations, the customer was impressed with the CMM accuracy and reliability that are second to none.

案例介绍（火箭发动机的检测应用）



METRIS 24/7 QUALITY CONTROL AT CUMMINS ROCKY MOUNT ENGINE PLANT

To maintain premium manufacturing quality and repeatability for powerful on-and-off-road diesel engines, Cummins Rocky Mount Engine Plant (RMEP) runs 24/7 inspection using 11 Metris LK CMMs. In the manufacturing process of cylinder blocks, connecting rods and cylinder heads, Metris CMMs automatically verify dimensions and features through touch probing and scanning. To respond to even more demanding precision and productivity requirements, Cummins RMEP recently invested in a Metris XC laser scanning probe for non-contact 3D feature and free-form inspection.

ESTABLISHING HIGHER DIMENSIONAL ACCURACY MEANS BETTER ENGINE

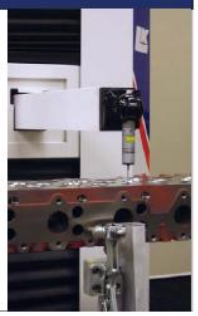
Established in 1980, Cummins RMEP manufactures diesel engines and components. Engines from the company are shipped worldwide to power agricultural and industrial applications, as well as buses, trucks and boats. At its 110,000m2 facilities in Whitakers, North Carolina USA, Rocky Mount Engine Plant (RMEP) counts approx 1,750 employees who turn out 600 engines per day, ranging between 70 and 00 horsepower. RMEP's non-stop metrology operations dedicate 4 Metris CMMs to four-valve cylinder head production, 4 to cylinder blocks, 1 to connecting rods and 2 for two-valve cylinder heads. For key engine parts, RMEP production personnel apply all their manufacturing excellence to obtain tighter geometric tolerances, which in turn further increase horsepower and reduce engine emission.

When production began, RMEP used as its primary measurement tools manual gauges and fixtures. Although these gauges provided immediate pass or fail status, it required a lengthy and costly process to modify these structures according to latest design changes. "A much higher degree of flexibility, and live electronic SPC, are needed to efficiently set up and run routine metrology tests in order to monitor the quality of our daily manufacturing operations," states RMEP's Quality Engineering Manager "At the time when Cummins introduced four valve engines, and steadily increased the number of engine configurations, we incorporated Metris CMMs as an integral part of our manufacturing process."

METRIS LK CMMS @ CUMMINS

11 LK CMMs and Camio software run non-stop inspection on diesel engine parts, including cylinder blocks, connecting rods and cylinder heads.

- ✓ Full off-line simulation of automatic inspection routine
- ✓ High degree of flexibility and live electronic SPC
- ✓ Service and support fit specific customer needs
- ✓ Metris identified as critical enabler to enforce tighter tolerances



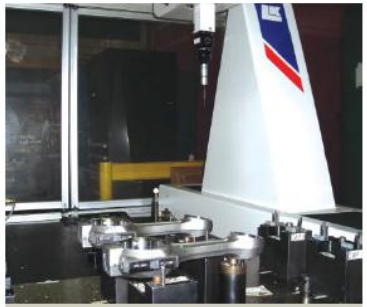
ACQUIRE, SHARE AND LEVERAGE ENGINE METROLOGY DATA

Located adjacent to production lines, Metris CMMs are set up for fast execution in separate temperature controlled rooms, away from dust and dirt. After clamping machined engine components or manufactured engine subassemblies on the CMM, a trained technician selects the appropriate metrology routine and starts the measurement run. It is a full-automatic routine that picks the right probe and points and scans numerous positions to evaluate milled surfaces and the position and profile of other features. The Metris CMMs consistently guarantee accurate measurement, as they monitor tight dimensional tolerances: 6 microns on connecting rods bores, 10 microns on valve guide diameters, and 25 microns of flatness on finished faces.

Every day, hundreds of parts pass CMM inspection. The Metris Camio software platform manages the operation of the CMMs and streamlines the data flow of the acquired geometric data. A technical specialist of the Rocky Mount Engine Plant explains that in order to keep track of all measurement data, RMEP made sure that the data are automatically processed and maintained in a dedicated Visual SPC database. "Over 300 operations managers, manufacturing and product engineers and quality professionals regularly use this structured RMEP knowledge base to consult measurement reports or look up specific data items. As CMMs acquire massive amounts of measurement data, we opted for concise reports for the production operators that only show the measurements that are outside of tolerance limits. It is important that we maintain the link between the inspection of engine parts and the production workers who manufactured the parts. Discussing key test results motivates our production people, because it maintains their involvement and allows them to improve their production practices. Over the years, Metris CMMs helped us develop manufacturing skills to machine characteristics at a capability we were unable to measure, let alone maintain, in the past.

METRIS CMMS INCREASE MANUFACTURING QUALITY AND PRODUCTIVITY

"To support the 1000+ engine configurations that we currently offer, Cummins RMEP strategically opted for high-performance quality control. "To keep our 11 CMMs going around the clock in 3 shifts with minimum operator intervention, we allocated a full-time programmer to create and simulate hundreds of inspection programs off-line," clarified the technical specialist. "We are satisfied with the Metris Camio software, which provides full simulation capability of all machine moves, probe touches and probe head indexing. The software also manipulates the position and orientation of the CAD model and runs full off-line collision detection."



Connecting rods measurement includes bore diameter measurement at 6 micron accuracy.

RMEP's non-stop metrology operations dedicate 4 Metris CMMs to cylinder block scanning.

"WE INCORPORATED METRIS CMMS AS AN INTEGRAL PART OF OUR MANUFACTURING PROCESS."

- RMEP's Quality Engineering Manager

Cummins runs many touch sensor inspection tasks, including the scanning of surface valve cover sealing.

To cash in on the trend to capture geometry faster and with greater data density, RMEP recently purchased a Metris CMM laser scanner device. It is a multi-stripe Metris XC cross scanner that offers superior 3D scanning efficiency by enabling non-contact scanning over clamped parts, digitizing freeform surfaces as well as areas inside holes and deep pockets. Compared to the programming effort that is required for tactile probing sequences, the definition of scan paths for the CMM mounted laser scanner is fairly straightforward.

UP TO TIGHTER PART SPECIFICATION AND HIGHER DAILY OUTPUT

Although RMEP was convinced about the quality and accuracy of Metris CMMs, the company ultimately selected Metris for its service and support package that fitted its specific needs. Metris provided in-depth CMM training at RMEP to compress the learning phase for programmer and users, and remained available for extra assistance. On the hardware level, Metris organized a local support engineer who periodically calibrates the systems and is available in case a machine needs repair. "Yearlong experience at RMEP demonstrates that this way of working guarantees nearly 24/7 operation on 11 CMMs, and reduces standstill time to an absolute minimum," concludes the Quality Engineering Manager of Cummins RMEP. "As part of our ambitious plans for the future, we identified Metris CMMs as a critical enabler to produce components to even tighter specification and increase our daily output to over 750 engines."

激光测头

精度

12µm

9µm

6µm

3µm

XC65Dx

LC60Dx

L100

LC15Dx

based on a factor of: stripe width X frames per second

测量速度

尼康激光的 – 应用范围

LC15Dx
世界上精度最高的激光测头，精度同触发测头相当。适应于小型高精度工件的扫描测量。

L100
高效的线扫描测头，可以同时满足客户对精度和速度的需求。

LC60Dx
入门级高速线扫描测头，适应于大型工件的曲线曲面检测和逆向工程。

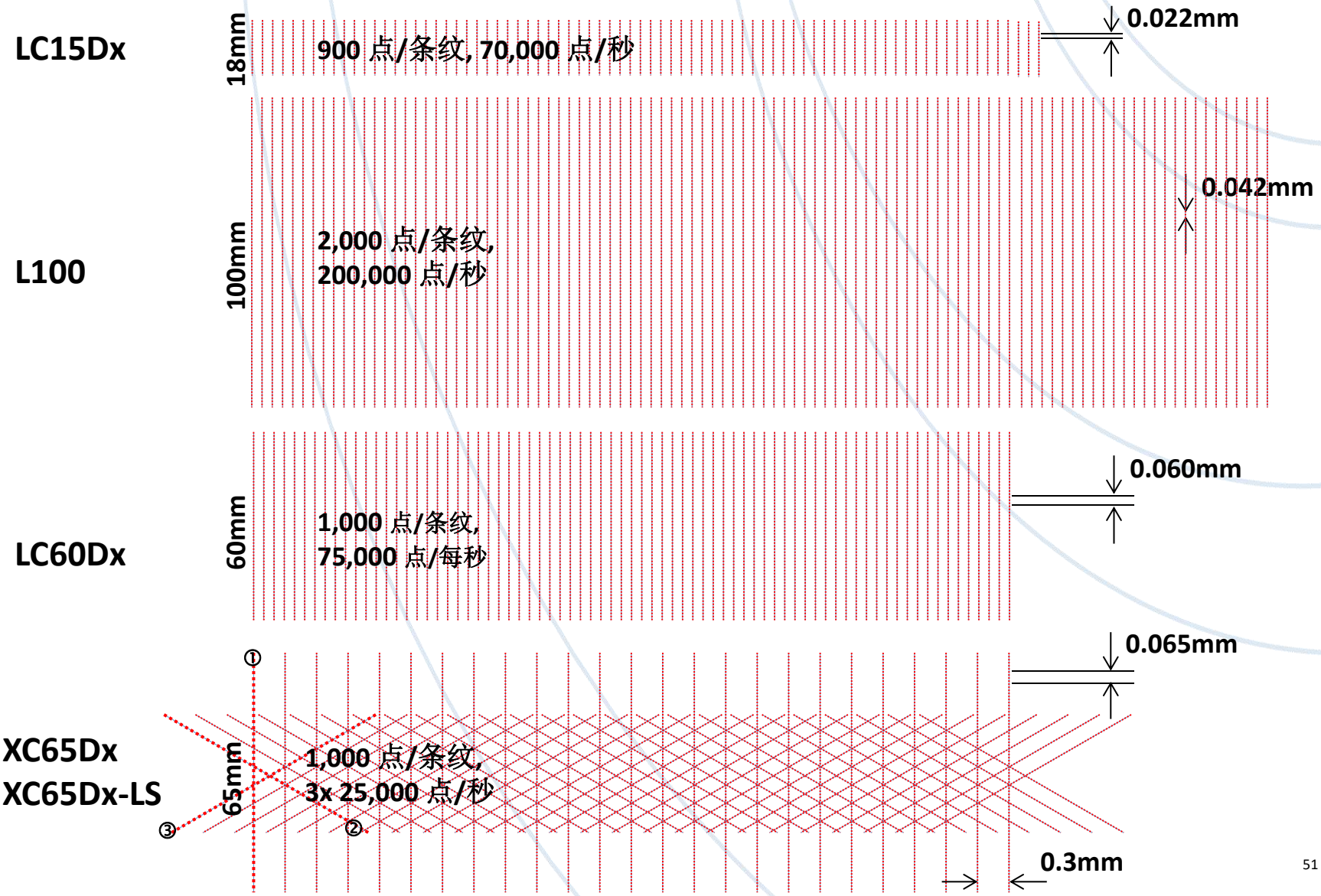
XC65Dx(-LS)
扫描于检测的终极解决方案，可以高速高精度检测各种几何特征及曲线曲面。其加长版（LS）具有更长的焦距，可以检测深孔，是世界上焦距最长的激光扫描测头。

尼康扫描测头的参数

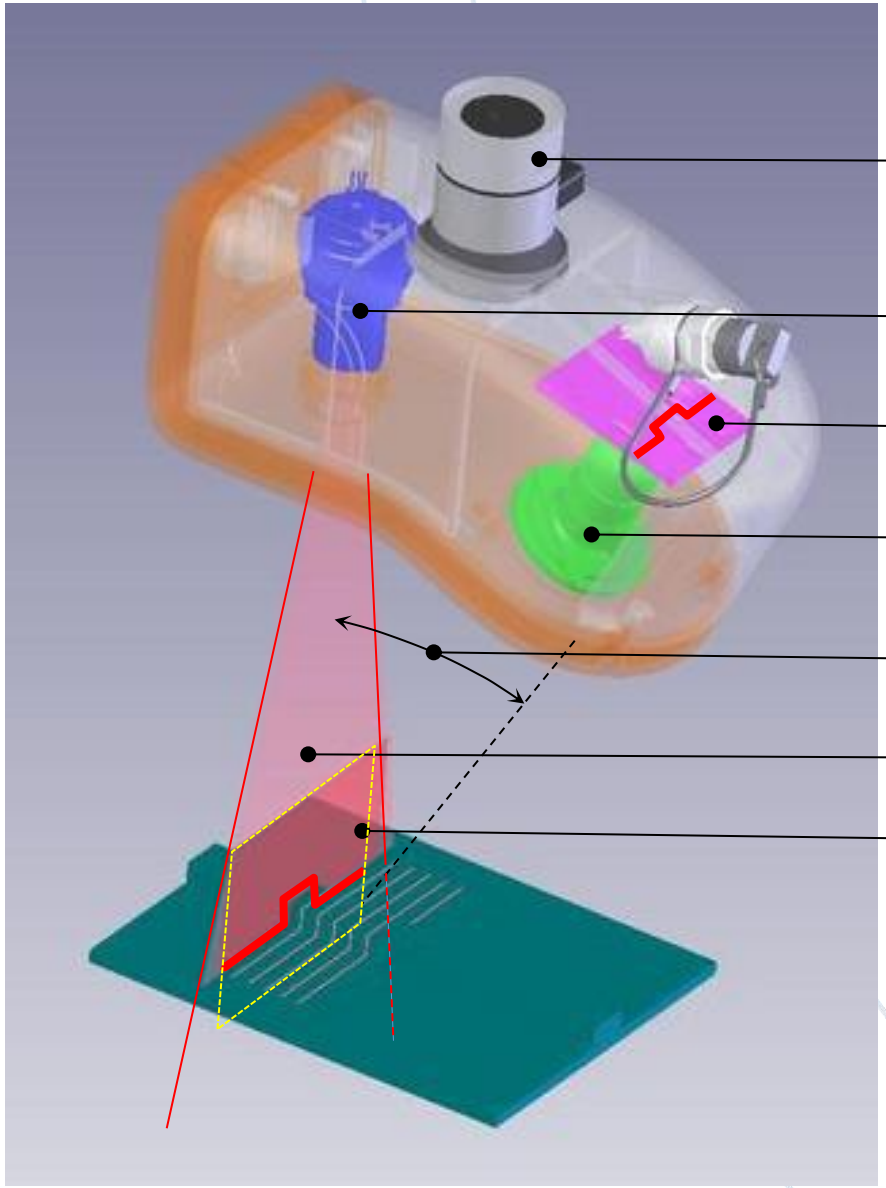
	LC15Dx	L100	LC60Dx	XC65Dx	
焦距	67.5 ±7.5mm	135 ±30mm	125 ±30mm	3x 107.5 ±32.5mm	
测头精度	1.9 µm	6.5 µm	9 µm	9um	
使用标准	EN ISO10360-2/-5 MPE_P / MPE_{AL}	EN ISO10360-2/5 MPE_P / MPE_{AL}	EN ISO10360-2/-5 MPE_P / MPE_{AL}	EN ISO10360-2/-5 MPE_P / MPE_{AL}	
采点间距	0.022mm	0.042mm	0.060mm	0.065mm	
综合精度‡	4um+L/350 mm	6um+L/350 mm	6um+L/350 mm	4um+L/350 mm	
视场宽度	18mm	max. 110mm	60mm	3x 65mm	
频率	78 Hz	100 Hz	75 Hz	75 Hz	
每秒扫描的点数	70,000	200,000	75,000	3x 25,000 or 1x 75,000	
激光等级	Class 2M	Class 2	Class 2M	Class 2M	
外形尺寸	100x104x58mm	114x134x70mm	111x135x71mm	155x86x142mm	
重量	370g	390g	390g	451g	

‡

每秒扫描性能(0.1mm 行距)



激光测头硬件描述



同PH10测座连接的接口

激光发射组件

图像抓取组件

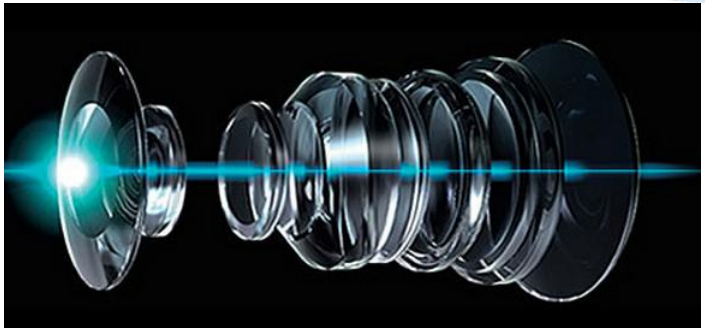
过滤器及镜头

测量角

激光扫描区域

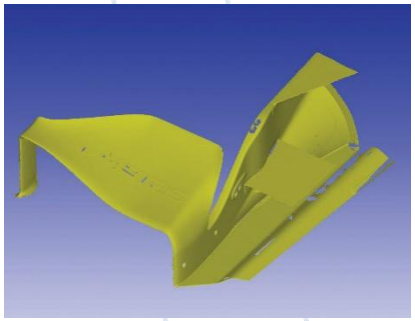
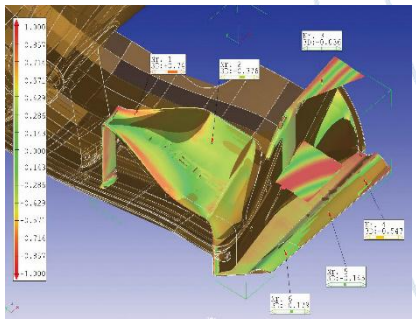
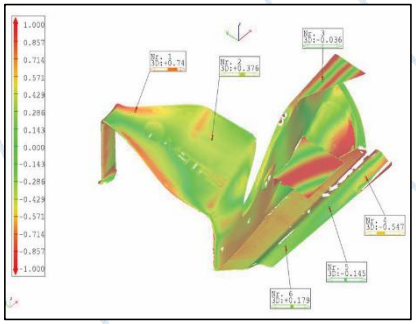
单次测量区域

用于LC15Dx & L100 的尼康镜头

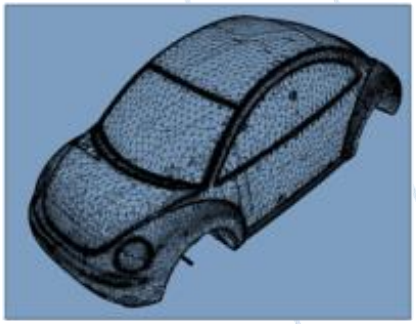
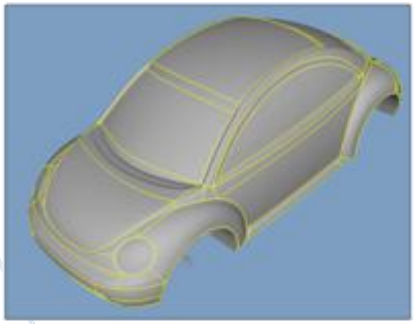
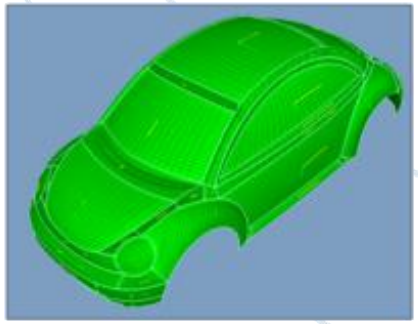


什么情况下需要使用激光测头?

尺寸检测

逆向工程

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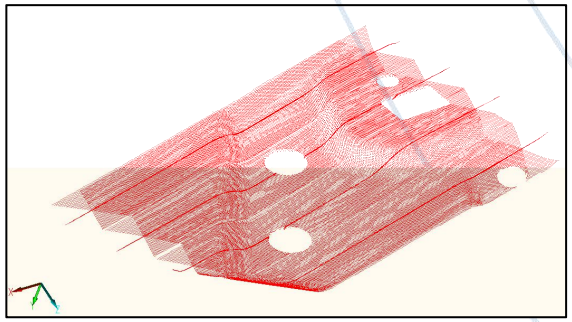


can be used for:

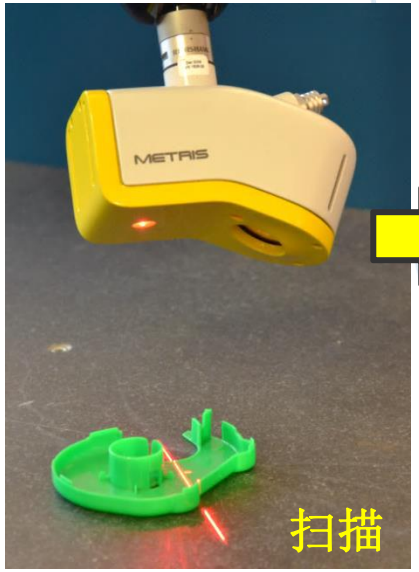
retrospective inspection

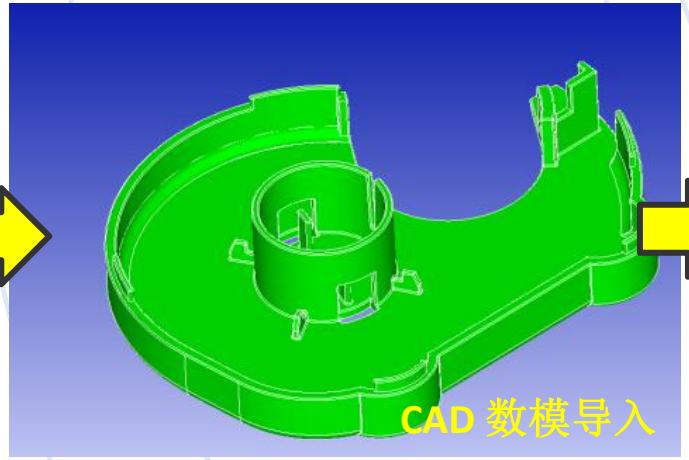
Finite element analysis (FEA)

CNC machine programming (from STL model)

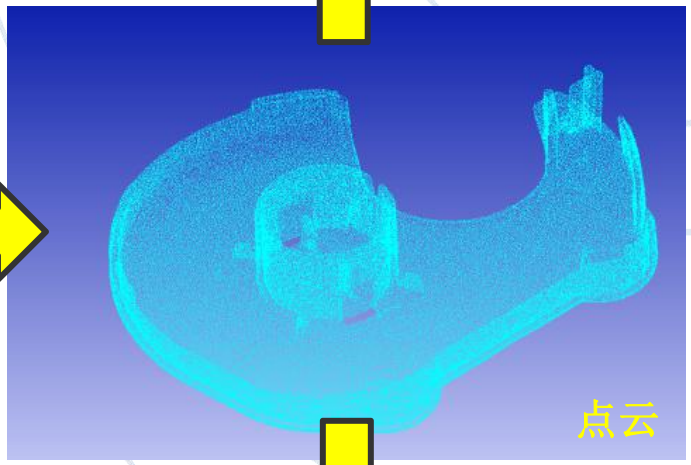
virtual assembly

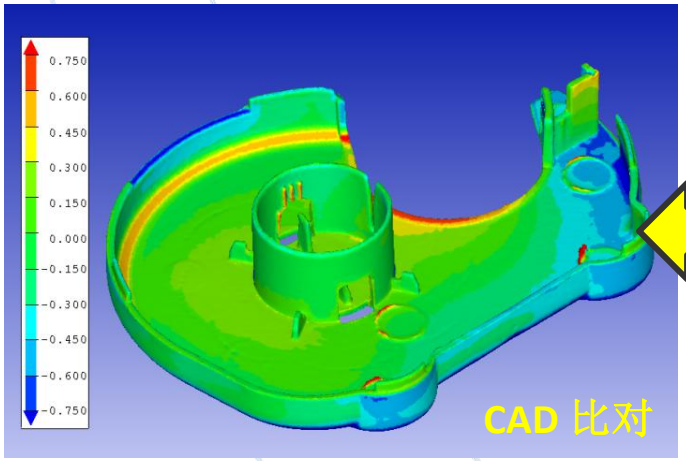
扫描应用示例

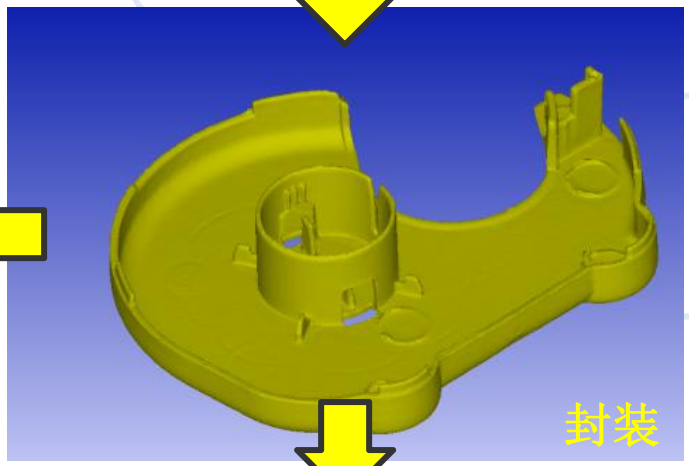




逆向工程

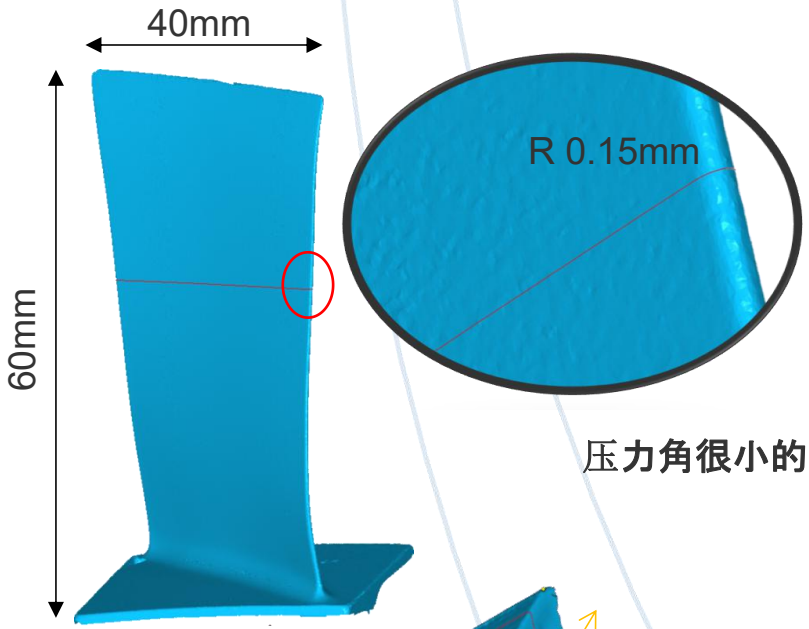




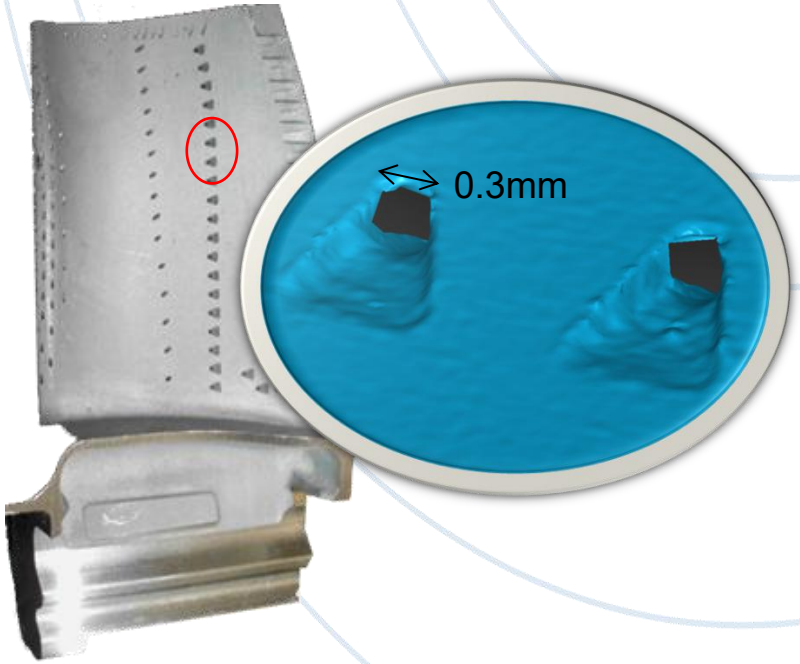


逆向工程
有限元分析
NC 加工

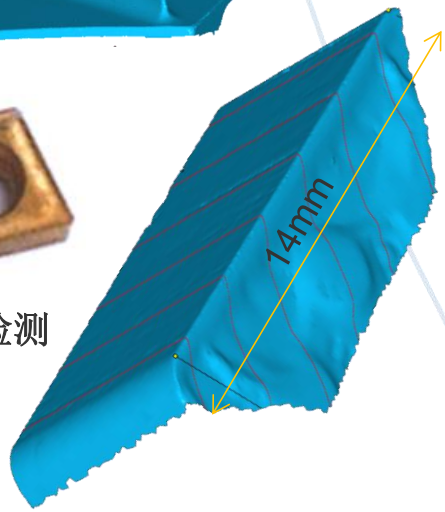
LC15Dx 扫描应用示例

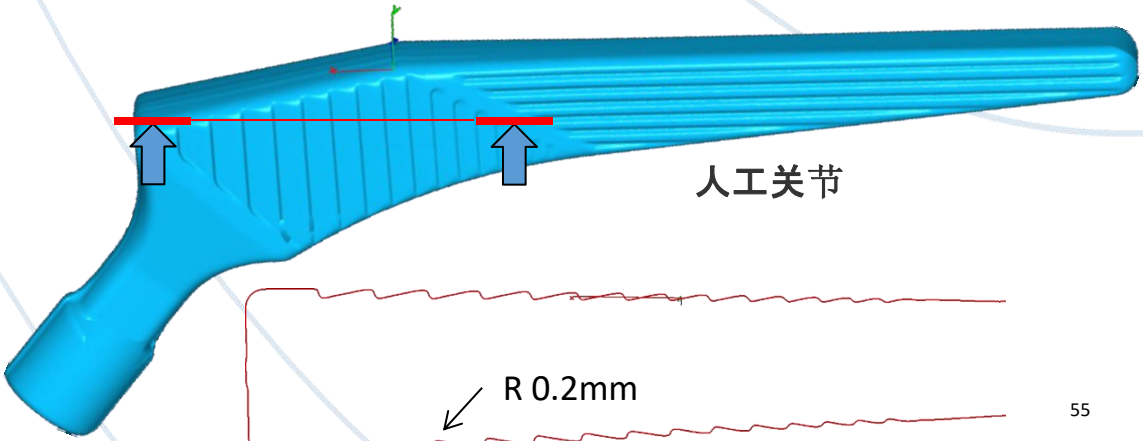


压力角很小的叶片

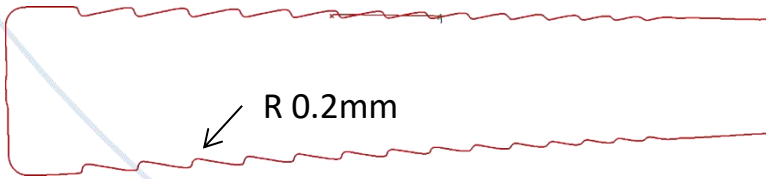


金属刀具检测



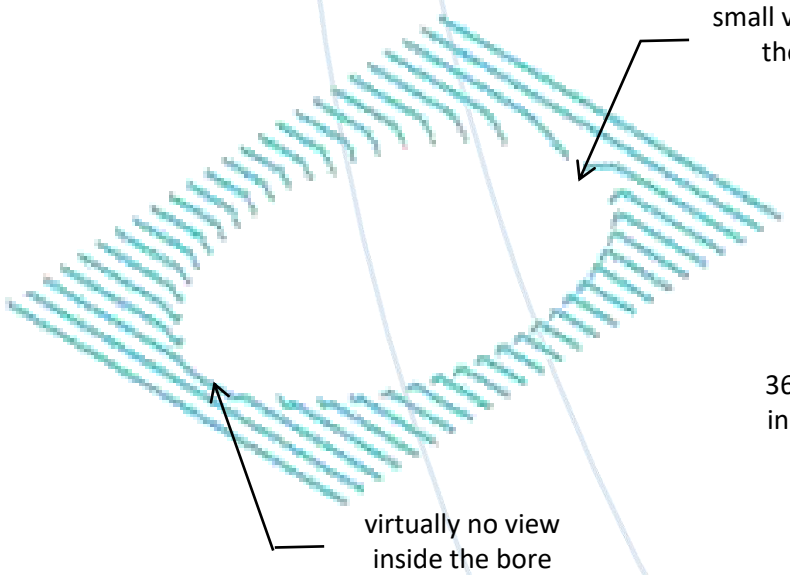


人工关节

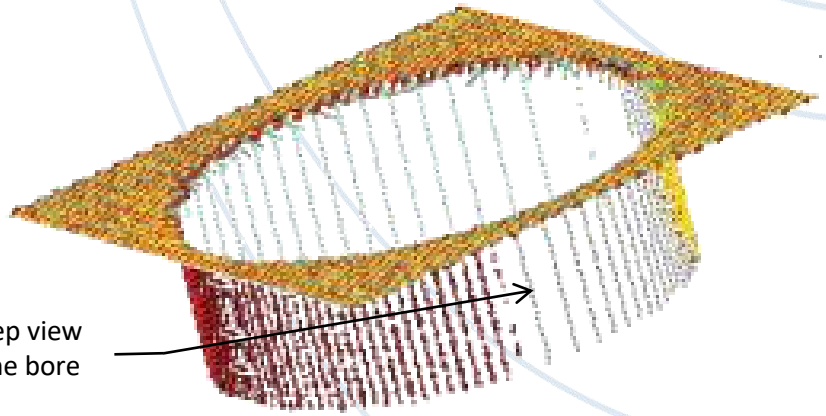


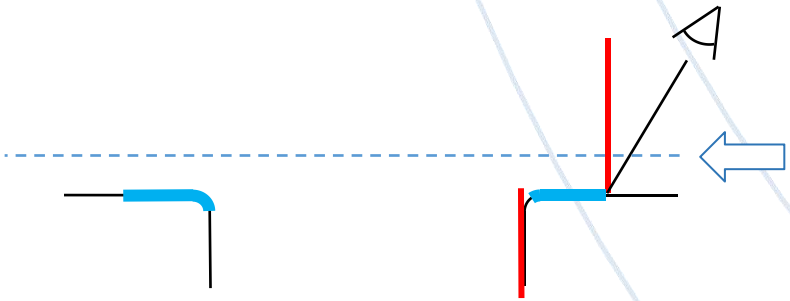
XC65Dx – 几何特征检测

单线激光扫描结果

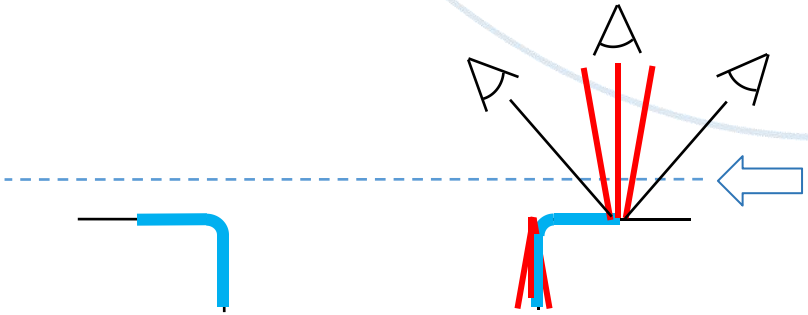


交叉线激光扫描结果





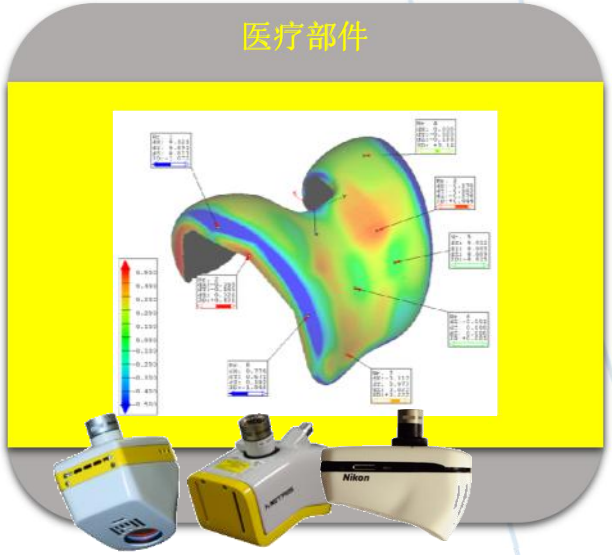
animation



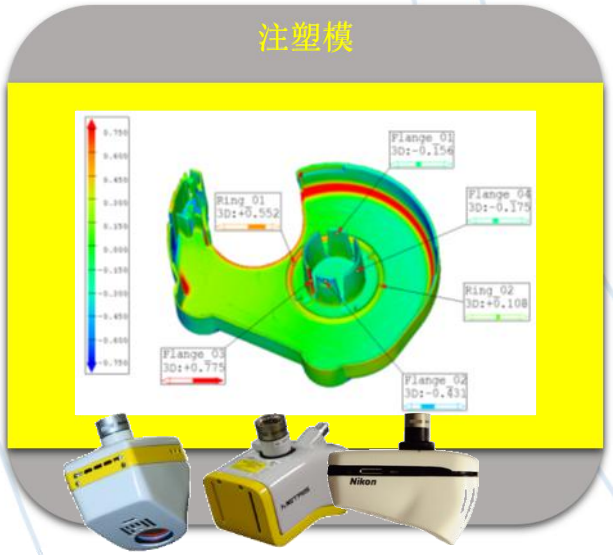
animation

激光扫描检测的典型应用

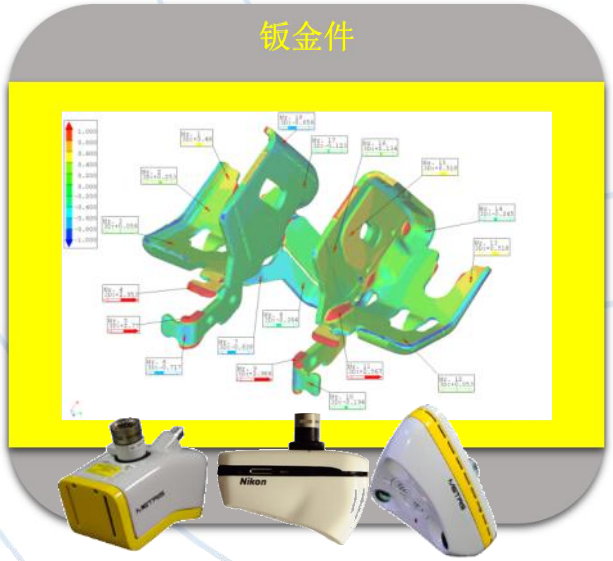
医疗部件



注塑模



钣金件



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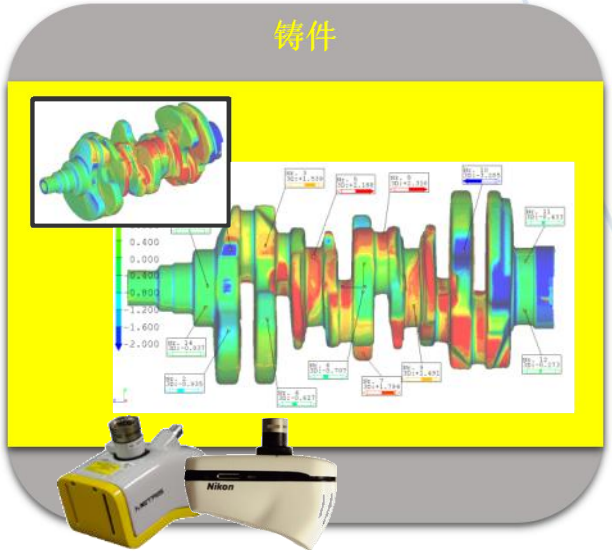
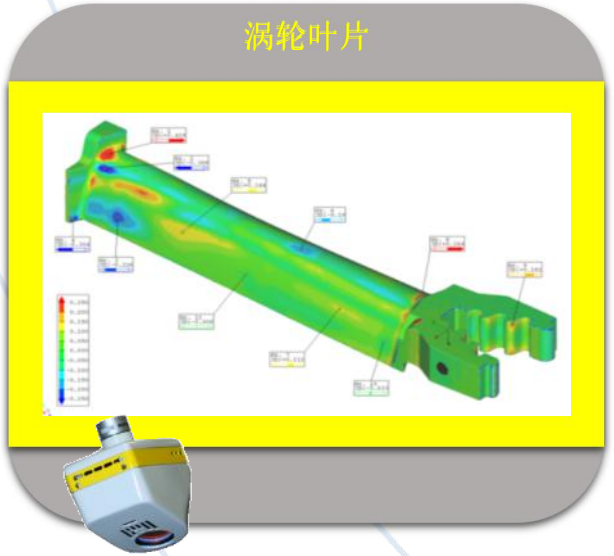
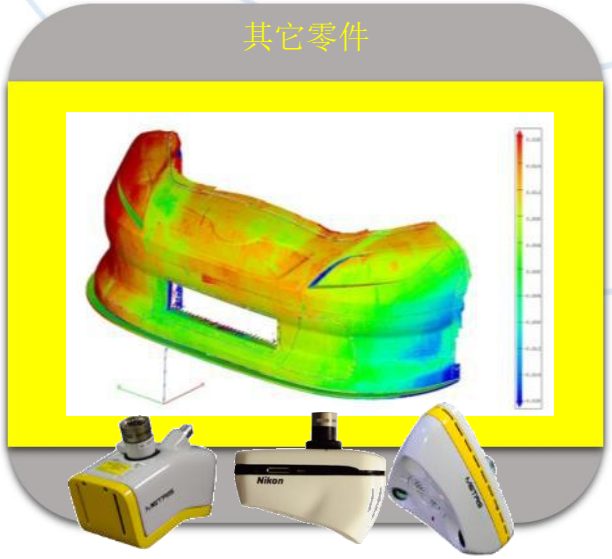


涡轮叶片



其它零件



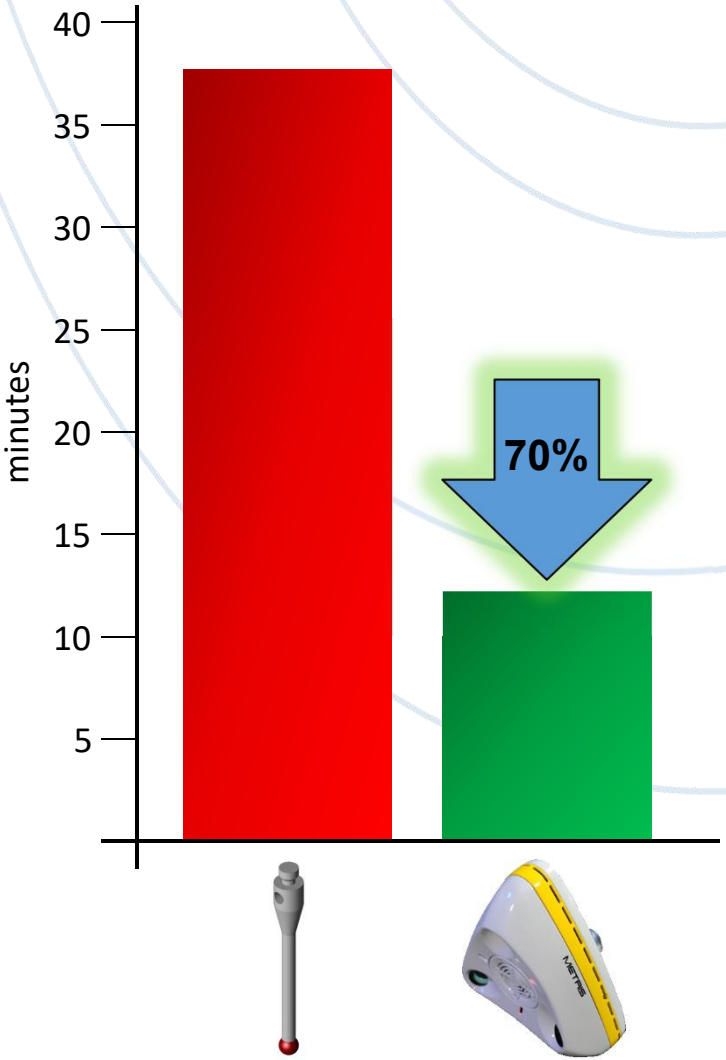
控制器兼容性

控制器厂家	控制器型号	补偿	备注
Nikon Metrology LK	2000 / 2000+	Linear	
	4000	Full	
	AIM/AIM	Full	
	MCC-200 / 250	Full	
	NMC100 / 300	Full	
Hexagon (DEA)	B3C-LC	Full + Rotation	
	B3C-S	Full + Rotation	
	B3P	Full + Rotation	
	B3P-S	Full + Rotation	
	B5P	Full + Rotation	
	B6C-S	Full + Rotation	
Hexagon (Brown & Sharpe)	Sharpe 32C	Full + Rotation	
Hexagon (Sheffield)	SMP300 / 400	Full	
Mitutoyo	UC200E	Full	
	UC220E	Full	
	UC200S / UC200H	Full	
	UC220S / UC220H	Full	
	UC300	Full	
Coord3	P3M	Full	
Wenzel	WPC2010	Full	
	WPC2020	Full	
	WPC2030	Full	
	WPC2040	Full	
Mora – Gemodek	ANC39	Linear	Mora dongle required
	ANC40	Linear	Mora dongle required
Renishaw	UCC1	Linear	
	UCC2	Linear	
Werth	Werth	Full	
Metrolog		Linear	Use Metrolog software
Dukin		Linear	
Zeiss	C99	Full	Requires PH10M, PH10MQ or RDS probe head
DEVA		Full	

为什么要使用激光测头?

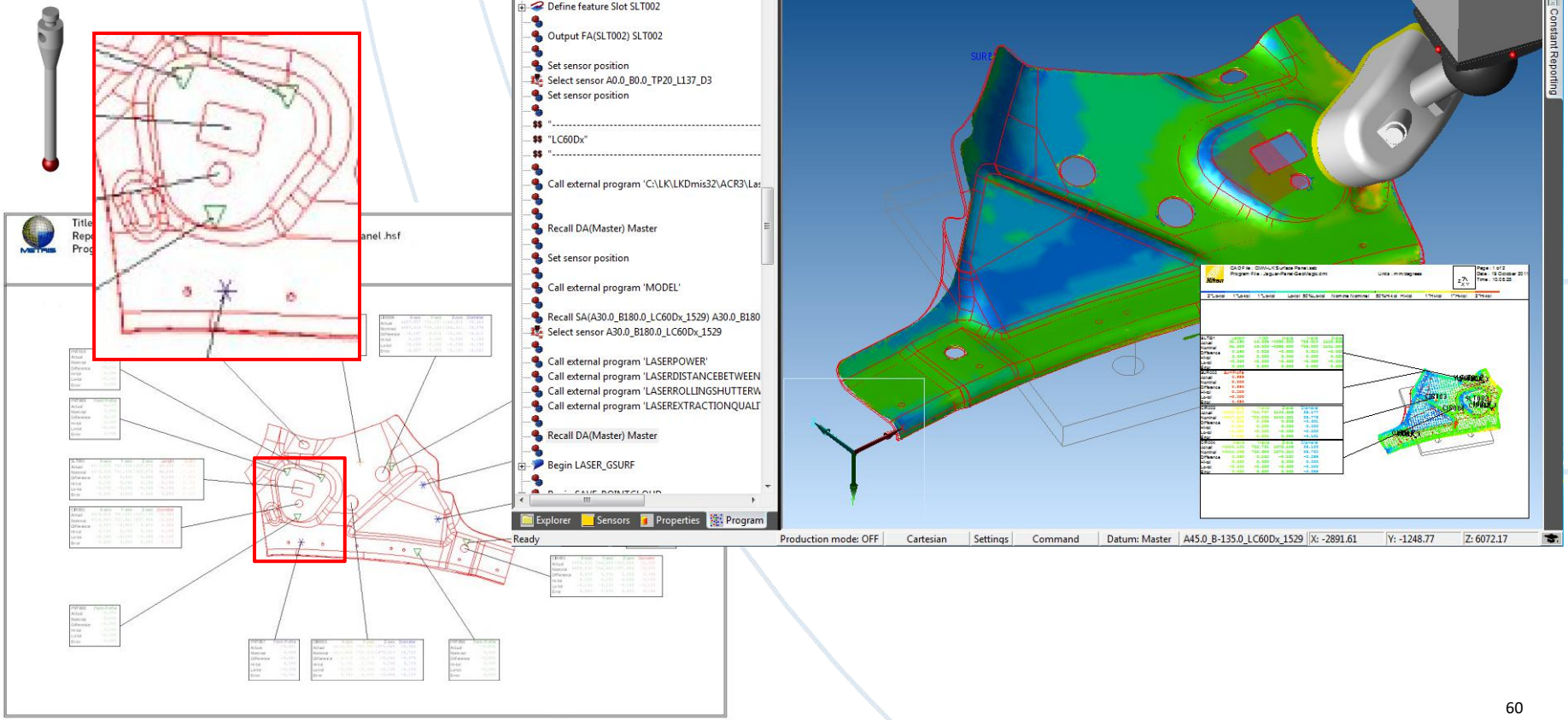
检测速度更快

111 measurements
202 dimensions to report



为什么要使用激光测头?

更多的检测数据




世界上精度最高的单线激光测头
Nikon
EN ISO10360 -2 精度
MPEP : 1.9μm
Nikon LC15Dx

LC60Dx

L100


最好的多线激光测头
Nikon
Nikon XC65Dx

激光测头应用示例 – 福特

Ford Otosan, Turkey's automotive industry leader, uses a Nikon Metrology XC65D laser scanner for the inspection of small commercial vehicles. As an early adopter, Ford Otosan saw laser scanning technology evolve from smaller niche applications to the full-vehicle body inspection of its popular Transit Connect model. Detailed Cross Scanner benchmark tests confirmed similar data quality compared to tactile inspection, and revealed 65% higher throughput. Ford Otosan plans to retrofit 6 cross-departmental CMMs with Nikon Metrology laser scanners, to speed up commercial vehicle production even further.

Technology-focused manufacturing of commercial vehicles

Ford Otosan's success story started in 1961, when Ford Motor Company and Koç Holding established the company in Turkey. Half a century later, Ford Otosan is the undisputed leader in the fast-growing Turkish automotive industry. In 2010, the company expanded its export volume of commercial vehicles by a remarkable 37%, extending total manufacturing capacity to 330.000 units.

"In 2004 the Kocaeli plant became Transit's main worldwide production center, owing to the production quality of Turkish workers and state-of-the-art manufacturing technology," says Murat Öztürk, Dimensional Control Team Leader at the Ford Otosan commercial vehicle plant in Kocaeli, Turkey. "3D laser scanning is an example of an enabling inspection technology currently being deployed more widely at Ford Otosan. We are long-time users of the LC 50 laser scanner for a variety of inspection applications. Today we use an XC65D Cross Scanner to inspect full-vehicle body structures of the Transit Connect, and decided to purchase an additional Nikon Metrology scanner."

The XC65D is a "3-in-1" scanner incorporating 3 laser/camera sets mounted in a cross pattern. Nikon Metrology pioneered multi-sensor scanner technology because it allows geometric features to be captured from different sides simultaneously. This is how the Cross Scanner accurately digitizes the complete shape of slots, sleeves, holes and other feature types in a single scan. Although inherently designed for scanning geometric features, the Cross Scanner is equally suitable for digitizing freeform surfaces and edges.

Tactile inspection on a single vehicle body lasted 36 minutes, whereas laser scanning completed the same job in less than 13 minutes,

Murat Öztürk, Dimensional Control Team Leader at the Ford Otosan

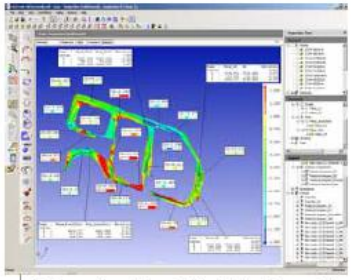
Murat Öztürk, Dimensional Control Team Leader at the Ford Otosan commercial vehicle plant in Kocaeli, Turkey.

Laser scanning versus tactile inspection

The purchase resulted from a detailed comparative study involving both laser scanning and touch probe measurement. Murat Öztürk explained that the study entailed the serial inspection of a number of Connect vehicle bodies. One CMM captured the right half of the body using the XC65D laser scanner, while the other took touch probe measurements on the left half of the body. The tactile inspection CMM was equipped with a TP20 probe mounted on a PH10M indexing head. Both automated inspection methods were set up to measure exactly the same features, pillars, panels, etc. in a mirrored layout.

"Tactile inspection on a single vehicle body lasted 36 minutes, whereas laser scanning completed the same job in less than 13 minutes," says Öztürk. "For data acquisition alone time savings exceeded 65% compared to tactile point-by-point data capture. The XC65D laser scanner generates point cloud data at a high scan rate, allowing it to digitize the body surface relatively fast. The Cross Scanner saves additional time by capturing the complete geometry of features without requiring repeated scans taken from different directions."

In terms of data quality, there was hardly any difference between laser scanning and touch sensor measurement. Detailed analysis of inspection results revealed that overall laser scanning results were slightly better. Although both technologies meet the 20-50 micron precision level required for sheet metal, the multitude of measuring points captured by laser scanners makes a difference. This aspect is critical in digitizing freeform surfaces completely and extracting geometric features accurately. Acquiring the accurate positions of features, edges and surface shapes is imperative to verify the process quality of mating parts and judge vehicle body assembly accuracy.



Graphic comparison against nominal CAD steers preventive measures in the vehicle body assembly line.

Laser scanners acquire point clouds that support accurate geometric feature extraction from the cloud.

Ford Otosan successfully made the shift to the XC65D laser scanner for mainstream vehicle body inspection.

The Nikon Metrology XC65D laser scanner captures geometric features from 3 sides simultaneously.

Faster inspection – Better insight – Higher vehicle quality

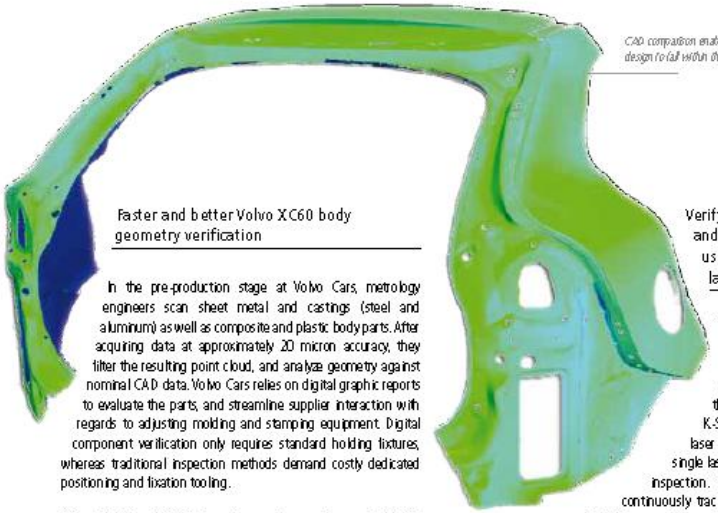
According to Öztürk, laser scanning simplified the entire vehicle body inspection process. "Defining the straightforward scanner travel paths is easier for us than specifying individual touch probe points for a tactile inspection job. After acquiring the data, the Nikon Metrology Focus software automatically filters the resulting point cloud and fits a 3D surface through the points. The same software processes the scan data for numerical analysis as well as graphic comparison against nominal CAD. Color-coded visual inspection reports help us understand the source of the slightest deviation in feature positioning or surface geometry. This information provides the insight we need to take appropriate preventive measures in the vehicle body assembly line."

"Non-contact vehicle body measurement speeds up every step in the process, and delivers more profound insight to take better-informed manufacturing decisions," concludes Öztürk. "With our latest scanner purchase, we will have a dual-arm CMM fully operational with laser scanning and Focus point cloud processing software. Also during new model vehicle launch projects, we use laser scanning to digitize complete individual parts for analysis purposes. In this regard, detailed scan reports are very useful for detailed evaluations run in our own department as well as collaborative work done with other departments. For the future, we consider having 6 CMMs in different departments equipped with laser scanners from Nikon Metrology. This complies with Ford Otosan's strategy to strengthen our competitive edge through technologies that increase product quality and process efficiency."

More information about Ford Otosan can be found at http://www.fordotosan.com.tr/en/default.htm

More information about Laser scanners can be found at http://www.nikonmetrology.com/cmm_scanners/

激光测头应用示例 – Volvo



CAD comparison enables Volvo Cars to alter component design to fall within the assembly processing window.

Faster and better Volvo XC60 body geometry verification

In the pre-production stage at Volvo Cars, metrology engineers scan sheet metal and castings (steel and aluminum) as well as composite and plastic body parts. After acquiring data at approximately 20 micron accuracy, they filter the resulting point cloud, and analyze geometry against nominal CAD data. Volvo Cars relies on digital graphic reports to evaluate the parts, and streamline supplier interaction with regards to adjusting molding and stamping equipment. Digital component verification only requires standard holding fixtures, whereas traditional inspection methods demand costly dedicated positioning and fixation tooling.

After digitizing individual parts, engineers align and virtually assemble sheet metal, interior, exterior and chassis components in software in order to build a complete virtual vehicle body. Even before body parts are physically assembled, the new geometric verification approach gives already information about potential part fitting issues. To run specialized investigations, virtual body assembly models are loaded into dedicated software for reverse engineering, variation analysis, and spring-back prediction, for example. Analysis between scanned and numerical vehicle body models enables us to efficiently tune component geometry to fall within the assembly processing window.

Verifying surfaces and features using handheld laser scanners

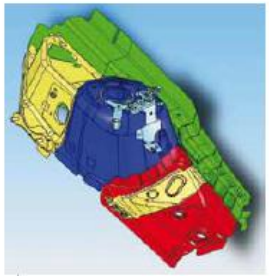
The collaboration project with Volvo Cars also contributed to the development of K-Scan, a handheld laser scanner with a single laser stripe for in-situ inspection. An optical CMM continuously tracks the scanner so that the operator can freely walk around and take scans in an area that spans an entire vehicle. Volvo engineers use K-Scan to verify flush & gap, body deformation and static/dynamic geometry on prototype or early production vehicles. Color-coded visual inspection reports illustrate how flush & gap evolves along complete spines in between hood and front fender, for example. Optical handheld verification also includes special cases where manual methods fall short, such as zero gaps, or in case an urgent issue comes up that needs fast troubleshooting.

Nikon Metrology's cross scanner @ volvo cars gent

XC50-LS is an innovative cross scanner that digitizes sheet metal and plastic body parts.

- Captures all details of geometric features in a single scan
- Accelerates inspection preparation and execution
- Drives virtual body assembly and speeds up pre-production geometry verification

Micro-CT helped reveal a 30 million-year-old fossil's internal anatomy, including stomach, gills, and even muscle tissue.

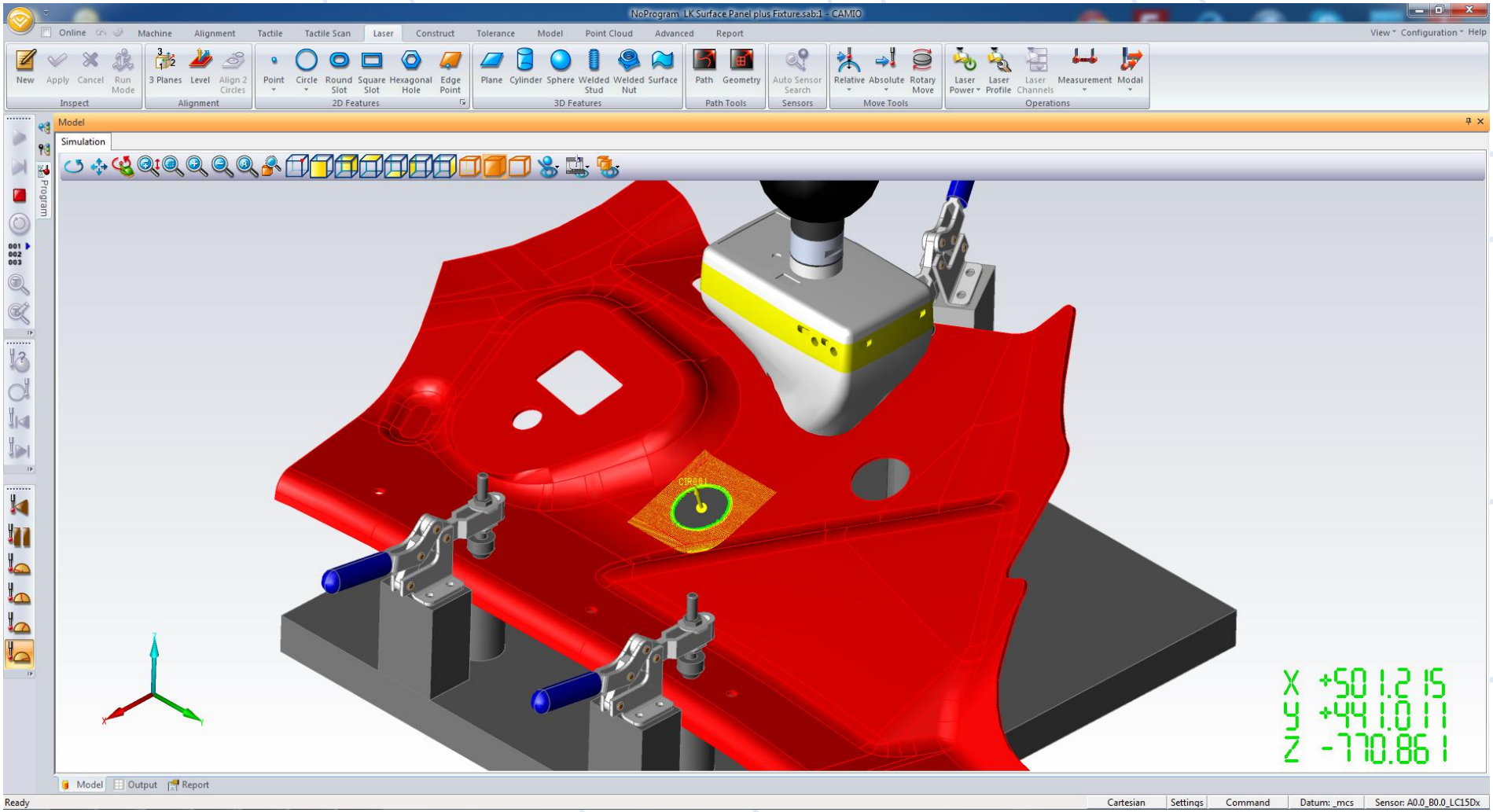


As body parts can be digitized, assembled and evaluated with metrology precision, 3D scanning speeds up the entire vehicle body development process.

More information about Volvo Cars Gent can be found at http://www.volvocarsgent.be/nl/index.htm

More information about XT H can be found at http://www.nikonmetrology.com/cmm_scanners/

CAMIO8


NoProgram LK Surface Panel plus Fixture.sab1 - CAMIO
Online
Machine
Alignment
Tactile
Tactile Scan
Laser
Construct
Tolerance
Model
Point Cloud
Advanced
Report
View
Configuration
Help
New
Apply
Cancel
Run Mode
Inspect
3 Planes
Level
Align 2 Circles
Alignment
Point
Circle
Round Slot
Square Slot
Hexagonal Hole
Edge Point
2D Features
Plane
Cylinder
Sphere
Welded Stud
Welded Nut
Surface
3D Features
Path
Geometry
Path Tools
Auto Sensor Search
Sensors
Relative
Absolute
Rotary Move
Move Tools
Laser Power
Laser Profile
Laser Channels
Measurement
Modal
Operations
Model
Simulation
Program
X +501.215
Y +441.011
Z -770.861
Model
Output
Report
Ready
Cartesian
Settings
Command
Datum: _mcs
Sensor: A0.0_B0.0_LC15Dx

CAMIO8 – CAD 格式支持

Formats	File Formats	Product Structure	Geometry	Semantic PMI
ACIS	.sat, .sab	R1 – 2017 1.0	R1 – 2017 1.0	N/A
CATIA V4	.model, .exp, .session	4.1.9 – 4.2.4	4.1.9 – 4.2.4	N/A
CATIA V5	.CATPart, .CATProduct	V5R8 – V5–6R2016	V5R8 – V5–6R2016	V5R8 – V5–6R2016
CATIA V6	.CATPart, .CATProduct	Up to V6 R2016x	V6 R2016x	V6 R2016x
IGES	.igs, .iges	Up to 5.3	Up to 5.3	N/A
NX	.prt	NX 1 – NX 11	NX 1 – NX 11	NX 1 – NX 11
Parasolid	.x_t, ..x_b	9.0.* – 29.0.137	9.0.* – 29.0.137	N/A
Pro/E / Creo	.prt, .asm	16 – Creo 3.0	16 – Creo 3.0	16 – Creo 3.0
SolidWorks	.sldprt, .sldasm	2003 – 2017	2003 – 2017	2014 – 2016
STEP	.stp, .step	203, 214	203, 214	N/A
VDA-FS	.vda	1.0 – 2.0	1.0 – 2.0	N/A
JT	.jt	JT 8.x and 9.x	JT 8.x and 9.x	N/A
DXF/DWG	.dxf, .dwg	2.5 – 2016	2.5 – 2016	N/A
Solid Edge	.par, .asm, .psm	V18 – ST9	V18 – ST9	N/A

CAMIO8 – 综合检测报告

Reporting toolbar

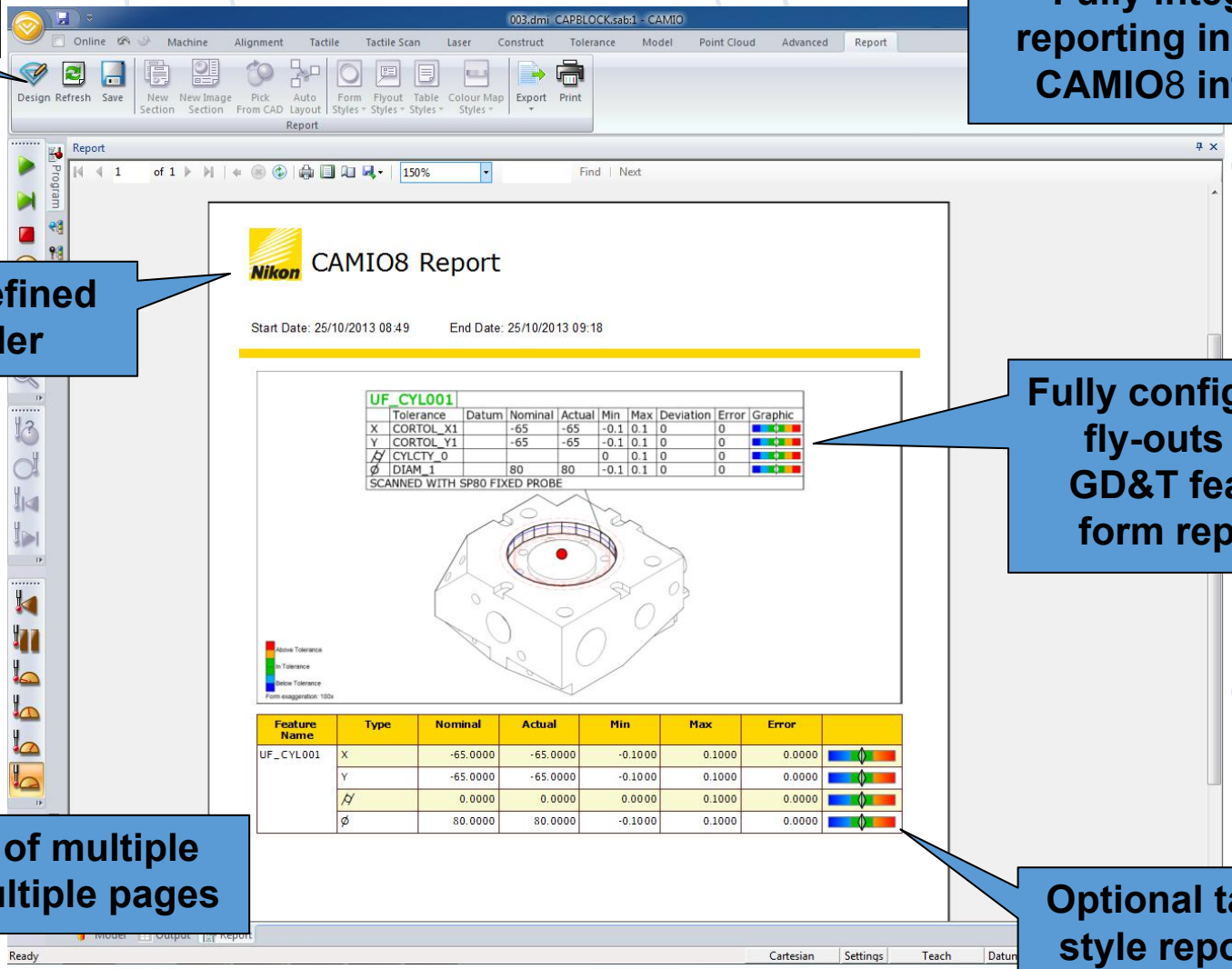
Fully integrated reporting inside the CAMIO8 interface

User defined header

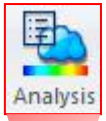
Fully configurable fly-outs and GD&T feature form reports

Capable of multiple views, multiple pages

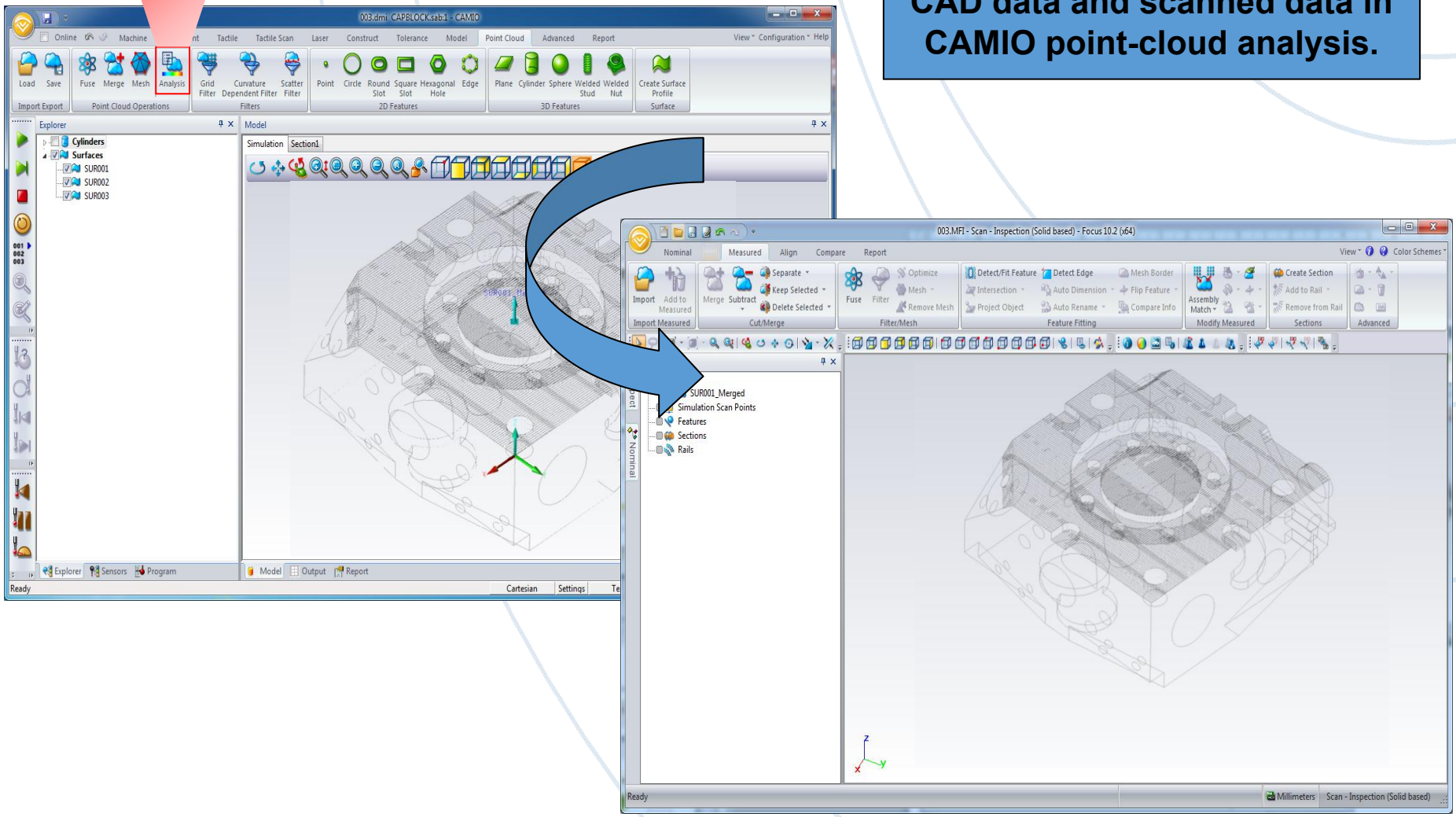
Optional table style reports



CAMIO8 – 点云分析模块（选件）

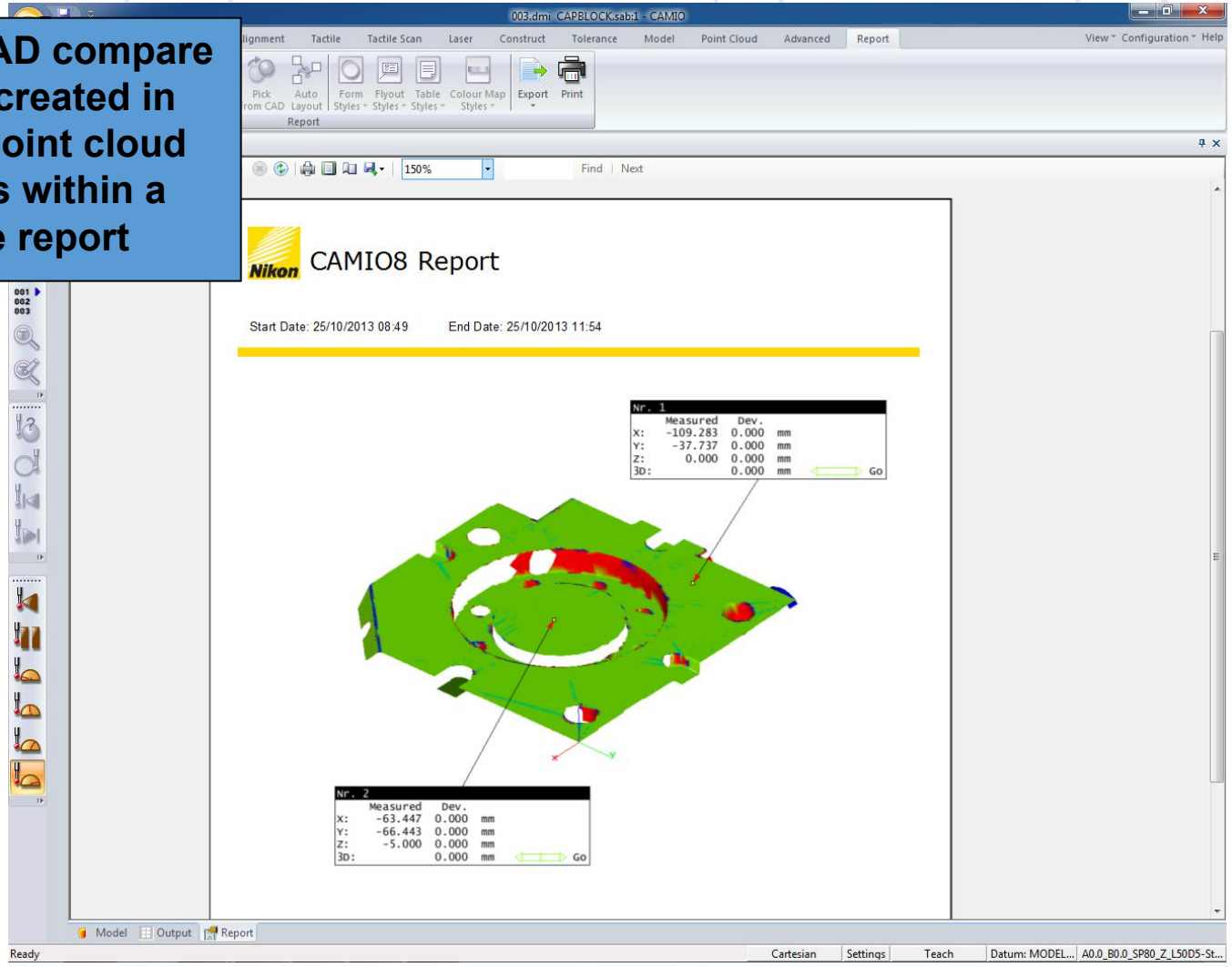


One-click operation to view CAD data and scanned data in CAMIO point-cloud analysis.



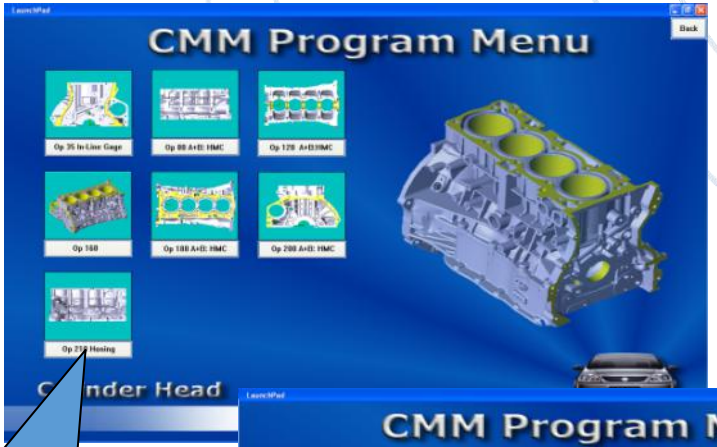
CAMIO8 – 激光扫描报告（选件）

Include CAD compare reports created in CAMIO point cloud analysis within a single report

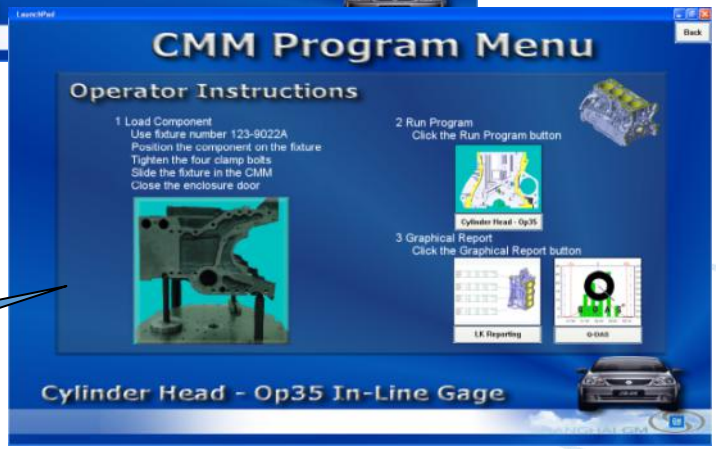


CAMIO8 – Launchpad (标准配置)

目录树式的菜单结构



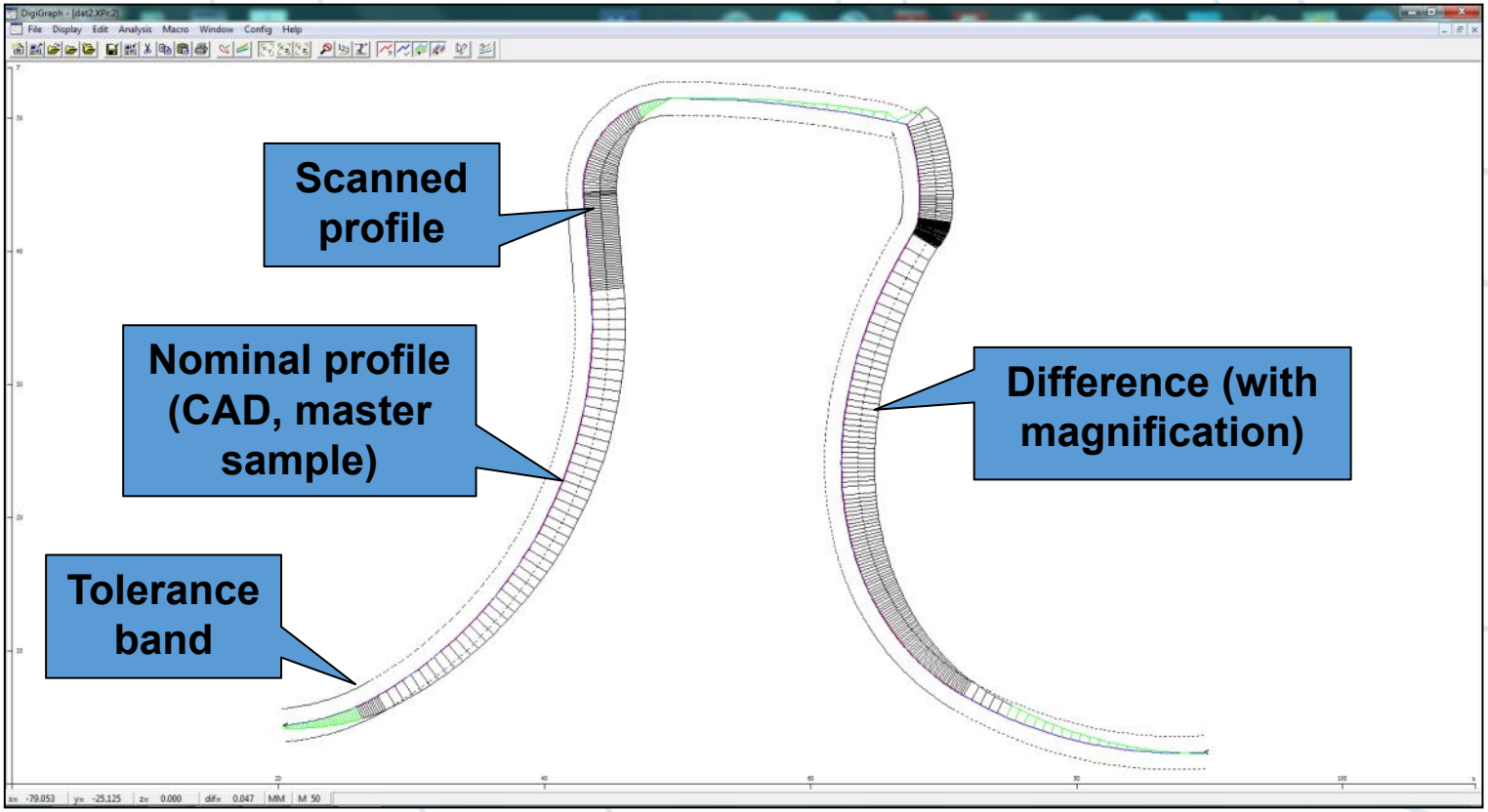
用户使用零件照片及其它媒体自动调用检测程序



… 不仅使用工件照片

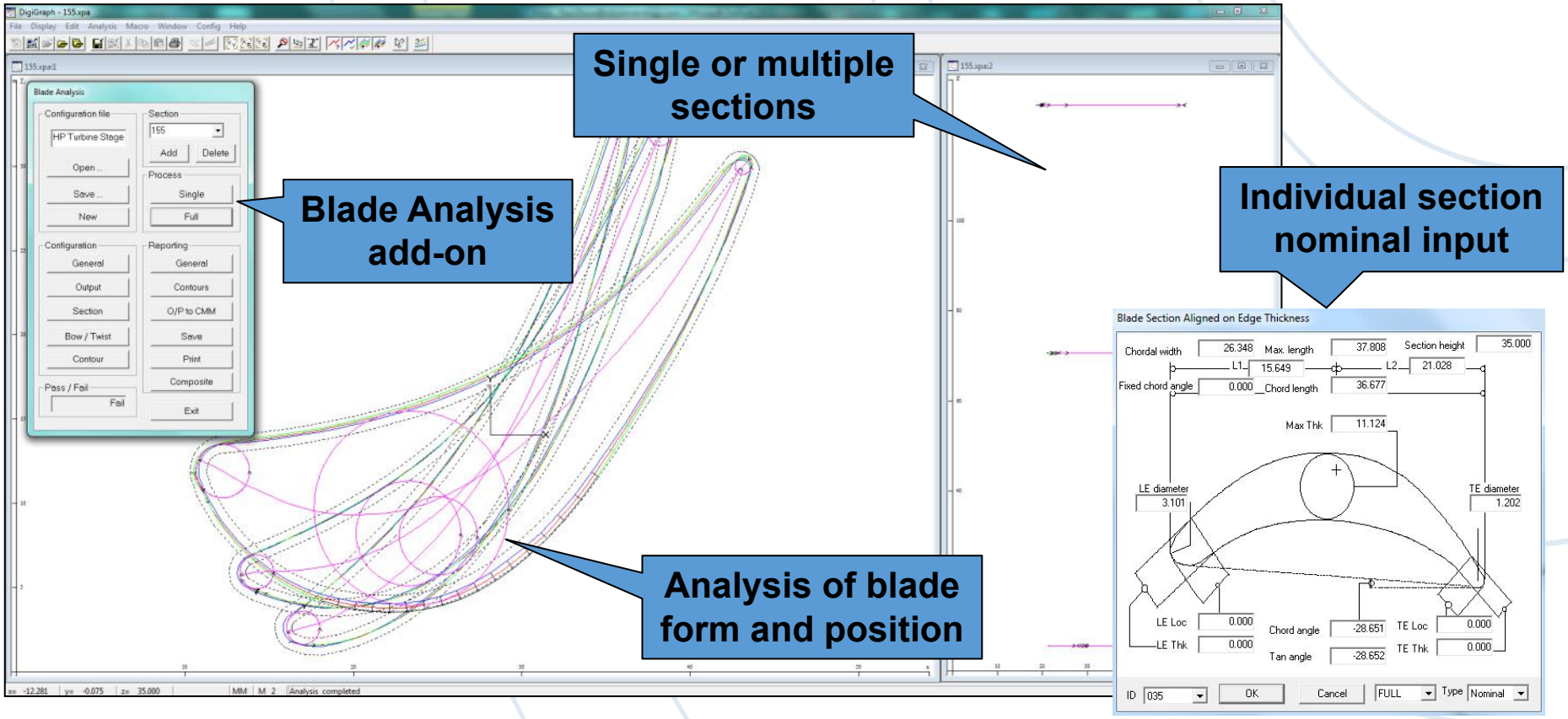
- 按照用户定义的工件照片，自动调用和执行测量程序并生成定制的检测报告
- 可记录用户选择的工件照片，或预先录制的音频及视频，指导后续操作人员如何摆放工件，然后自动执行检测程序

CAMIO8 – Digigraph 曲线分析软件（选件）



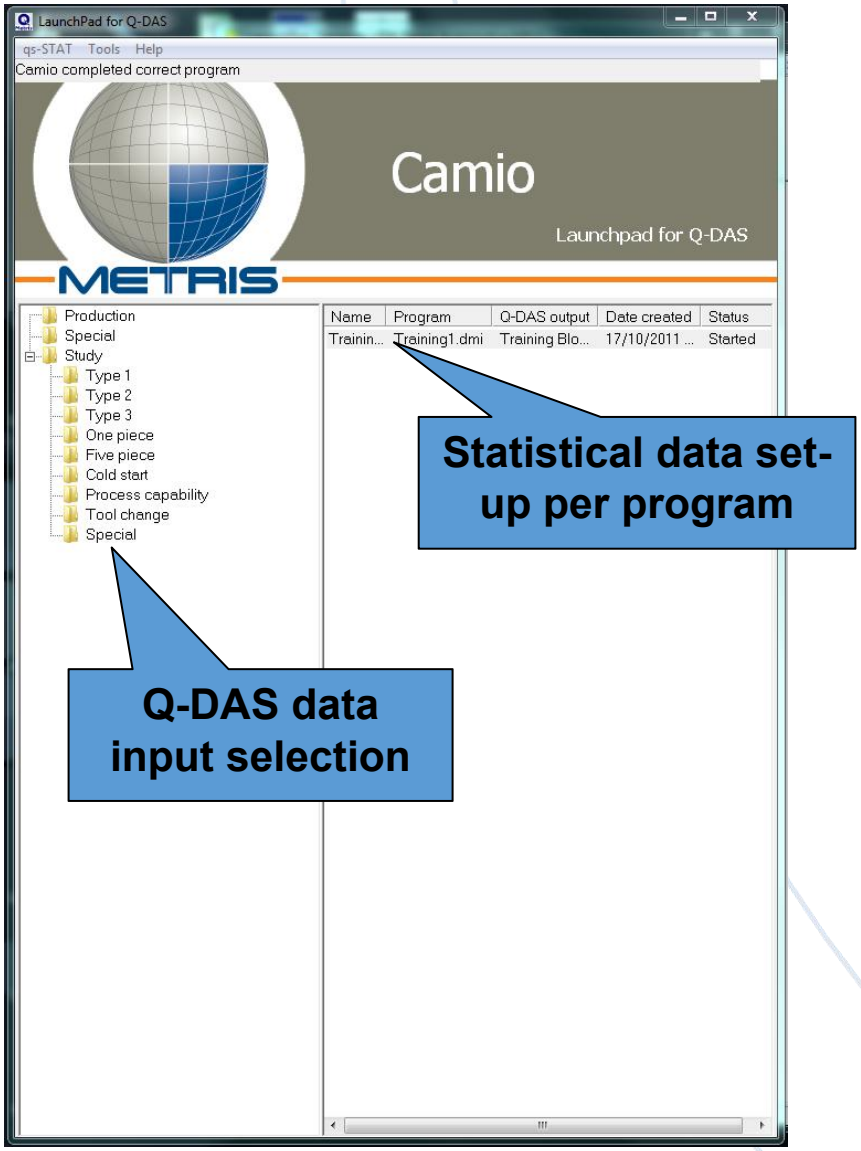
- **Automated 2D shadowgraph with automatic (or manual) best-fit function**
- **Macro record/playback capability**
- **Ideal with digital or analogue scanning**

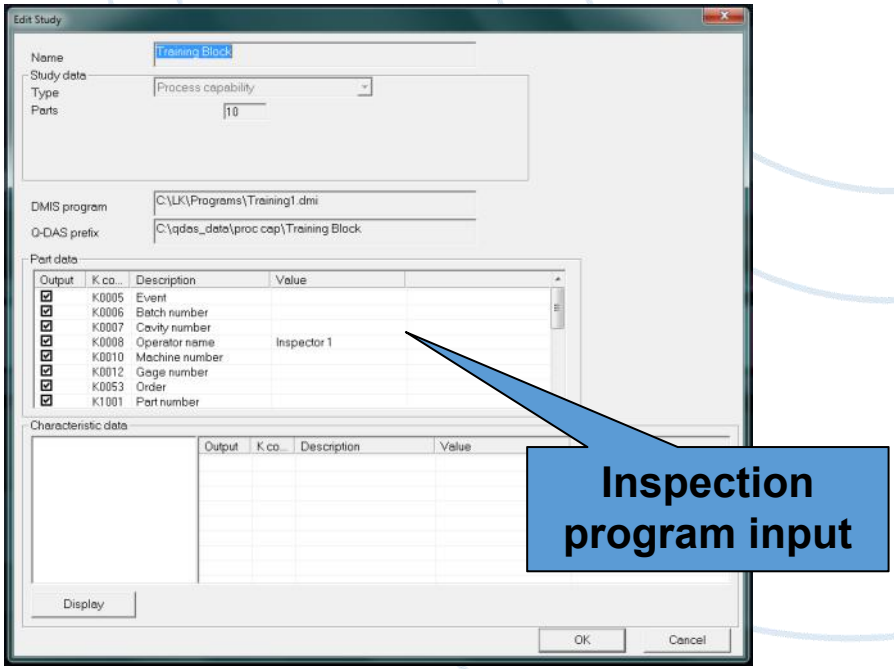
(...continued) 叶片分析模块



- **Automated 2D shadowgraph with automatic (or manual) best-fit function PLUS specific analysis and reporting for blade form section(s)**
- **Macro record/playback capability**
- **Ideal with digital or analogue scanning**

CAMIO8 – Q-DAS（选件）





- **Execute measurement programs with data output for Q-DAS software**
- **Automatic creation of Q-DAS data input files for analysis of SPC in Q-DAS**
- **Q-DAS software not supplied**
- **Fully approved by Q-DAS**

FOCUS11.x 软件

FOCUS software – two applications, sharing one interface

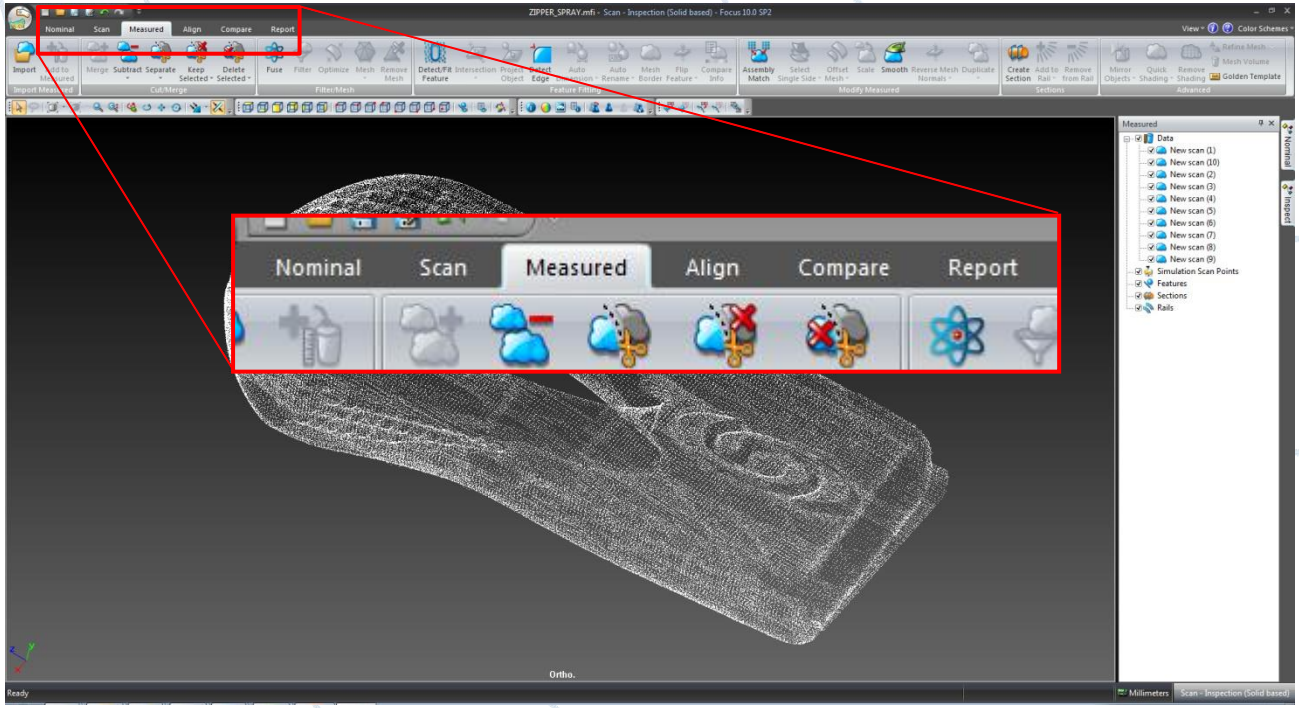
FOCUS10 Scan: Data collection

➔ **Data collection and point cloud editing (online/offline with CAD)**

FOCUS10 Inspection: Point cloud analysis and reporting

➔ **Point cloud editing, alignment to CAD, CAD compare, geometric analysis, GD&T and graphical reporting**

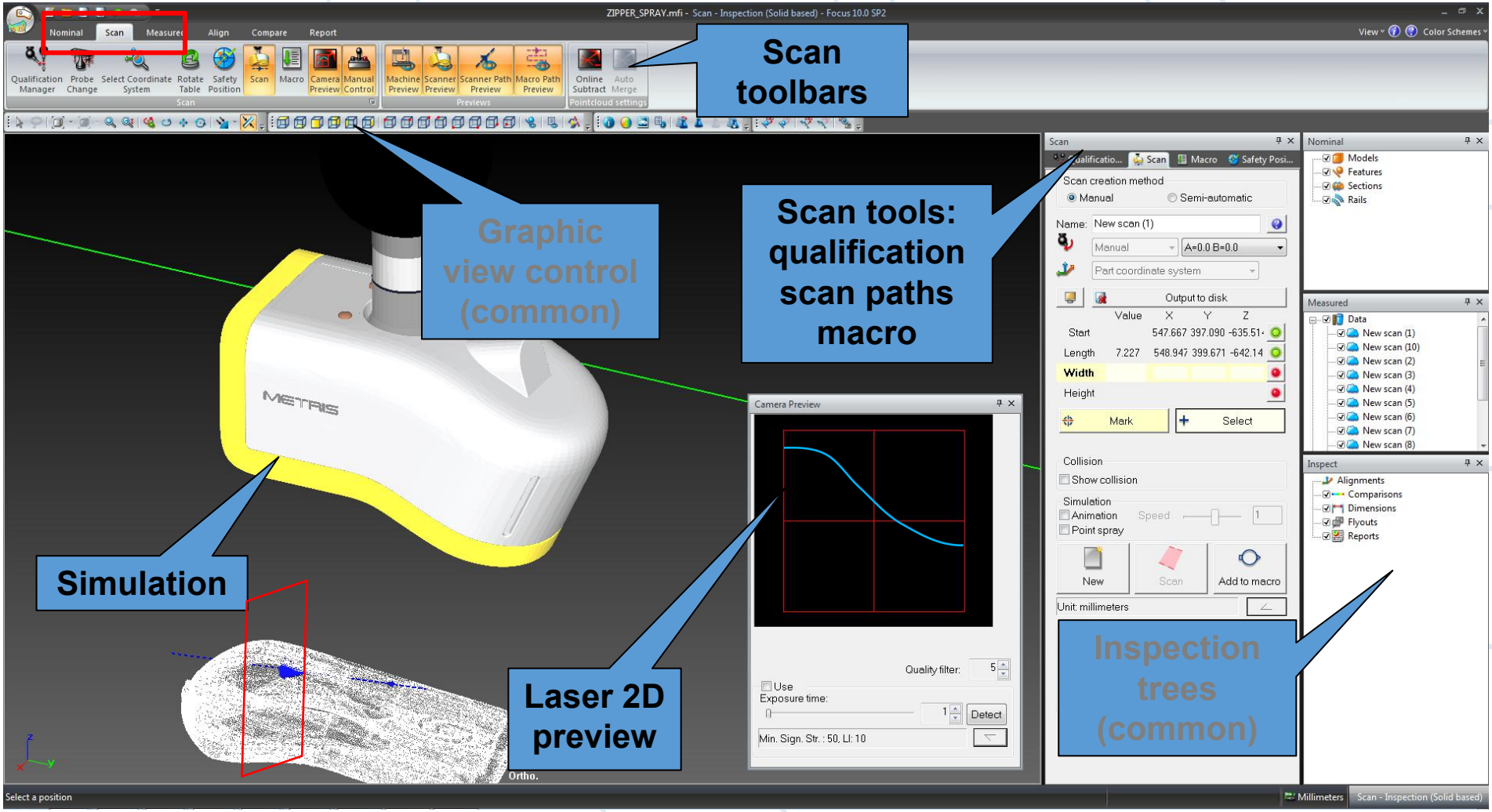
'Fuse'
assembly match
remove points
merge
filter
smooth
mesh
export/save



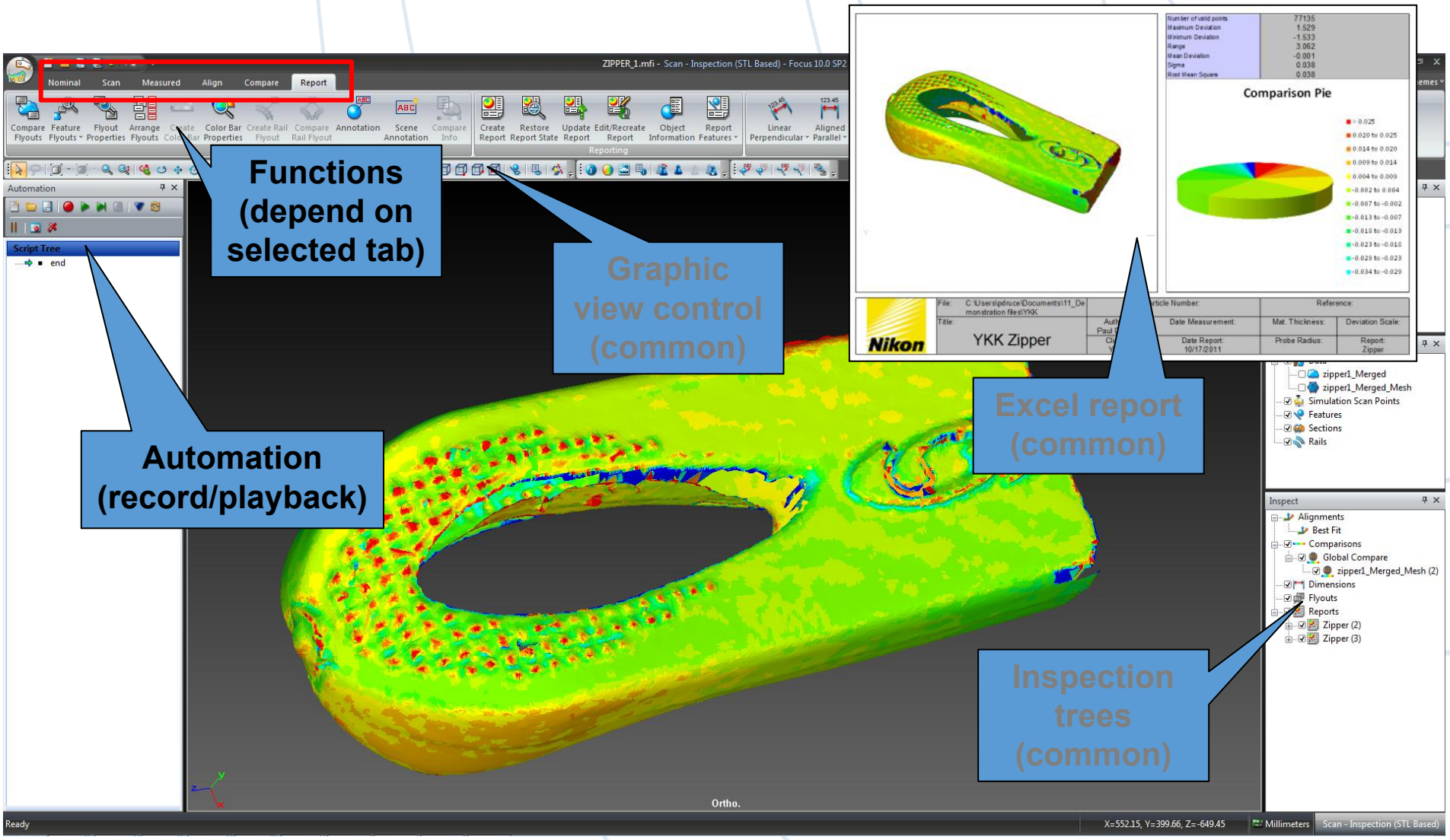
FOCUS11 – CAD 格式支持

Formats	File Formats	Product Structure	Geometry	Semantic PMI
ACIS	.sat, .sab	R1 – 2017 1.0	R1 – 2017 1.0	N/A
CATIA V4	.model, .exp, .session	4.1.9 – 4.2.4	4.1.9 – 4.2.4	N/A
CATIA V5	.CATPart, .CATProduct	V5R8 – 5–6R2016	V5R8 – V5–6R2016	V5R8 – V5–6R2016
3DExperience (CATIA V6)	.CATPart, .CATProduct	Up to V6 R2016x	Up to V6 R2016x	Up to V6 R2016x
IGES	.igs, .iges	Up to 5.3	Up to 5.3	N/A
NX	.prt	NX 1 – NX 11	NX 1 – NX 11	NX 1 – NX 11
Parasolid	.x_t, .x_b	9.0.x – 29.0.x	9.0.x – 29.0.x	N/A
Pro/E / Creo	.prt, .asm	16 – Creo 3.0	16 – Creo 3.0	16 – Creo 3.0
SolidWorks	.sldprt, .sldasm	2003 – 2017	2003 – 2017	2014 – 2017
STEP	.stp, .step	AP203, AP214, AP242	AP203, AP214, AP242	N/A
VDA-FS	.vda	1.0 – 2.0	1.0 – 2.0	N/A

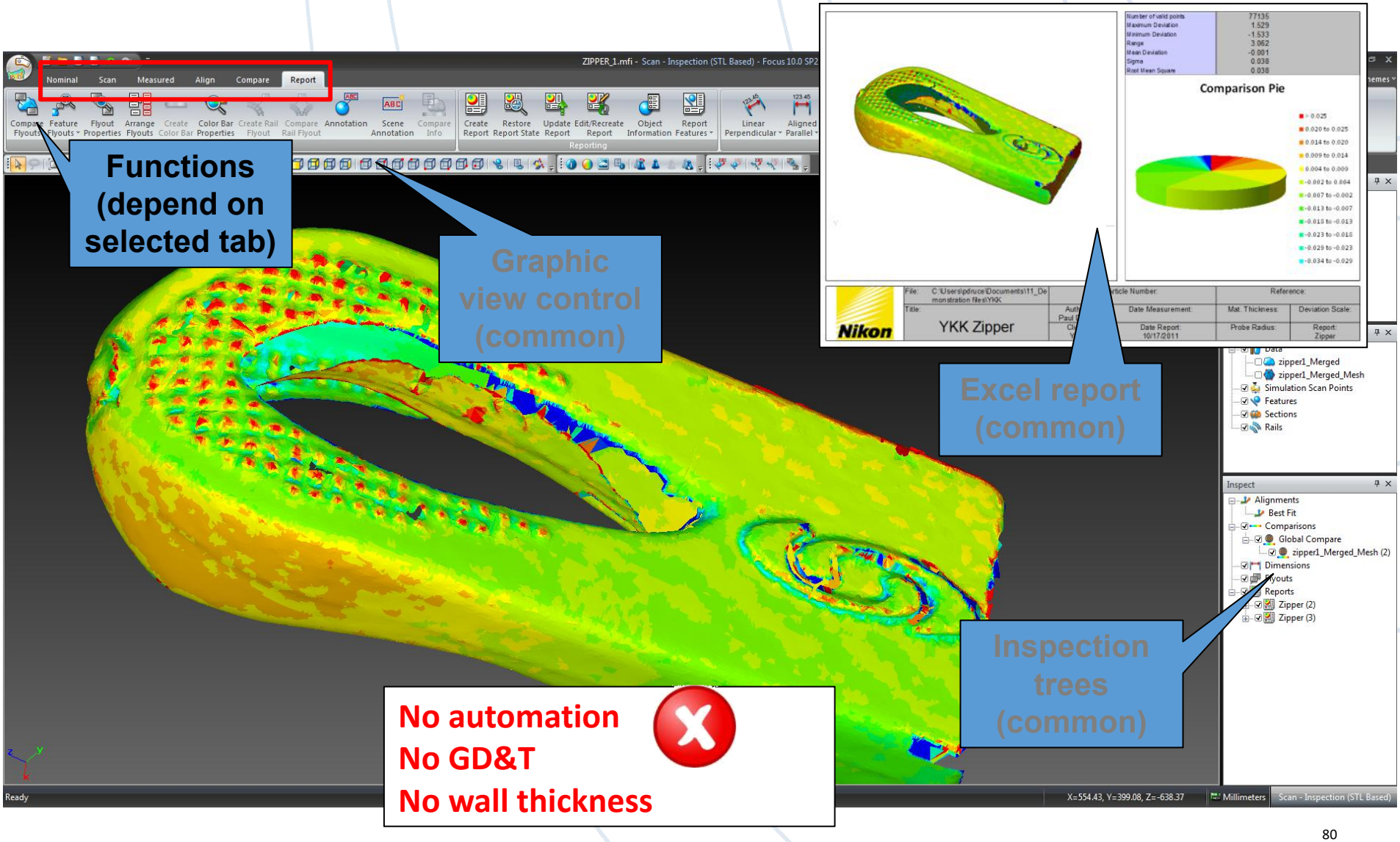
FOCUS11 扫描


Scan toolbars
Graphic view control (common)
Scan tools: qualification scan paths macro
Simulation
Laser 2D preview
Inspection trees (common)
ZIPPER_SPRAY.mfi - Scan - Inspection (Solid based) - Focus 10.0 SP2
Nominal
Scan
Measured
Align
Compare
Report
Qualification Manager
Probe Change
Select Coordinate System
Rotate Table
Safety Position
Scan
Macro
Camera Preview
Manual Control
Machine Preview
Scanner Preview
Scanner Path Preview
Macro Path Preview
Online Subtract
Auto Merge
Scan creation method
Manual
Semi-automatic
Name: New scan (1)
Part coordinate system
Output to disk
Value X Y Z
Start 547.667 397.090 -635.51
Length 7.227 548.947 399.671 -642.14
Width
Height
Mark
Select
Collision
Show collision
Simulation
Animation
Speed
Point spray
New
Scan
Add to macro
Unit: millimeters
Camera Preview
Quality filter:
Use
Exposure time:
Detect
Min. Sign. Str. : 50, LI: 10
Nominal
Models
Features
Sections
Rails
Measured
Data
New scan (1)
New scan (10)
New scan (2)
New scan (3)
New scan (4)
New scan (5)
New scan (6)
New scan (7)
New scan (8)
Inspect
Alignments
Comparisons
Dimensions
Flyouts
Reports
Ortho.
Select a position
Millimeters
Scan - Inspection (Solid based)

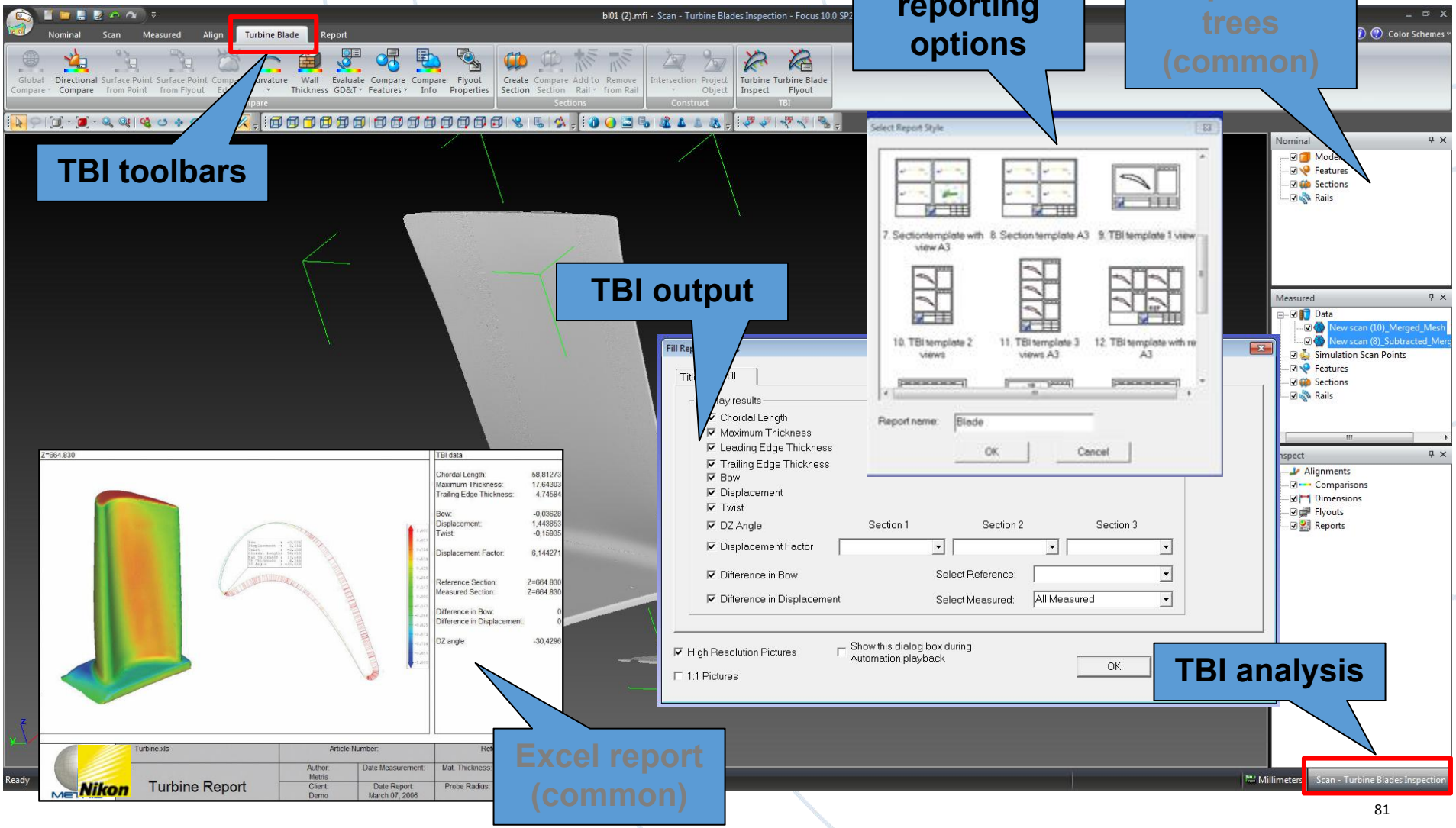
FOCUS11 检测


Functions (depend on selected tab)
Graphic view control (common)
Automation (record/playback)
Excel report (common)
Inspection trees (common)
Nominal
Scan
Measured
Align
Compare
Report
Comparison Pie
YKK Zipper
Nikon
Automation
Script Tree
end
Inspect
Alignments
Best Fit
Comparisons
Global Compare
Dimensions
Flyouts
Reports
Ortho.
Ready

FOCUS11 检测简单版



FOCUS11 检测 – 叶片分析模块（选件）



中国区部分客户

- 1. 汽车行业
- 2. 航空行业
- 3. 加工行业
- 4. 机车行业
- 5. 激光应用客户
- 6.大机器客户
- 7. 大学研究所

汽车行业部分客户

一. 最大客户：通用集团

1.上海通用：　　15台 桥机11台（EV+SP25） 双悬臂4台

2. 武汉通用：　　桥机3台（REVO）双悬臂3台

3. 沈阳北盛通用：　双悬臂2台

4. 烟台通用东岳动力总成：　桥机2台（EV+TP20）

测量车身及发动机

汽车行业部分客户

二. 东风集团

康明斯及东风集团其他厂

桥机8台（**EV+SP25**） **+**双悬臂**2**台

三. 江铃汽车 奇瑞汽车 上海拖拉机等

江铃桥机**(EV+SP80)**

拖拉机（**LKVSLHA+SP25+L15**）

四. 汽车零配件

上海万泰（永茂泰）东风本田（广州、惠州工厂） 上海汇众 重庆敏特 珠海武汉铭祥 昆山显亮 大连迈艾特 延锋百利得 宁波汇众 沈阳万泰 皮尔博格上海，

航空行业部分客户

一. 最大客户：赛峰集团

1. 苏州斯奈克玛： 7台

2. 苏州梅西埃： 2台

二. 北京中航 桥机4台 (EV+SP25）

三. 西航 桥机4台 (EV+SP25）

四. 上海航天设备制造有限公司 中国航天长征机械厂（成都） 首都航天机械有限公司 天津火箭211研究所，深圳光启高等理工研究院，贵州黎阳航空动力有限公司，沈阳飞机工业（集团）有限公司，中航商用航空发动机有限责任公司，波音747（国外），台风战斗机（国外），F35战斗机（国外），I.U.G. - Romania（国外），波音总部-USA（国外），空客 (UK) – 英国（国外），英国航空 – 英国（国外），Bae 系统公司 – 英国（国外），洛克希德·马丁- USA（国外），TechSpace Aero - Belgium（国外）

加工行业部分客户

一. 福耀集团

上海 北京 厦门 郑州 湖南 重庆 沈阳 长春 福建

苏州新厂 共有**20**多台

桥机**EVXX.15.10**较多

二. 模具厂

上海紫燕 宁波合力 温州合兴 东莞森熵 上海钜祥，东莞翔通塑胶，东莞乐福塑胶、深圳百汇精密等

桥机

三. 电子厂

成都天奥电子 深圳微电子 惠州金山电子 温州合兴电子

小型桥机，深圳欣天科技，深圳创维集团，捷普电子，惠州住润电子、深圳方正微电子

机车行业部分客户

一. 中车戚墅堰

Ultima 60.25.20 LK V20.12.10SLHA

二.广州机车检修基地 LKV25.12.10SLHA

三. 天津铁路信号

G80C桥机

激光行业部分客户

霍尼韦尔涡轮增压技术（武汉）有限公司
显亮（昆山）汽车配件有限公司
深圳信维通讯股份有限公司
骏伟塑胶制品（太仓）有限公司
伯恩光学（惠州）有限公司
桐乡市凯盛精密机械有限公司
晓星金融设备（惠州）有限公司
苏州强生医疗器械
珠海铭祥汽车有限公司
南京14所 北京电子所
晓星金融设备（惠州）有限公司
山东隆基机械股份有限公司
上海万泰汽车零部件有限公司
昆山凯意隆气动元件有限公司
沈阳福耀玻璃
山东三金玻璃机械有限公司
山东永茂泰汽车零部件
安徽永茂泰汽车零部件有限公司
上海万泰汽车零部件有限公司

大机器

悬臂 双悬臂 **HC90**：
东风康明斯 上海通用 沈阳通用 江阴万奇 上海紫燕

大桥机 龙门：
江阴万奇 **Evolution 63 16 20**
卡特比勒徐州 **LY90SWTR 80.16.20**
上海光华印刷机机械有限公司 **Evolution 40.35.25**
戚墅堰机车车辆厂 **Ultima60.25.20**
卡特彼勒(苏州)有限公司 **HY90 80.16.25**
南航立科 天津**211**所 **LKV GP 60.60.30**

大学研究所

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四. 南京理工大学
五. 沈阳工业大学
六. 长春理工大学
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八. 南方科技大学
九. 沈阳理工大学
一〇. 郑州铁路学院
一一. 浙江台州大学
一二. 北京现代职业技术学院
一三. 浙江大学宁波理工学院

一. 沈阳科学仪器研究所
二. 北京机床研究所
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九. 上海应用物理研究所
一〇. 中国航天运载火箭研究院**211**所
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一二. 深圳计量质量检测研究院
一三. 北京计量测试技术研究所
一四. 北京电子所

谢谢