HP-FX

Empowering Precision,
Elevating Automation.

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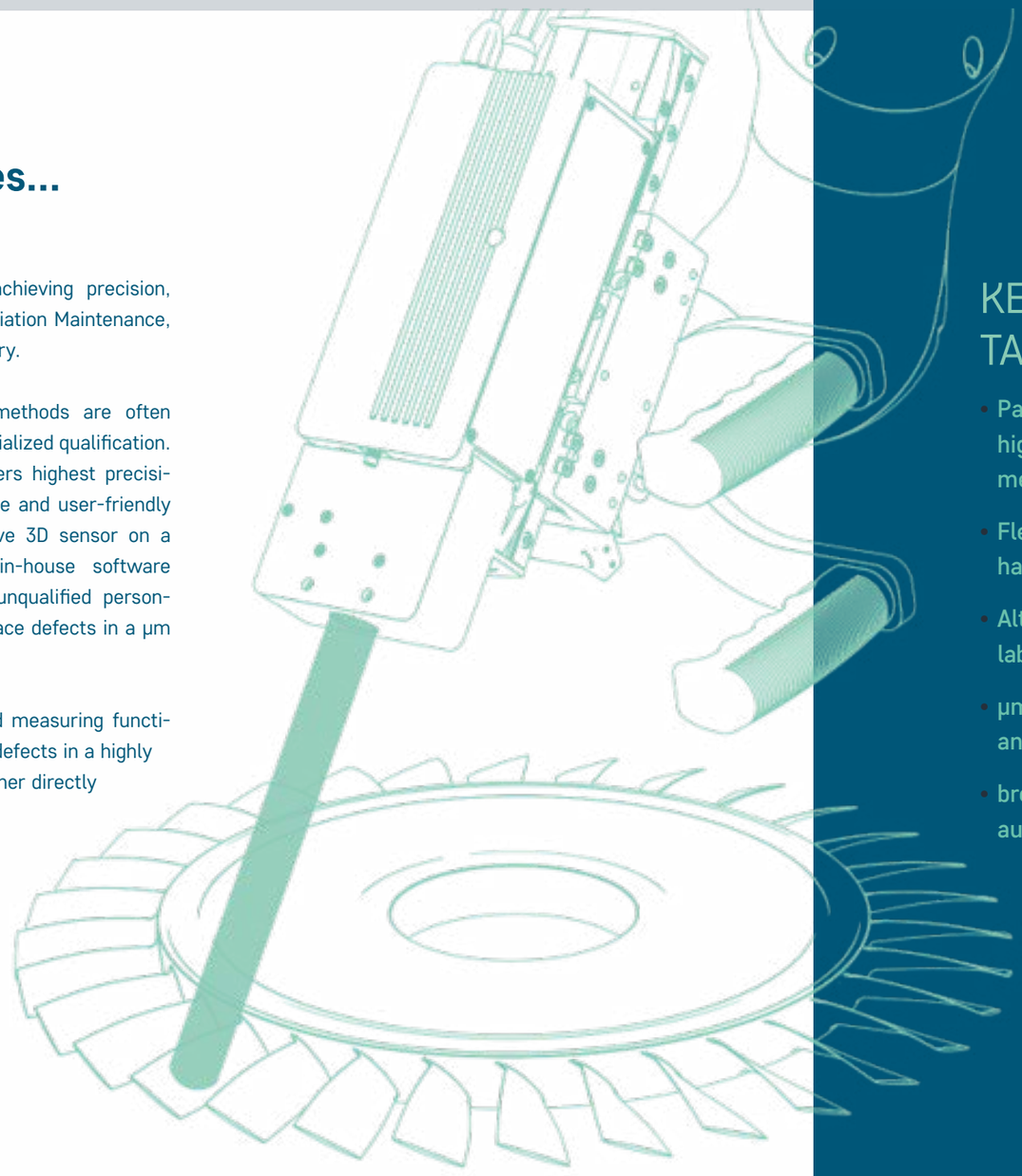
Introduction

HP-FX addresses...

... the current challenges of achieving precision, efficiency and reliability in the aviation Maintenance, Repair and Overhaul (MRO) industry.

Traditional surface inspection methods are often time-consuming and require specialized qualification. Our non-destructive solution offers highest precision on surface inspection in a flexible and user-friendly alternative. Utilizing an innovative 3D sensor on a collaborative robot with our in-house software framework iX3D enables even unqualified personnel to capture and measure surface defects in a µm accuracy within seconds.

A broad bandwidth of automated measuring functions helps the worker to analyse defects in a highly objective and reproduceable manner directly on the shop floor.



KEY TAKEAWAYS

- Part- and surface-independent high precision 3D defect measurement
- Flexible and user-friendly handling
- Alternative to complicated lab machines
- µm accuracy in 3D surface and defect measurement
- broad, expandable toolset for auto-mated measurements

Importance of Inspection

Surface inspection and defect measurement are a crucial aspect of maintenance, repair and overhaul in the aviation industry. Ensuring the integrity of surfaces and the geometries of different defect classes helps maintain safety and performance standards. Especially in the aviation sector, the precision and reliability of a measurement system determine the safety of the aircraft and the passengers. However, current inspection practices often involve taking replicas of defects and sending them to measurement labs, a process that is time-consuming and where results are inspector dependent.

Also, defects are never evaluated directly on the part but always on the defect negative on a different material.

Our **HP-FX** solution in the **High Precision Surface Inspection** (**HP-X**) product line addresses all of these challenges by providing a faster, more reliable and user-friendly alternative that can be used directly on the part and in the workshop. Thus, enhancing efficiency, reliability and safety in the MRO process.

The challenges of surface inspection

An overview of current practices

In the aviation industry it has become the standard inspection process to take a replica of a defect that then needs to be measured in specialized measurement laboratories.

For this process, the worker needs to individually find damages on the part, prepare a special impression compound and take the replica of that damage. Here it is crucial to not include additional contaminating particles like dust to get an optimal replica of the damage. After the compound is hardened, the replica has to be marked, packaged and sent to a measurement laboratory, where a different evaluator performs the measurements. These measurements use complicated lab equipment that need a very high level of specialized training to create and analyse 3D surface data. The points and reference planes have to be calculated and selected manually to find the parameters for each individual defect.

There is also a problem with long queues in the labs, as the measurement with this complex equipment takes and time and is prone to the slightest handling errors. It can therefore takes days or even weeks to get the results for these defects.The evaluation results are undoubtedly in a very high accuracy and highly reliable, but the efficiency can be questioned in such a time-consuming process.

But in the end, these measurements of the replica might still not show the extent of the actual damage. Also, the surface quality on the part can never be inspected with the imprint as well.

Another current practice is to measure damages with hand tools and special gauges directly in the workshop. Also, special tools like the ruby ball stylus pens are used to initially decide if a defect is “large” enough to be measured or if it is below the tolerance.

With these very subjective measures, false negatives are very likely to happen.

By deciding subjectively whether a damage might be within or outside of the tolerance might lead to damages that might have a critical impact on part safety to be dismissed as “too small”.

Here, the human factor is not supported by the right tools to identify the actual damage size in a small amount of time to be efficient and safe at the same time.

Introducing the new solution

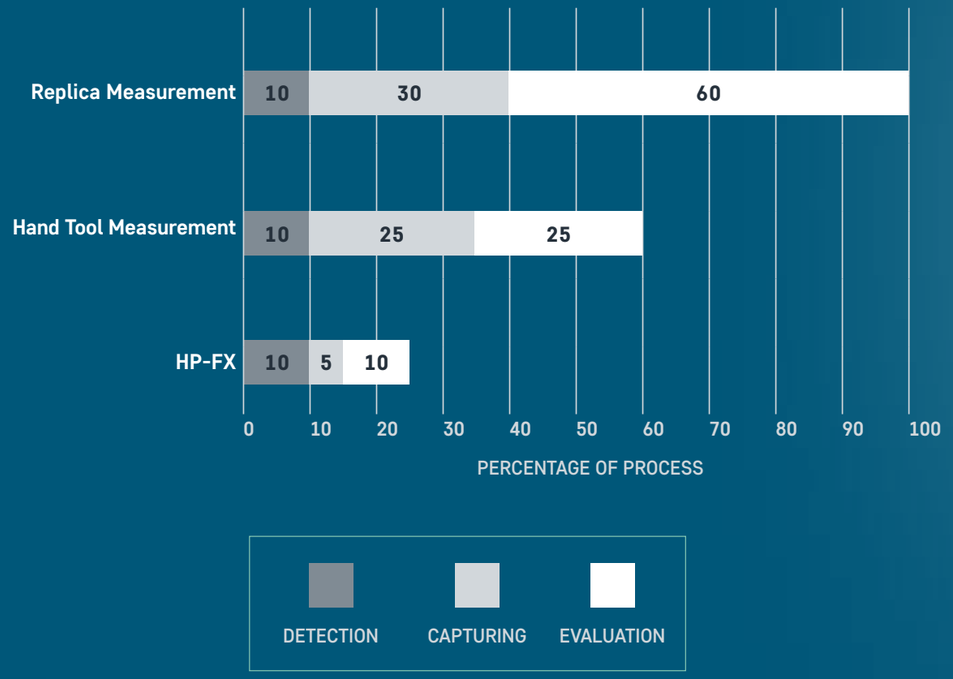
The **HP-FX** system is especially designed to tackle the task of flexible inspection in the workshop. Our optical sensor technology is based on whitelight interferometry, combined with a collaborative robot (cobot) for precise and flexible positioning. This technology enables highly accurate 3D surface measurements, achieving µm-range lateral accuracy and sub-µm vertical resolution.

The system is versatile, capable of measuring various types of surfaces, including highly reflective and absorptive black surfaces, even within the same captured image.

Our software allows for individual measurements within a 3 x 3 mm area and the ability to stitch multiple images together, generating a comprehensive 3D pointcloud. This data can be evaluated without prior image processing expertise, making the system accessible to a broader range of operators.

Our defect evaluation software is highly customizable to individual customer requirements and gives the ability to automatically analyse certain defect types using in-house developed algorithms to find f.e. a defect depth in relation to the part surface (even on curved surfaces).

Time needed for inspection



Technology overview WLI

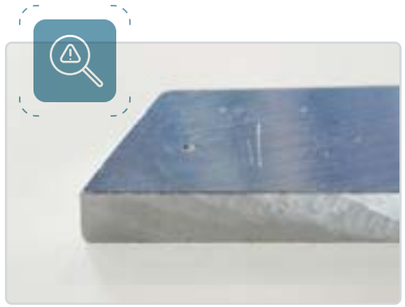
Sensor technology using whitelight interferometry have some key advantages compared to other optical sensors. In the principle of whitelight interferometry, a measurement beam is sent to the part surface and a reference length simultaneously.

The two reflections of these two beams are combined within the sensor and create positive interferences when the two lengths are exactly the same. This delivers an absolute distance measurement for each measurement point within a sub-µm resolution in depth.

The lateral resolution is defined by the sensor optics and creates a trade-off between measurement area and resolution.The optics used in our **HP-FX** solution has a measurement area of 3 x 3 mm and a lateral resolution of 10 µm. While there are other optics with higher resolution but a smaller area or larger area but lower resolution available, our experience shows that this exact combination gives the best results for aviation critical damage sizes.

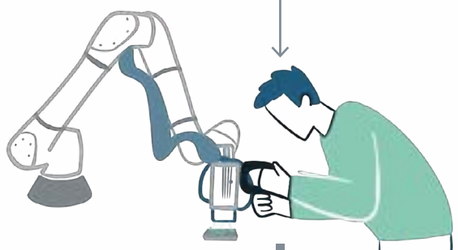
Workflow and Data Examples

The Workflow of the HP-FX system is designed with simplicity, efficiency and user-friendliness in mind:



STEP 1

Anomaly Detection:
The inspection of a defect always starts with the first step: detecting where the anomaly is located.



STEP 2

Manual Sensor Positioning:
Guiding the cobot by hand, the sensor can be positioned accurately over the area to be inspected.

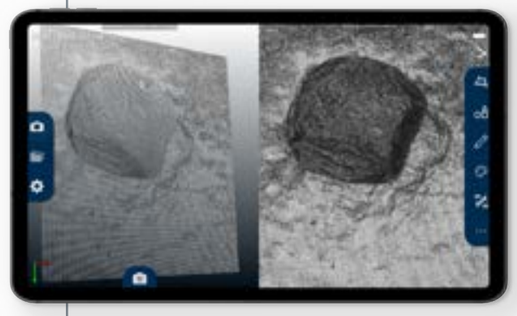
A guiding laser helps to find the optimal distance and position.

STEP 3

Trigger Measurement:
Once the sensor is in position, a measurement can be performed. Individual measurements can be taken in a 3 x 3 mm area, or multiple images can be captured automatically and stitched together for larger areas.

STEP 4

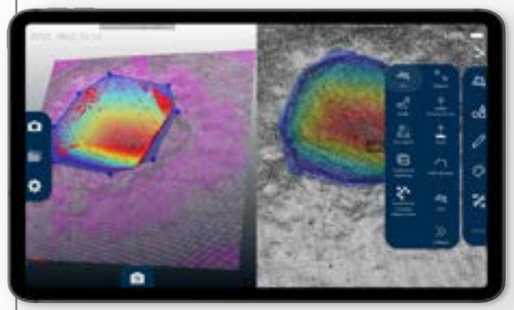
3D Point Cloud Capturing:
The system generates a detailed 3D point cloud of the surface, showing a 2D overview simultaneously.



STEP 5

Defect Evaluation:
Operators can evaluate the surface supported by the system to measure defects without needing advanced image processing skills.

The measurement simply uses a measurement toolbox that lets the operator select an area, where evaluation of dent depth/corrosion area/ crack length etc. takes places automatically.



STEP 6

Reporting:
With our customizable reporting function, a completely individual reporting sheet can be set up and generated in seconds.

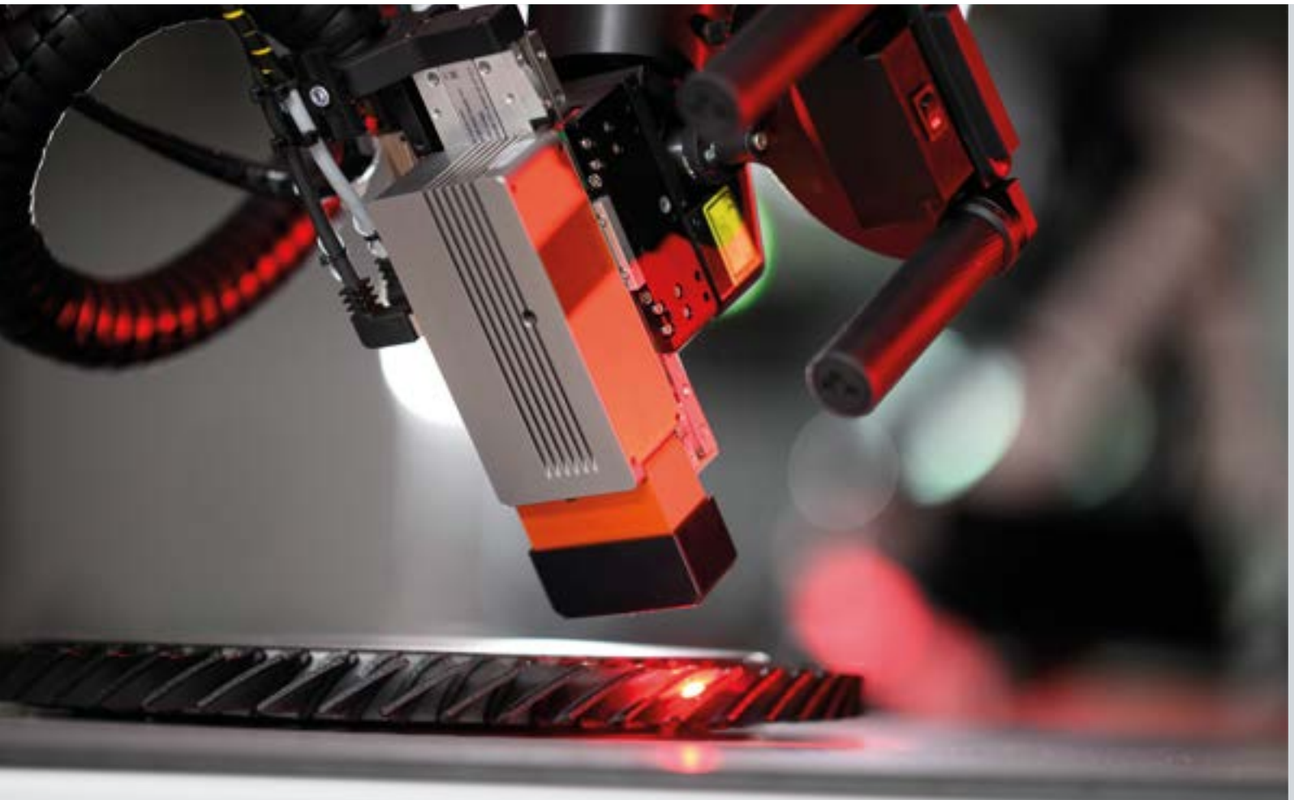
This includes measurements, images of the point cloud and generic data like the part number.

This streamlined process significantly reduces the time and expertise required for high-precision surface inspection.

Benefits

- Surface- and component-independent
- µm accuracy measurement
- Output as 2.5D image and 3D point cloud
- Automated capturing of anomalies > 1 image
- Easy handling and simple user interface
- Target laser and smart software assistants
- Toolset for automatic evaluation of different defect types
- Recording speed < 1s
- Coaxial (line-of-sight) measurement for cavities
- Suitability for shop floor usage
- Mobile system (tool ➔ workpiece)
- Fully calibrated according to VDI/VDE 2617 Sheet 6

Case Studies



DefectMeasurement

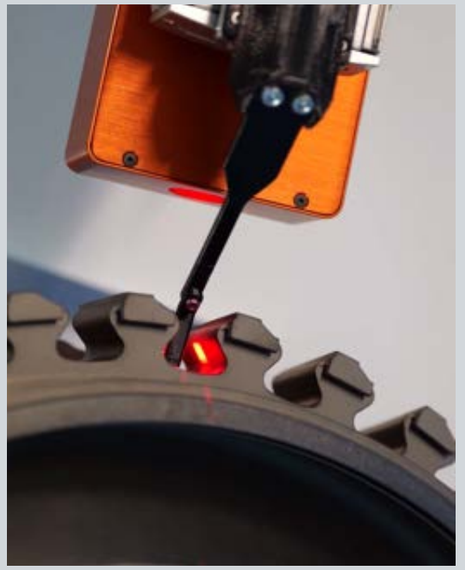
A leading aviation MRO provider uses our sensor solution **HP-FX** to inspect several different defect types on engine parts.

The system was able to cut down the inspection and evaluation time in the process between detection and a finished report from several days down to an hour. Delivering an alternative to the replica measurement has saved valuable time that was previously invested in tediously preparing the impression compound, taking and labeling the replica, sending it to the measurement lab for evaluation and going through several communication loops.

After an operator training of only one day, the workers were well-equipped to use the system autonomously and without our help. Results for damages like dents down to 20 µm depth were reliably and precisely measurable including a fully individualized report as an end result.

Mirror Probe Attachment

Using a special mirror probe attachment that can be mounted via a magnetic connector, measurements behind 90 degree corners or in cavities are now possible. This attachment was initially developed for the measurement of fretting in turbine disk slots. These slots were not easily accessible before, which made replica measurements an even more tedious and unergonomic task. Being able to use the flexible **HP-FX** sensor positioning together with a small 90 degree mirror probe now makes it possible to manoeuvre the probe inside the disk slot to measure the pressure faces and evaluate defects.



CoverageCheck

The common practice of shot peening metal parts to improve their hardness and strength has been used since over 50 years now in the aviation industry. With this process it is crucial to cover a surface with close to 100% indentation to actually improve hardness and not to weaken the surface strength. To evaluate the coverage, several subjective or 2D measurement methods were used like pocket microscopes for the worker or 2D image comparison to an “optimal” image. This never delivers a precise value of coverage but only an estimation. Using the 3D surface data captured with the **HP-FX** system, a specially developed software is able to detect individual indentations and find the “uncovered” surface. This gives us the ability to calculate the coverage within 0,5 % accuracy to give the worker a reliable and precise implication whether more shot peening is needed or the value of 100% coverage has already been reached. Not only does this improve precision and reliability of the shot peening process, but also ensures safety in the crucial parts of the aircrafts.

Suitability Matrix

SCENARIO	HP-FX	FITTING BENEFITS
Time-critical defect measurement	**+++**	Mobility, measurement on shop floor, capturing in seconds
Highly precise and reliable inspection of damages	**+++**	µm accuracy, 3D point cloud, automatic evaluation toolset, 1s recording speed
Quick inspector training	**+++**	Easy handling, simple user interface, target laser guidance, smart software assistants
Component independent measurement routines	**+++**	Component-independent, automated capturing of larger anomalies
Measuring highly reflective machined parts	**++**	Surface-independent measurement technology
Dimensional measurement on larger parts	**---**	Too many stitched images lead to geometrical inaccuracies
Large measurement areas	**---**	Time-consuming coverage of large areas with 3x3 mm measurement frame

Conclusion

Our optical sensor solution offers a transformative approach to high-precision surface inspection in the aviation MRO sector.

We offer the possibility to perform test measurements on your parts and damages for free at any time!

Just give us a call!

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