

3D Model-based Large-volume Metrology for Smart Manufacturing and Digital Twins

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Digi-Q research project (Q3 2021 – Q3 2024): Digital quality assurance for sustainable industry



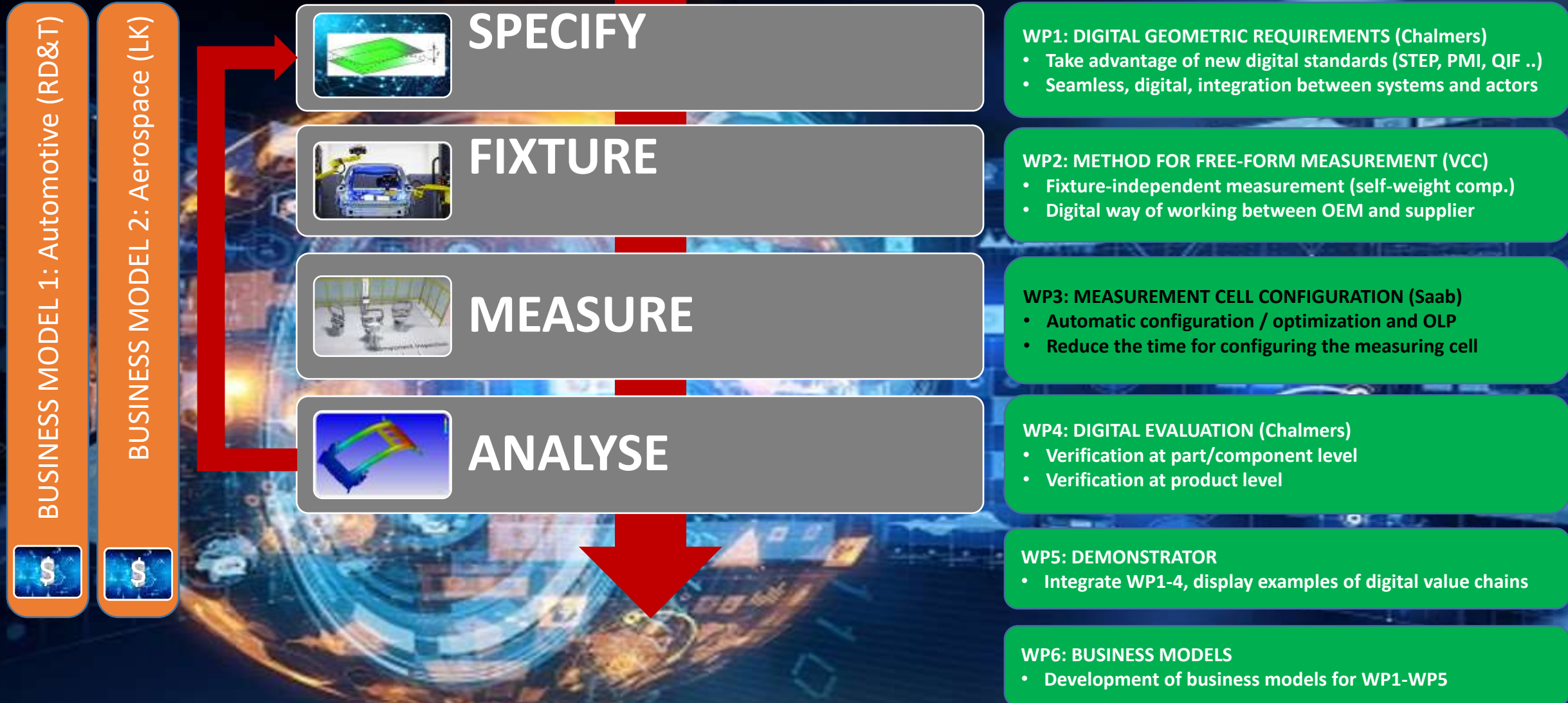
Summary:

WHAT: The project realizes a digital quality assurance process that can be scaled up and enable efficient, sustainable and competitive global production.

HOW: Through further development and industrial verification (TRL5-7) of previous results - from a player constellation consisting of OEM, SME and research performers

WHY: Increase the competitiveness and sustainability of Swedish industry through better digital collaboration, resource-efficient value chains, better material utilization, fewer scraps, increased traceability and higher quality

Digi-Q project: Digital quality assurance for sustainable industry



WP3: MEASUREMENT CELL CONFIGURATION (M1-M33)

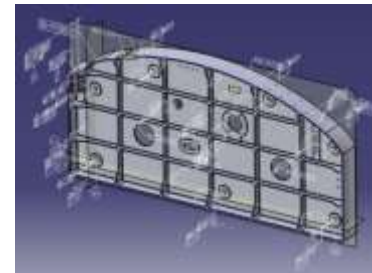
This work package tests, verifies and validates a coherent concept for automatic configuration, off-line programming and optimization of automated laser radars in an industrial environment..

Work package manager: Saab, Richard Lindqvist

- Polyworks (software and interface)
- LK (interface hardware and software for laser measurement)
- IPS AB (software for Path Planning and optimization)
- FCC (Algorithms for Path Planning and Optimization)
- RD&T Technology (feedback measurement result to RD&T)

Deliveribles:

- D3: 1 Specification of data and information flow (M6, M18)
- D3: 2 File-based information and data exchange in the digital thread (M12)
- D3: 3 Program optimization of minimum number of measurement configuration (M12)
- D3: 4 Protocol-based information and data exchange (M24)
- D3: 5 Geometric optimization of number of sensor positions (M24)
- D3: 6 Software solutions connected "as a service" (M30)
- D3: 7 Optimal layout of measuring and reference equipment (M33)



IPS for Nikon laser radar

- What is and Why do we need: IPS Laser Radar simulation software capability?
- Physical measuring cell and components overview
- Key Capabilities in IPS LR 2.0
- Overview – Process map
- Step 1: Import measurement data to IPS
- Step 2: Task planning
- Step 3: Sequence optimization
- Step 4: Program export
- Summary and Progress: First half-year 2022

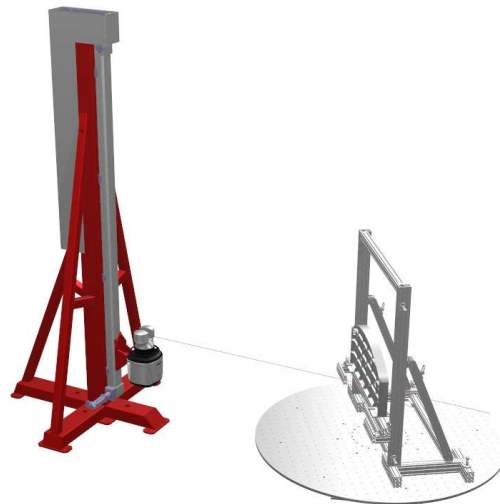
IPS for Nikon laser radar



Source: <https://www.saab.com/newsroom/press-releases/2021/saab-celebrates-u.s.-expansion-with-opening-of-new-facility>



Source: <https://www.saab.com/products/T-7A>



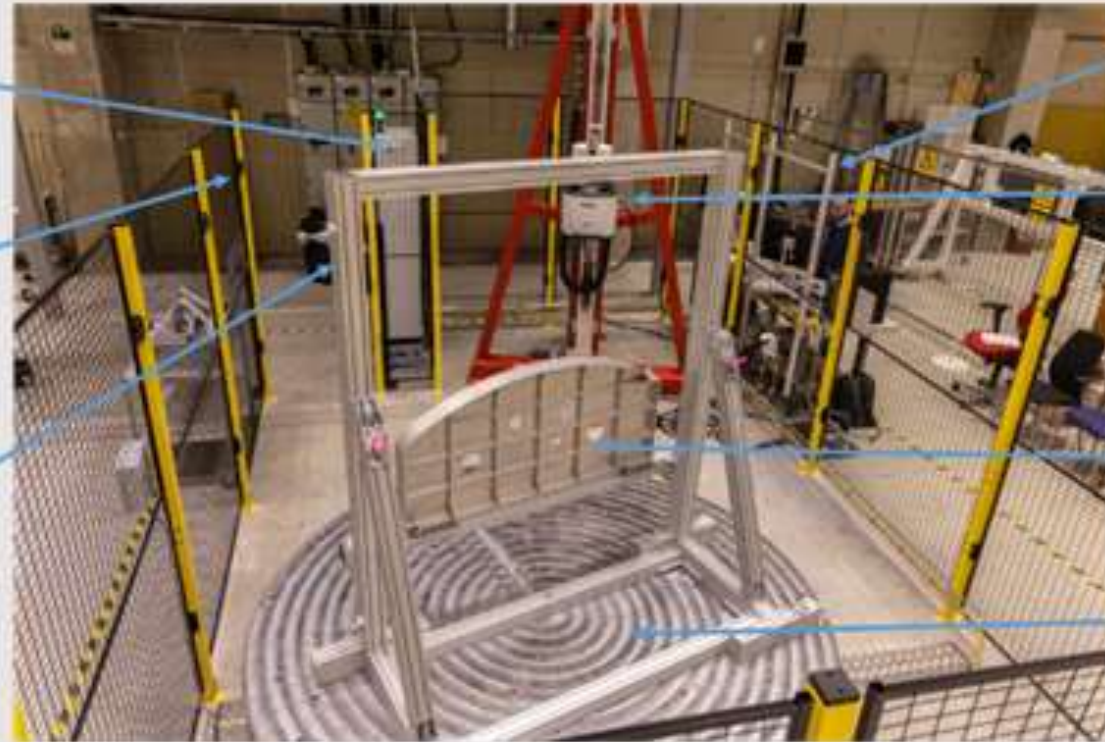
IPS for Nikon laser radar

Laser radar metrology system overview

PLC control box

Security fences, all around, and light curtain for human passage into the cell

Novel research and development fixture with mounted reference spheres



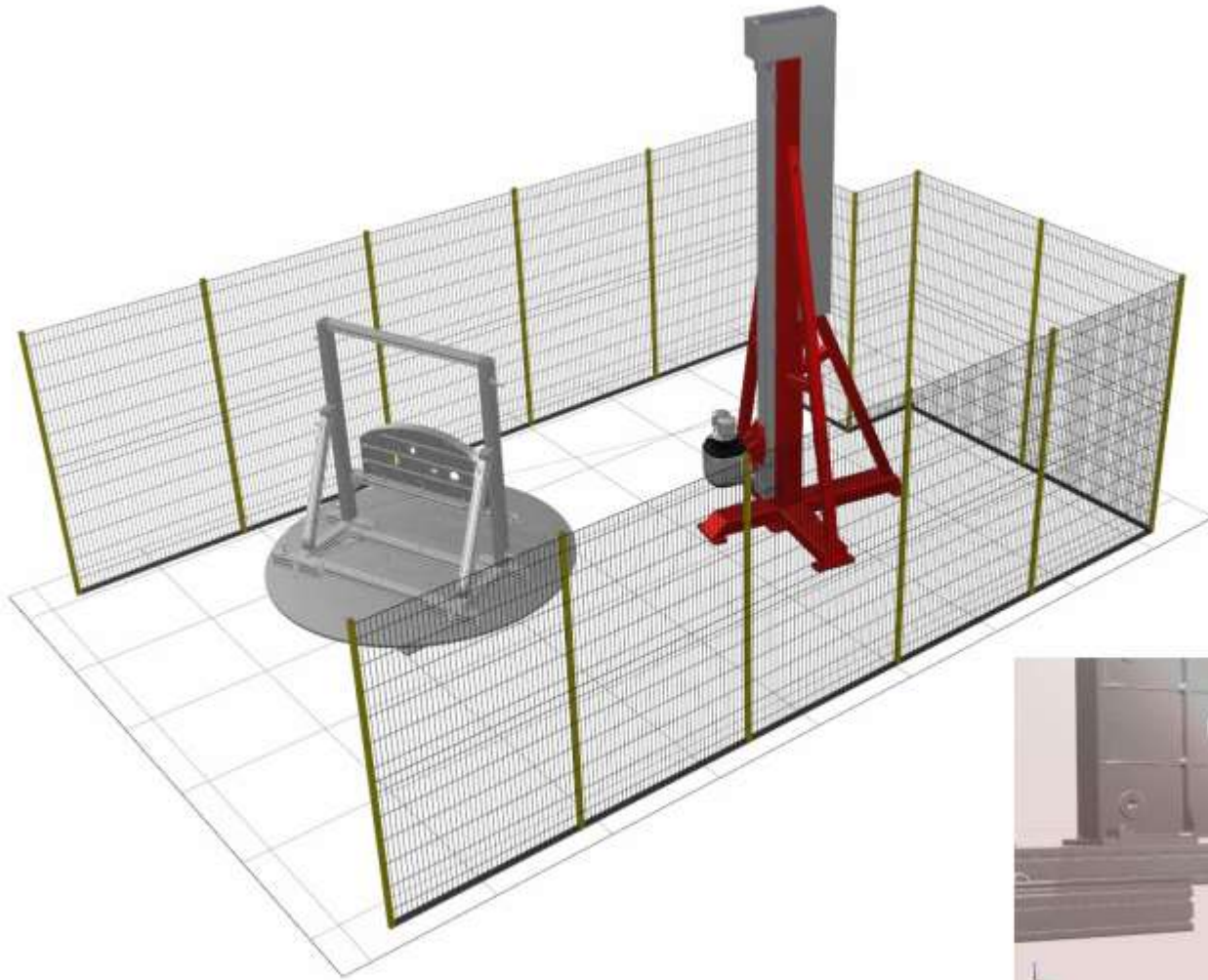
Operator panel and human machine interface

Laser radar mounted on a programmable vertical linear drive (Working range: 0 – 3000 mm Resolution: minimum 0,1 mm)

MPQP test artifact mounted in novel fixture

Programmable rotational table (Working range: $\pm 360^\circ$ Resolution: minimum 1°)

IPS for Nikon laser radar

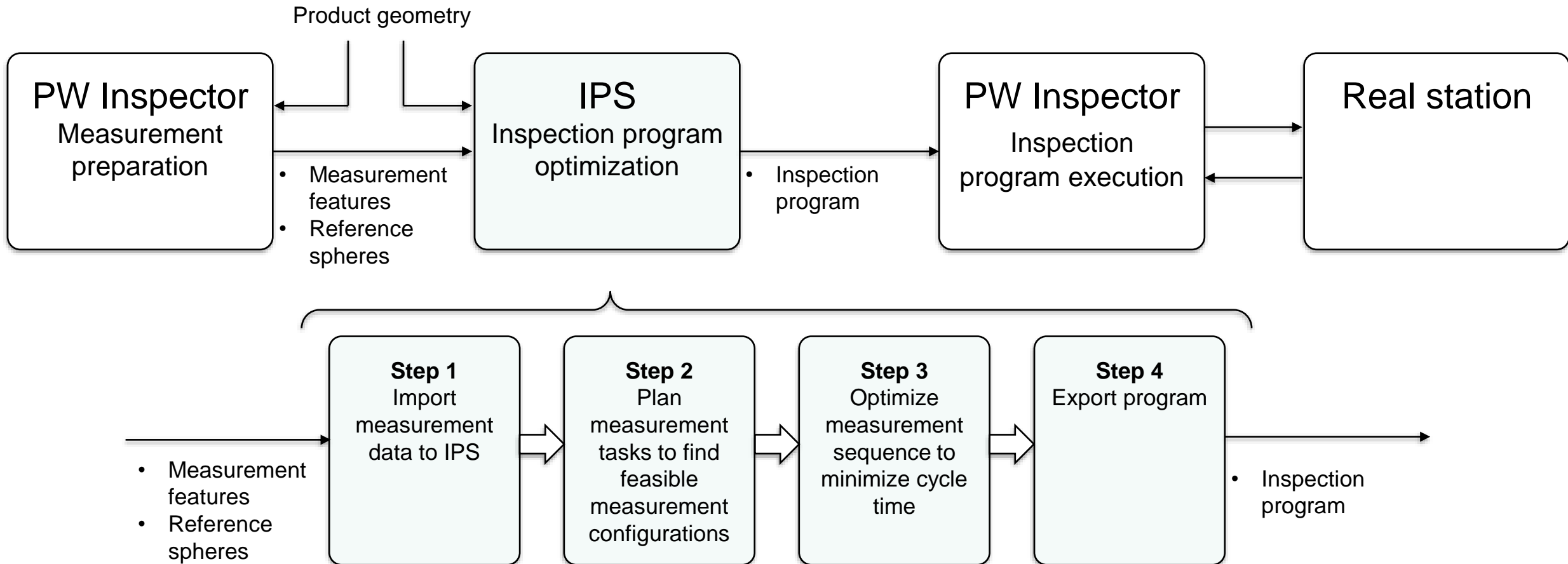


Key capabilities of IPS LR 2.0

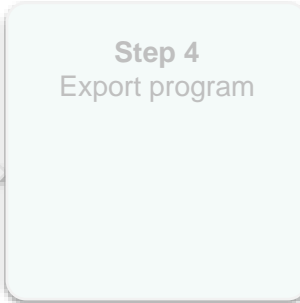
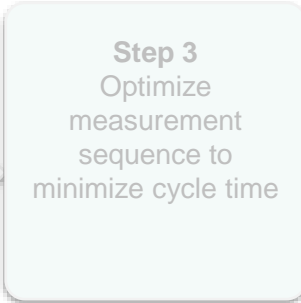
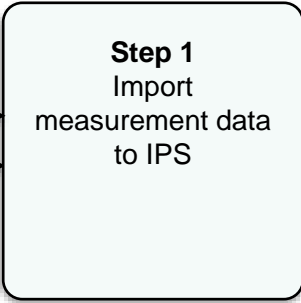
- Automatically find feasible measurement configurations
- Automatic sequence optimization to minimize cycle time
- Follow the generated animation process through the augmented camera window
- Customizable code export



IPS for Nikon laser radar – process overview



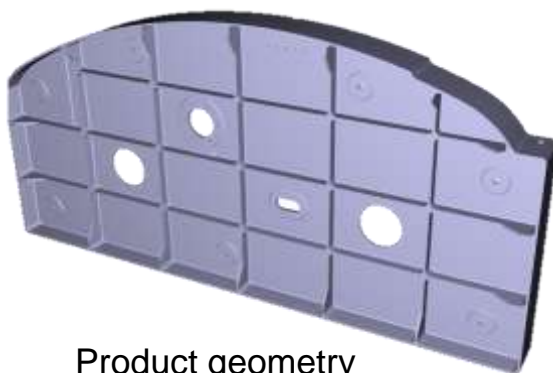
- Product geometry
- Fixture
- Measurement features
- Reference spheres



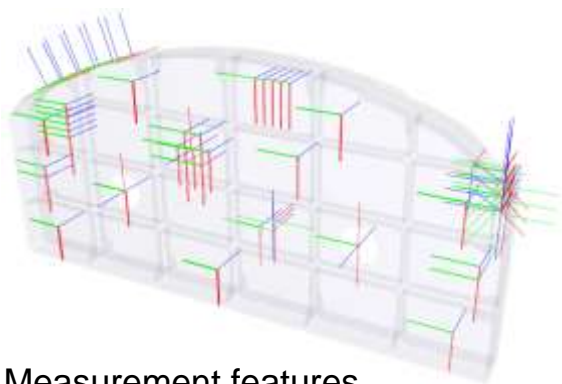
Inspection program



Fixture



Product geometry

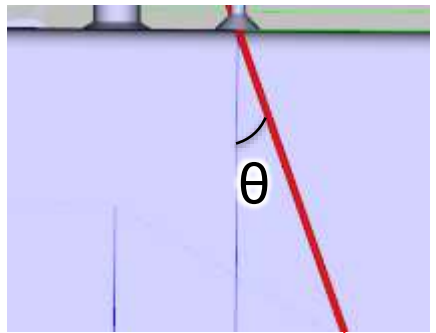
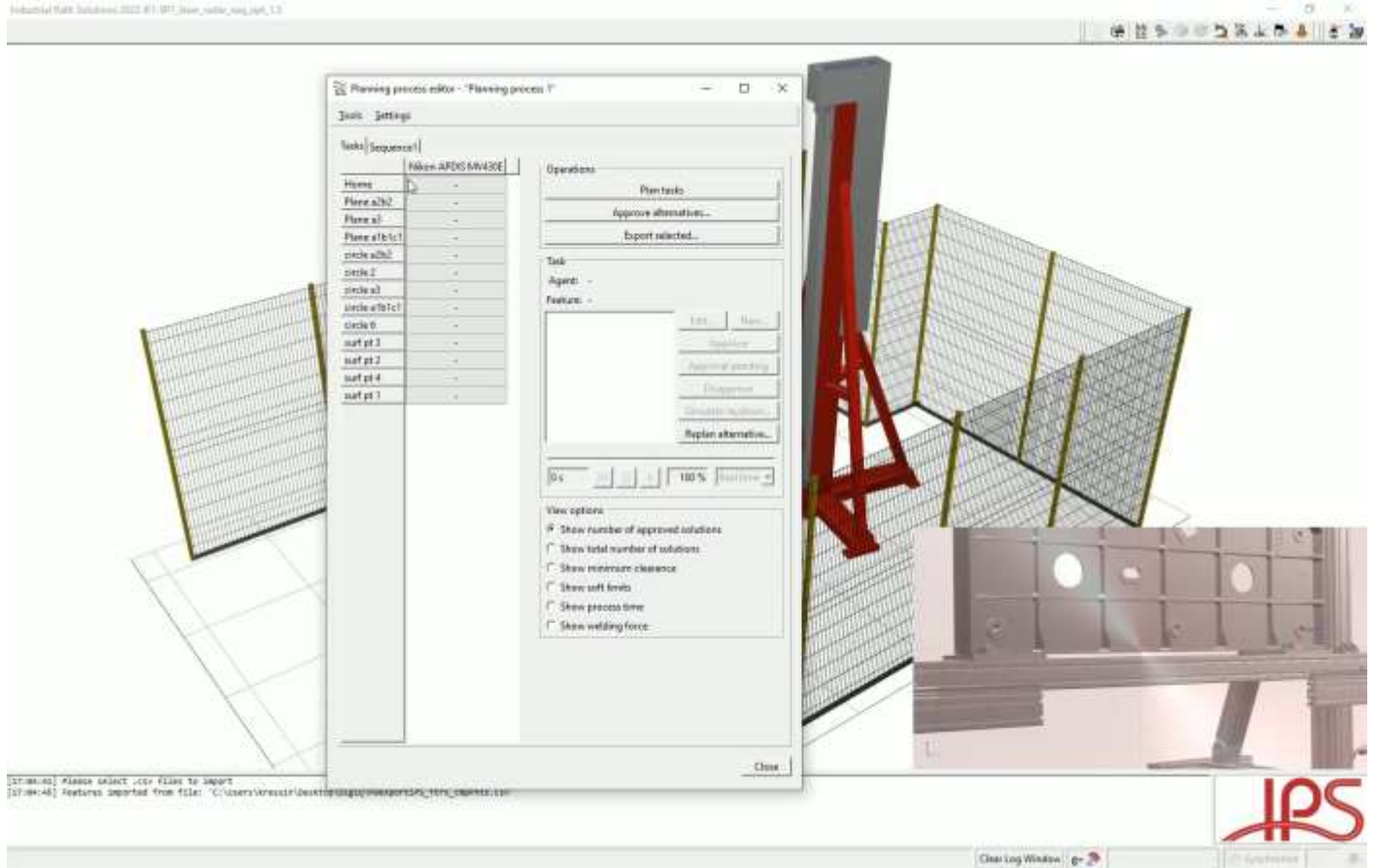
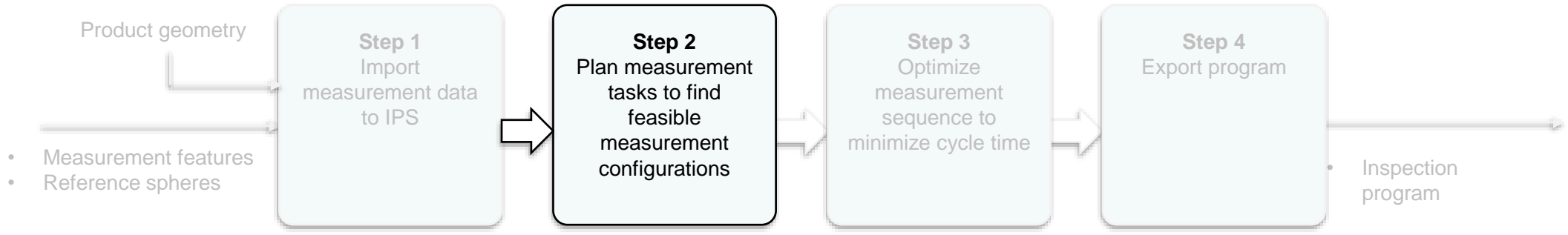


Measurement features



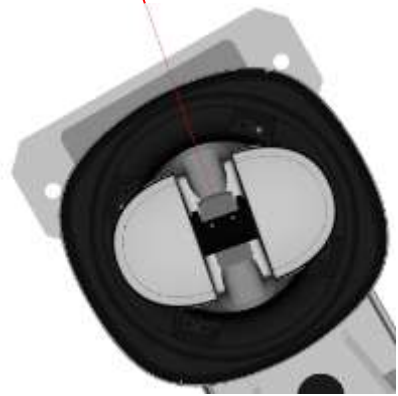
Reference spheres

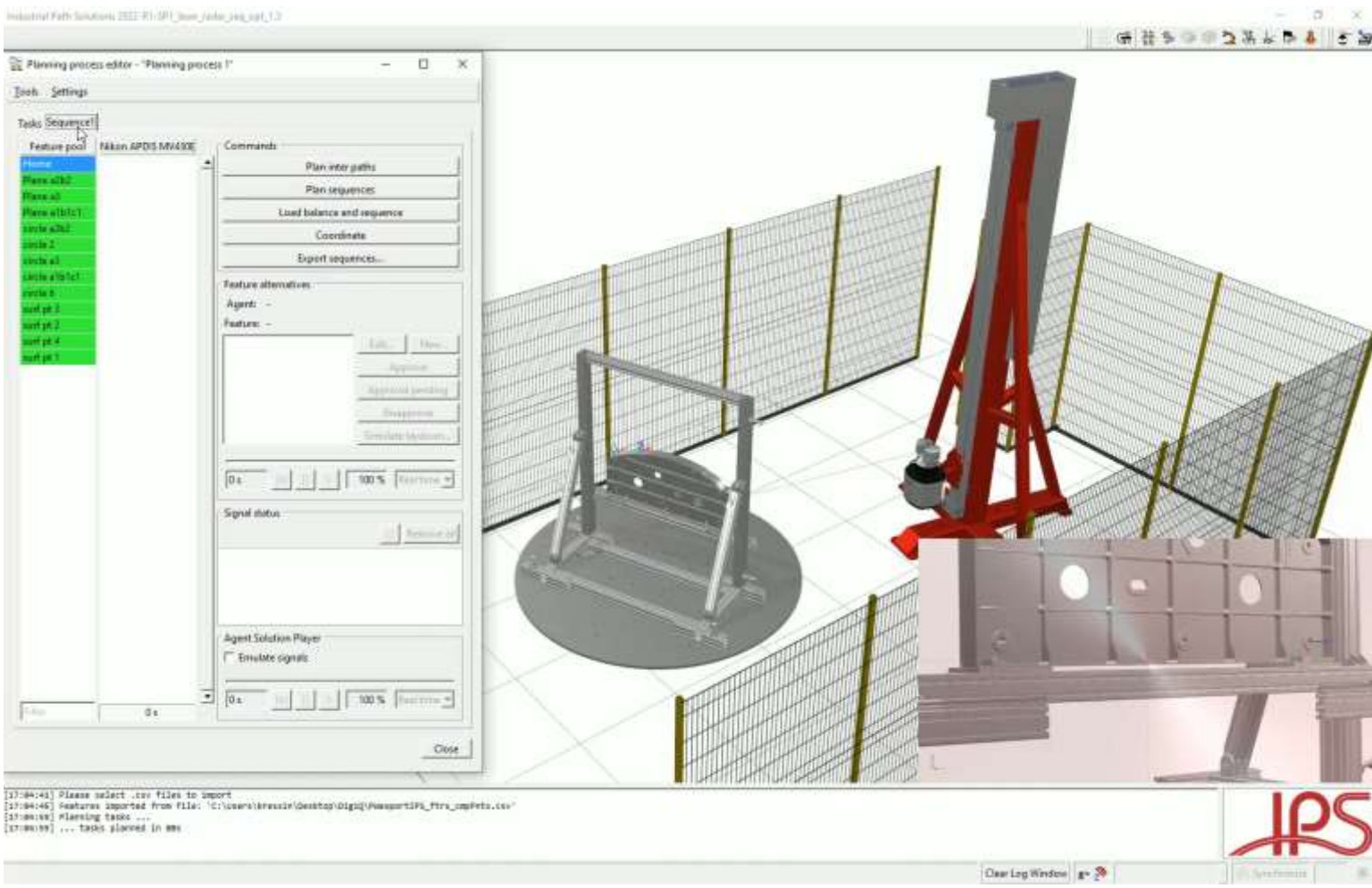
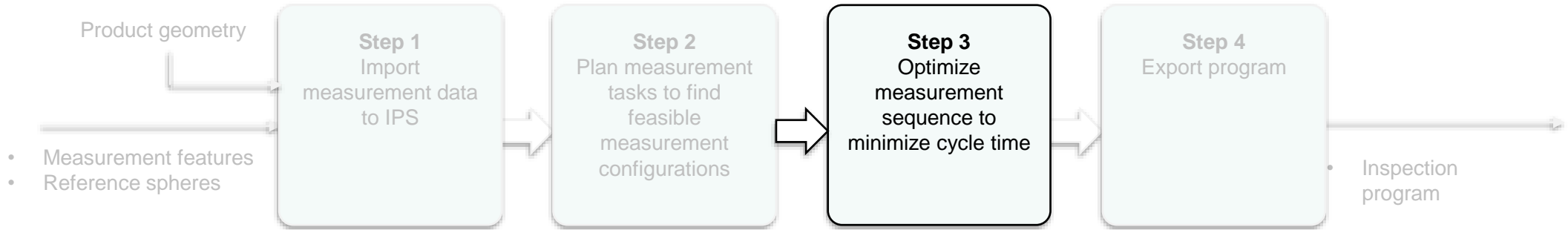




Automatically checks:

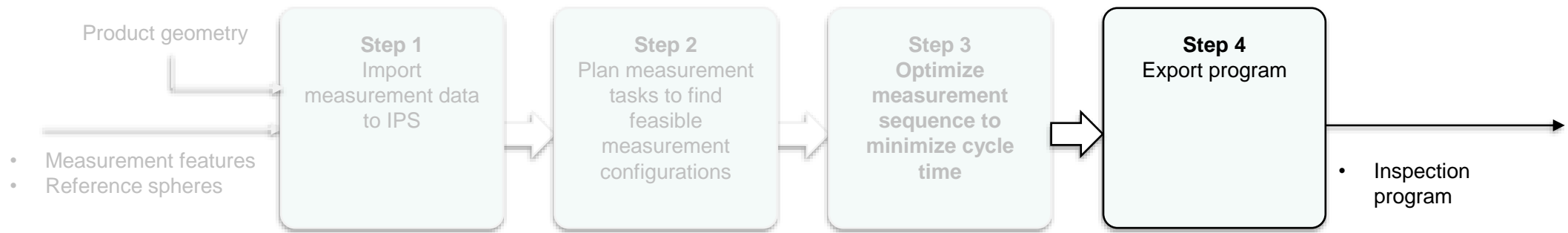
- Kinetically reachable
- Collision-free
- A ray can be cast from the laser to the feature without any obstacles in the way
- The measurement angle towards the nominal axis of the feature (θ) must be within allowed range.
- A certain number of reference spheres must be visible





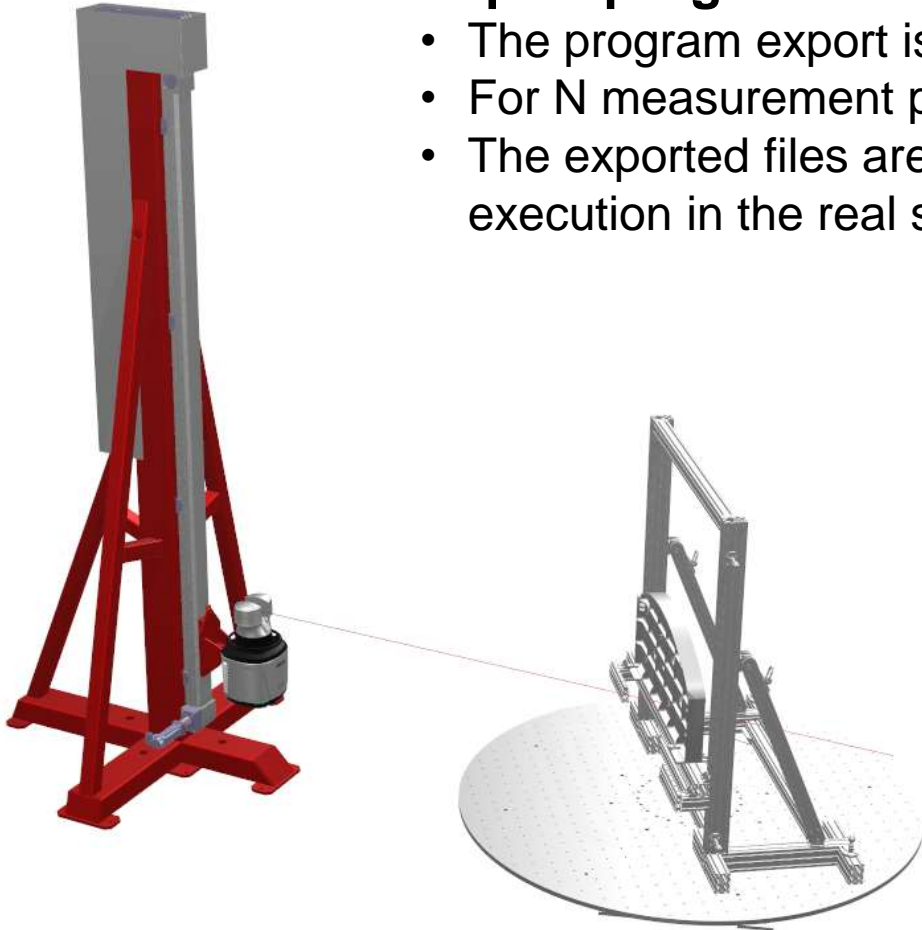
Automatic sequence optimization:

- Optimize visiting order for all measurements
- Optimize configuration alternative
- Automatic path planning
- Automatically add measurement of reference spheres each time the linear axis or turn table moves



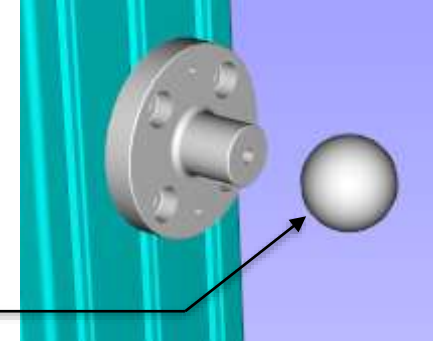
Export program

- The program export is customized in scripts outside the IPS core
- For N measurement positions, a total of (N+8) files are exported
- The exported files are then passed on to PW Inspector for program execution in the real station



1. Start position (Zero position) (0 s)


Summary and Progress: First half-year 2022





- Updated IPS version
 - Import reference spheres and create sphere geometries
 - Make import reference spheres work for new PW format
 - Speed-up initialization step in optimization
 - Handle larger problem instances in optimization
 - Set max number of reference spheres to consider in task planning
- Scripts
 - Export inspection program to Polyworks Inspector (txt-files, csv-file)
 - Script for automating scene build up based on Saab CATIA start model
 - Create laser beam geometry
- Work in progress
 - Algorithm dev: Minimize no. of needed measurement positions
 - Measurement rules, specification


objectType	ref	objectName	X	Y	Z	I	J	K
Circle		∅2 (2)	1	1315	299.75	1	0	0
Circle		∅2 (3)	1	1315	329.75	1	0	0
Circle		∅2 (5)	1	190	299.75	1	0	0
Circle		∅2 (6)	1	190	329.75	1	0	0

Laser radar

Min angle 

Max angle 

Min no. of reference spheres 

Max no. of reference spheres 

Acknowledgements and further reading

- **Acknowledgements:** KTH, Saab Aeronautics, FCC and the Digi-Q AP3 project partners and stakeholders are very grateful to Swedish Innovation Agency - Vinnova for their support of the Digi-Q research project.
- **Further reading:** Keep your eyes open for an open access article published in the special issue of Metrology MDPI - "Advances in Portable 3D Measurement"
 - https://www.mdpi.com/journal/metrology/special_issues/3D_Measurement

The background of the slide features a large, semi-transparent Saab logo on the left and the word 'SAAB' in large, stylized, multi-layered letters on the right. The logo includes a crown and a griffin. The text 'SAAB' is rendered in a dark, metallic-looking font with a gold outline. The word 'A posteriori' is written in a gold, cursive font on the left side, with a horizontal gold line underneath it.

A posteriori

Note:

Funding: The Digi-Q research project and work has benefited from funding from Saab Aeronautics T7-A internal development project and from the Swedish Innovation Agency - Vinnova, as part of its Digi-Q research project.

Data Availability Statement: The virtual 3D model of the MPQP test artefact is by the courtesy of Saab Aeronautics made available, after specific request from individuals and/or stakeholders who wish to use the artefact for research, development, standardization, education and learning activities. The 3D model can be supplied in the following formats: Catia V5 native format, neutral STEP AP 242 format.

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