Demonstration and evaluation of a measurement-assisted shipbuilding assembly process

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Summary

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Introduction
Block-wise construction technique

- Blocks are constructed independently and afterwards positioned and welded. Each block is composed by panels, structural profiles, machines, pipes and other parts.
- Equipment with high load capacity, such as platform vehicles, cranes and hydraulic jacks are needed to accurately position and align the blocks.
- Theodolites, laser levels, plumb-bobs and measuring tapes are frequently used as measurement systems.
- Assembly process is highly time consuming since it has to be done iteratively, intercalating positioning/alignment and measurement tasks.

Introduction

Block-wise construction technique

Introduction

Block-wise construction technique

Introduction
Measurement-assisted assembly

- Use of advanced 3D measurement systems to enable accurate, fast and even automatic part-to-part assembly without iteration.

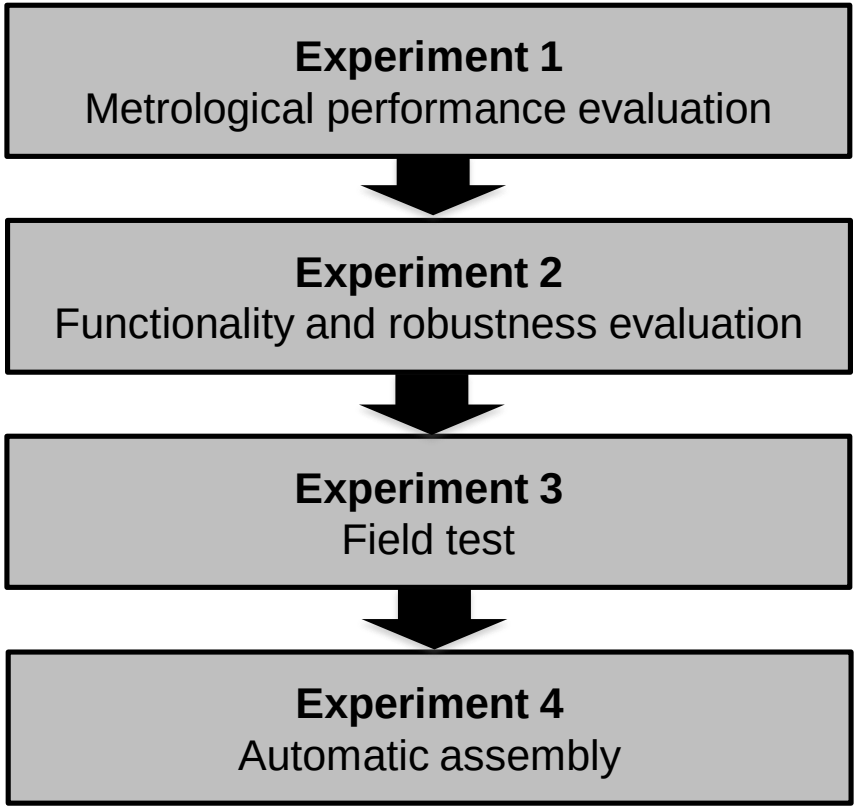
- Laser trackers, robotic total stations, photogrammetry systems and indoor-GPS (iGPS) are some of the measurement technologies available for MAA.

- To the best of our knowledge, no specific research on MAA for shipbuilding has yet been conducted.

Summary

- Introduction
- Project goal and methodology
- Measurement equipment
- Experimental procedure and results
- Conclusion

Project goal and methodology



Project goal:
To evaluate the potential of measurement-assisted assembly for shipbuilding applications.

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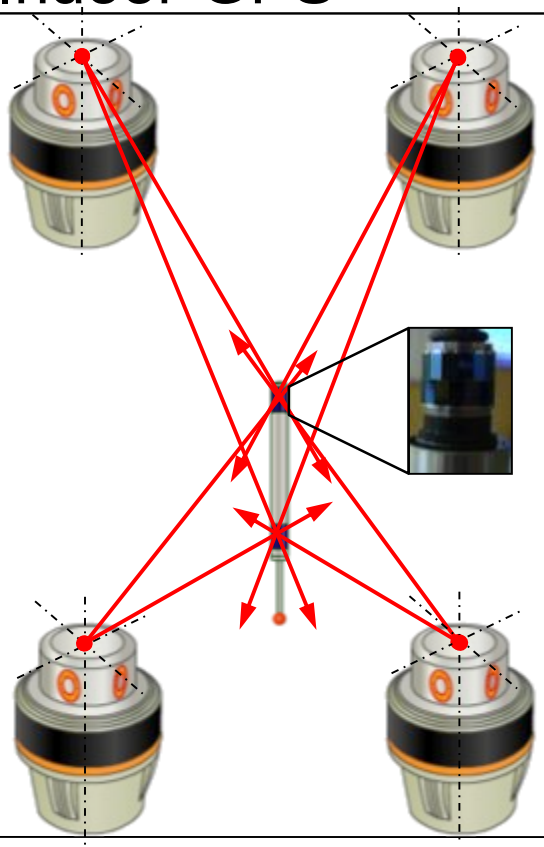
Measurement equipment

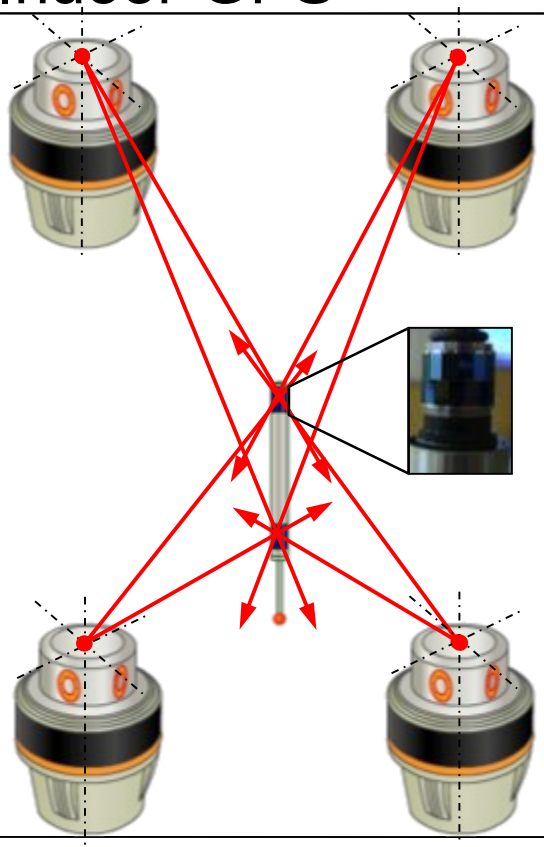
Indoor-GPS



- Transmitters transmit IR light signal.
- Optical receivers detect the signal that is used to determine horizontal and vertical angles between transmitters and receivers.
- With at least two visible transmitters with known position and orientation it is possible to determine the 3D position of a receiver.

Measurement equipment

Indoor-GPS



- Additional transmitters enable reduction of measurement uncertainty, enhancement of robustness against visibility issues and enlargement of measurement volume.
- Typical maximum length measurement error, under good measurement conditions: 0,5 mm.
- System used in this project is a Nikon Metrology (formerly Metris) iSpace 6i manufactured in 2008.

Measurement equipment
Robotic total station

- Measurement of vertical angle, horizontal angle and distance between total station (TS) and a point of interest – position in spherical coordinate system.
- Robotic (motorized) TS enable automatic location and tracking of a target.
- A 38.1 mm (1.5 inch) diameter spherical mounted cube corner reflector is used as target.

Measurement equipment
Robotic total station

- In this project we used a Leica TS12 with a maximum length measurement error of 1.0 mm + 1.5 ppm manufactured in 2015.

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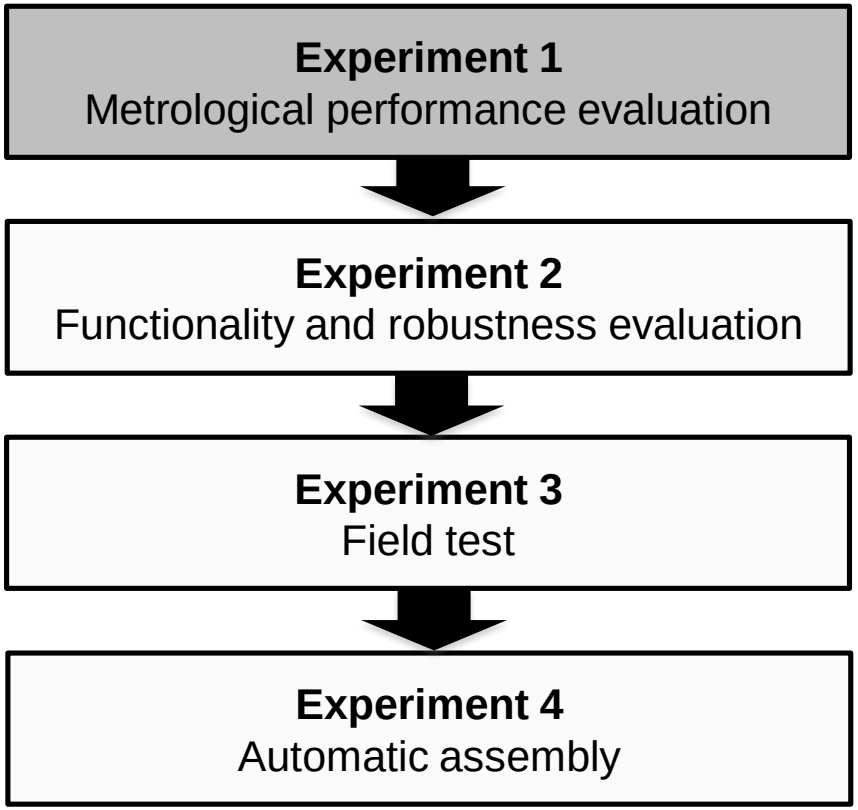
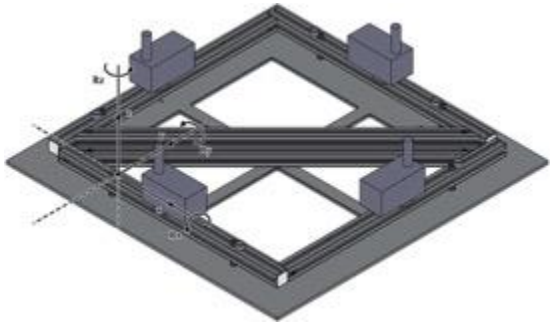
Experimental procedure and results

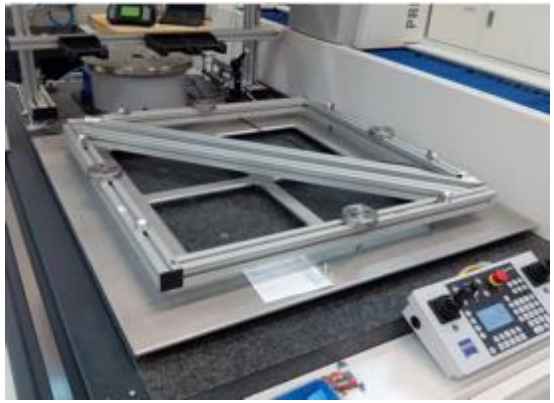
Experiment 1: metrological performance



Experimental procedure and results

Experiment 1: metrological performance

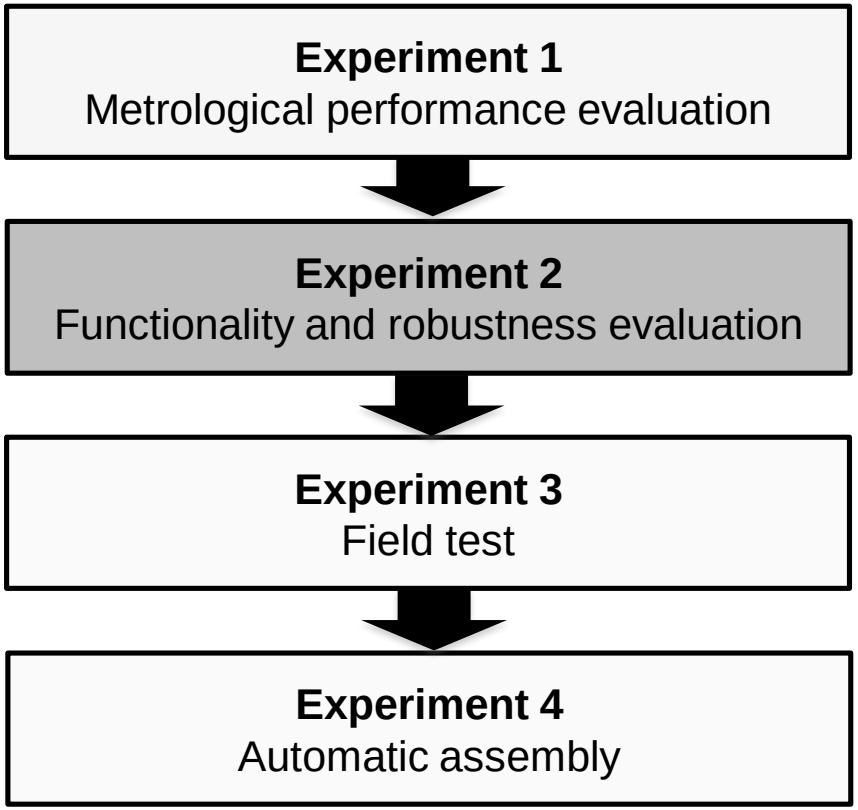




- Device composed of two “L”-shaped parts that can be positioned and aligned in 3-DOF (pitch, roll and heave) in relation to each other using iGPS as measurement system.
- Three conical nests are used to materialize reference points on each part.
- After alignment, position of reference points are measured with a calibrated CMM.
- A residual error <0,5 mm was observed.

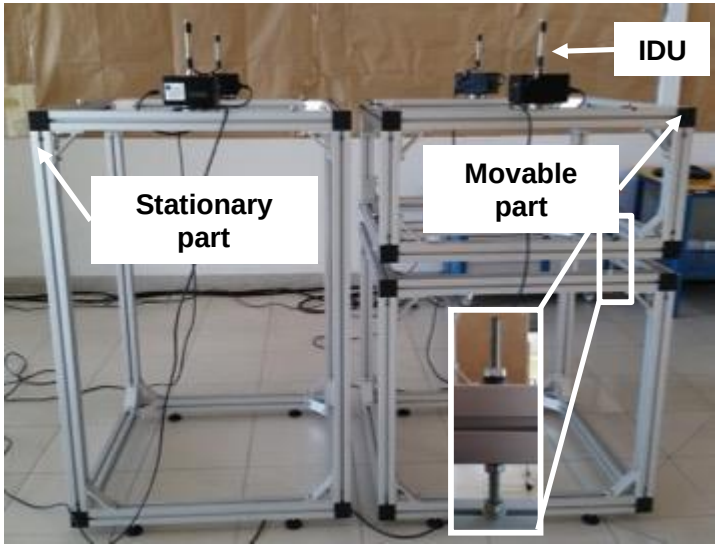
Experimental procedure and results

Experiment 2: functionality and robustness



Experimental procedure and results

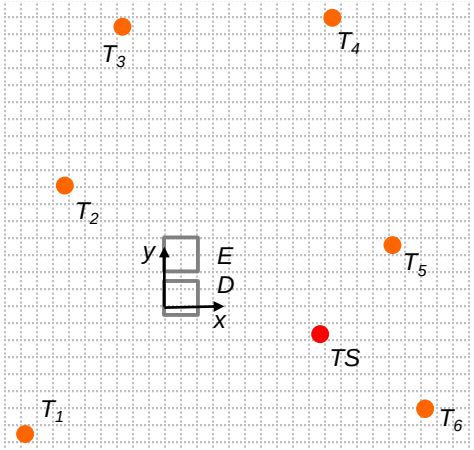
Experiment 2: functionality and robustness



- Experimental device composed of a stationary and a movable part. Size of each part: 1 m x 1 m x 1,4 m.
- The upper half of the movable part can be aligned in relation to the stationary part.
- Functionality of iGPS and robotic total station in outdoor measurements and robustness in presence of welding arcs have been investigated.
- Measurement results of both systems have been compared under laboratory conditions.

Experimental procedure and results

Experiment 2: functionality and robustness



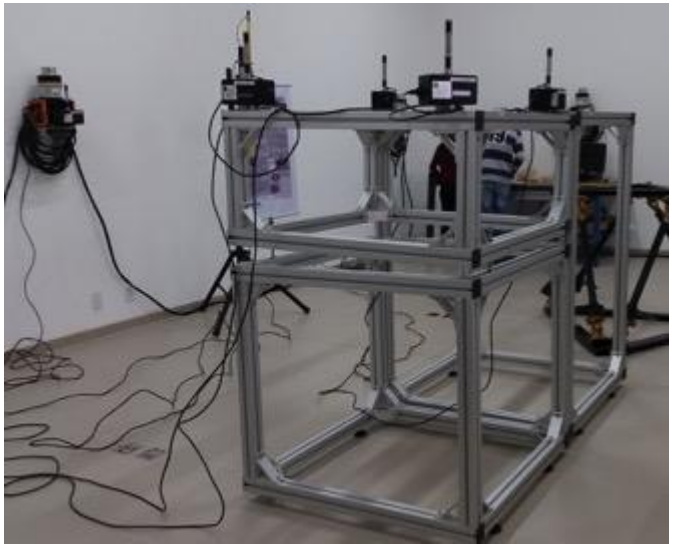
	x [mm]	y [mm]	z [mm]
T_1	-5220	-5519	-126
T_2	inactive		
T_3	-1866	10448	-53
T_4	6374	10851	208
T_5	8599	2036	365
T_6	9940	-4294	451
TS	5974	-1432	73

Experimental procedure and results
Experiment 2: functionality and robustness

- iGPS presented signal instability when arc welding was performed close to a receiver (< 3 m).

Experimental procedure and results

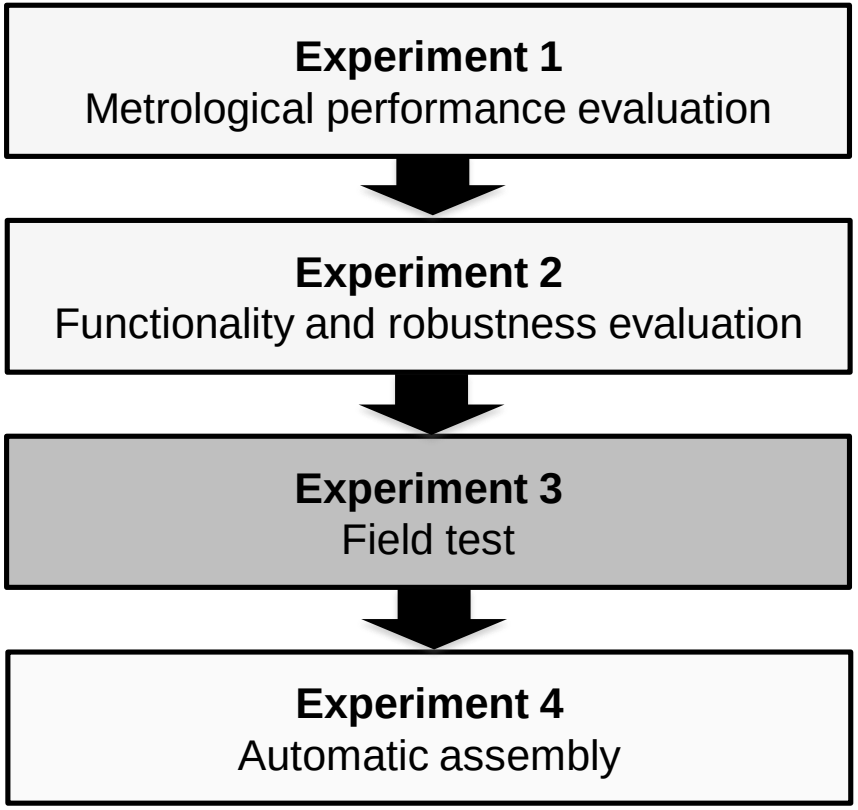
Experiment 2: functionality and robustness



- Comparison of measurement results of iGPS and TS performed under laboratory conditions.
- Total station in two different positions in relation to the device.
- 5 repeated measurements.
- Positions of all measurements agreed within ±1 mm.

Experimental procedure and results

Experiment 3: field test



Experimental procedure and results

Experiment 3: field test

Goals of the field test

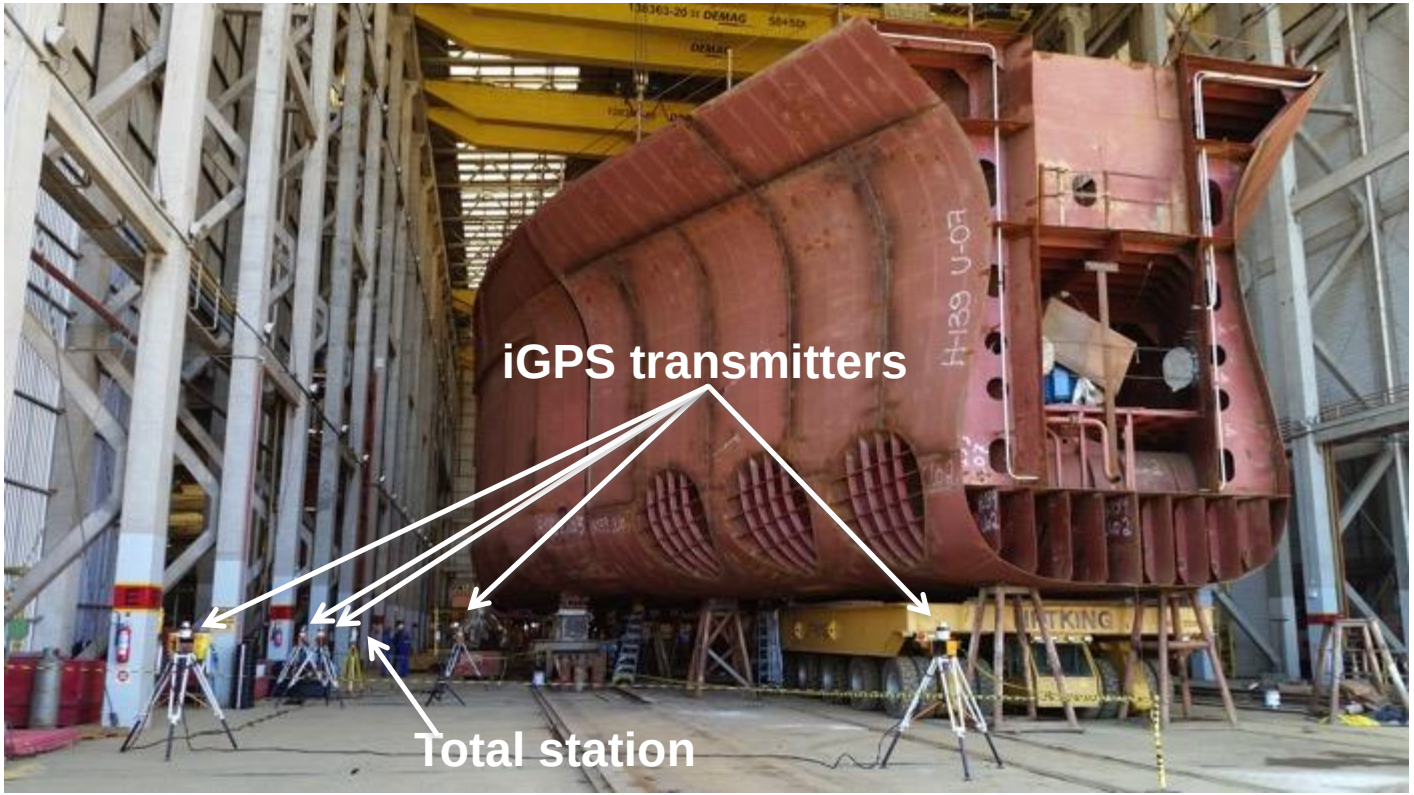
- To evaluate robustness and productivity of the measurement-assisted assembly (MAA) processes with indoor-GPS (iGPS) and robotic total station at real production environment.

- To understand practical issues involved in the block assembly (erection) process.

- To understand positioning/alignment process currently adopted by the shipyard.

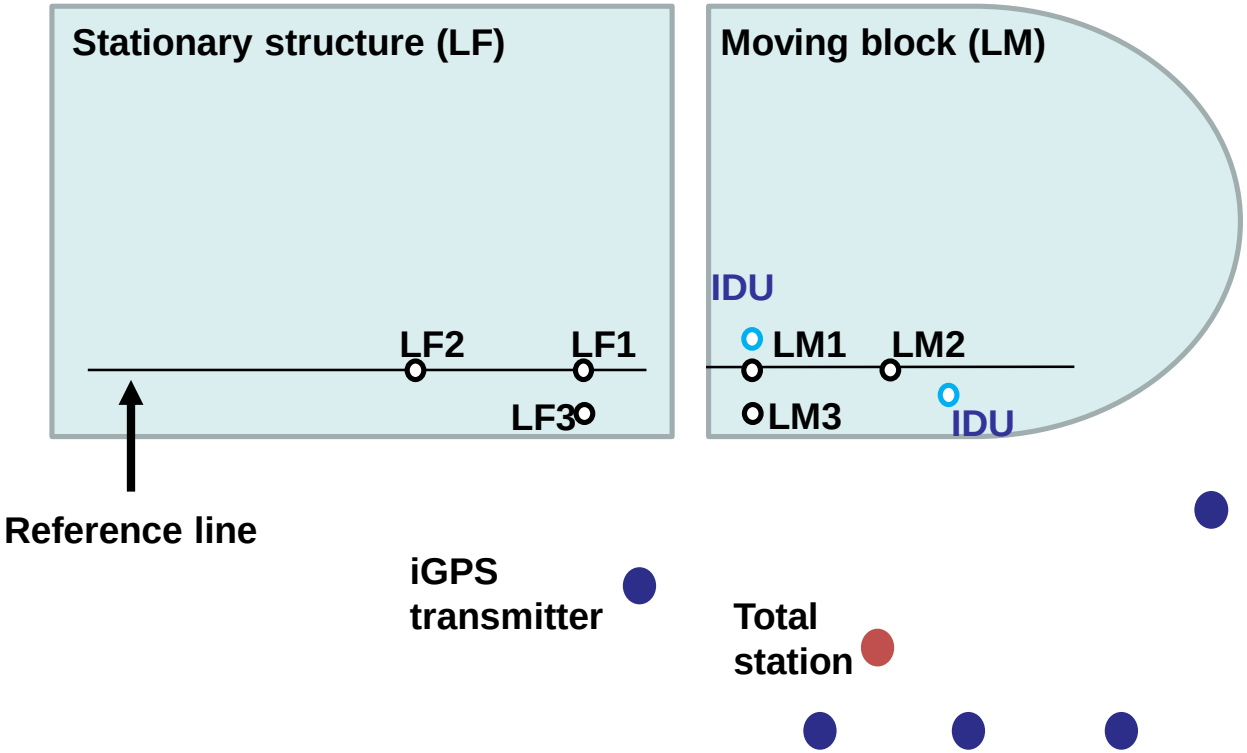
Experimental procedure and results

Experiment 3: field test



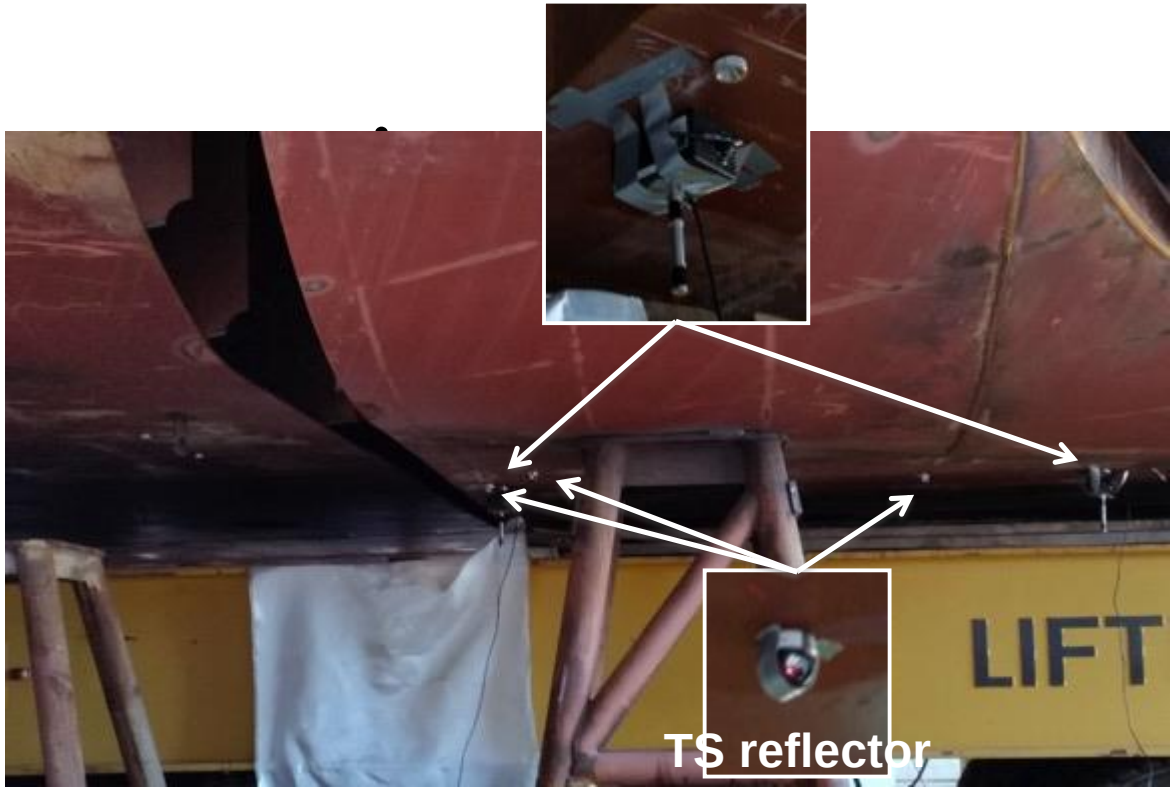
Experimental procedure and results

Experiment 3: field test



Experimental procedure and results

Experiment 3: field test



Experimental procedure and results
Experiment 3: field test

- Tracking of position (x, y, z) and orientation (roll, pitch, yaw) of movable block in relation to the stationary one was possible with iGPS. Information available both on notebook as on portable wireless device (iPod).

- Tracking of single points were possible with TS.

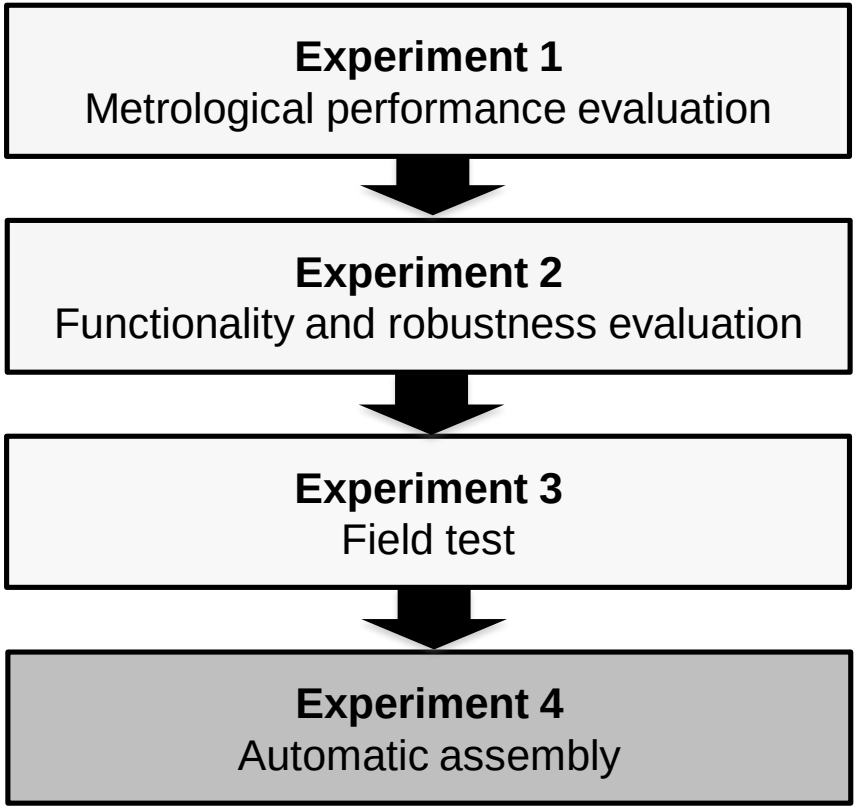
Experimental procedure and results

Experiment 3: field test

	iGPS	Robotic total Station
6-DOF tracking?	yes	no
Multiple points tracking?	yes	no
Robustness	↓	↑
Portability	↓	↑
Cost	↑	↓
	↑: higher	↓: lower

Experimental procedure and results

Experiment 4: automatic assembly



Experimental procedure and results

Experiment 4: automatic assembly

- Robotic Stewart platform has been designed and constructed.
- 3D measurement system will be used to automatically guide the platform.
- Goal is to evaluate the feasibility of using one of the measurement systems and a robotic platform to enable automatic block assembly.

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Conclusion

- The potential of measurement-assisted assembly in the erection process could be confirmed by both laboratory and field tests.
- iGPS and robotic total station feature appropriate levels of accuracy and robustness.
- The possibility of automatic assembly will be further investigated.

Acknowledgement

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