

COMPARISON OF 3D MEASUREMENT SYSTEMS FOR AEROSPACE APPLICATIONS

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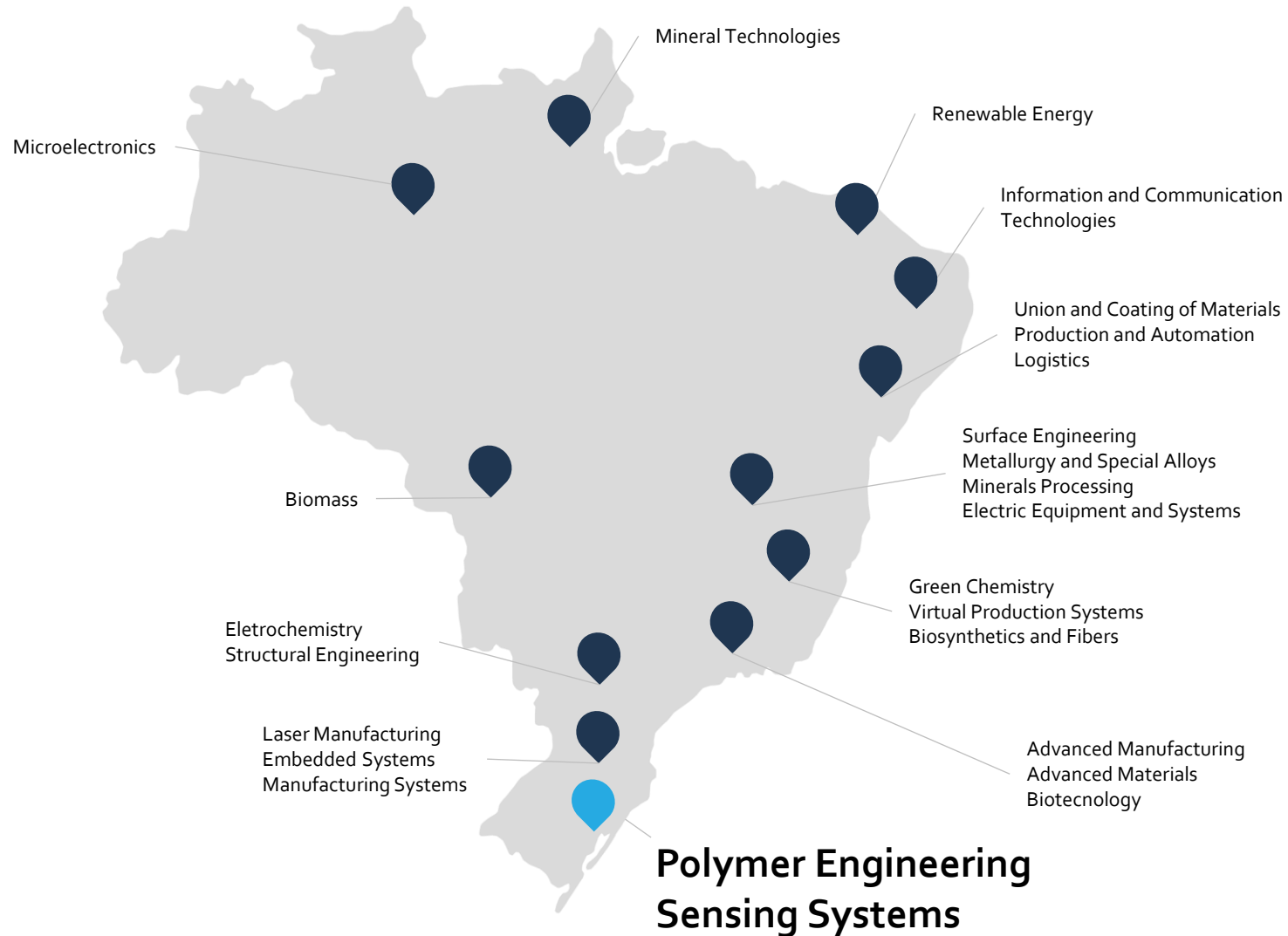
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Largest Private Research and Development Network in Brazil



SENAI *Brazilian National Service for Industrial Training*



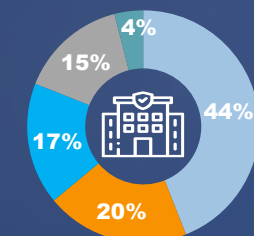
+3350
R&D Projects



+1325
COMPANIES SERVED



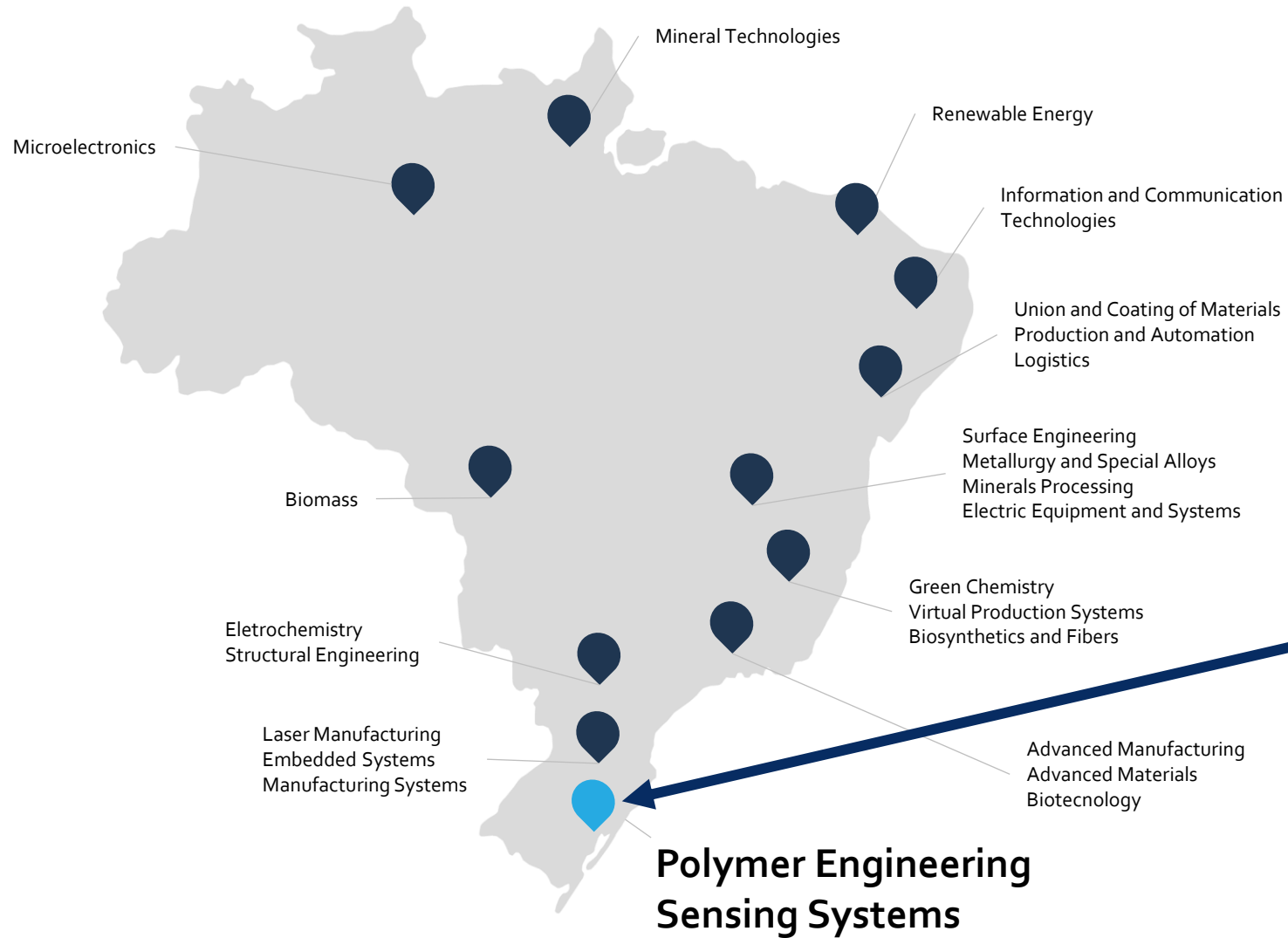
+R\$ 2,5 BI
R&D Projects



% OF PROJECTS BY COMPANY SIZE

- Large
- Medium
- Small
- Micro

Largest Private Research and Development Network in Brazil



Sistema
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Introduction

Introduction

- Purpose: Compare four 3D measurement technologies in a non-controlled environment.
- Focus: Accuracy, repeatability, and metrological suitability.
- Technologies:
 - V-Stars/N (Photogrammetry)
 - Faro Focus Premium (Laser Scanner)
 - AT960 (Laser Tracker)
 - ATS600 (Hybrid Tracker/Scanner)



ATS 600



Laser Tracker+AS1

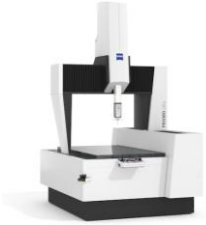


Laser Scanner



Photogrammetry

Preliminary test in the laboratory with a ball bar



Ø Sphere 1 = 49.975 mm
Ø Sphere 2 = 50.007 mm
Between Spheres = 999.985 mm



Deviation
Ø Sphere 1 = 0.145 mm
Ø Sphere 2 = 0.115 mm
Between Spheres = 0.321 mm



Deviation
Ø Sphere 1 = 0.034 mm
Ø Sphere 2 = 0.040 mm
Between Spheres = 0.032 mm



Deviation
Ø Sphere 1 = -2.799 mm
Ø Sphere 2 = -1.595 mm
Between Spheres = 0.729 mm



The Experiment

Object of Study

- Aircraft: EMBRAER E2 190
- Measurement Targets:
 - Specific linear and angular dimensions
- Instrumentation:
 - 100 mm white spheres for scanning systems
 - Reflective spheres and retroreflectors for photogrammetry



Utilized methods



Photogrammetry



Utilized methods



Leica Tracker



Utilized methods



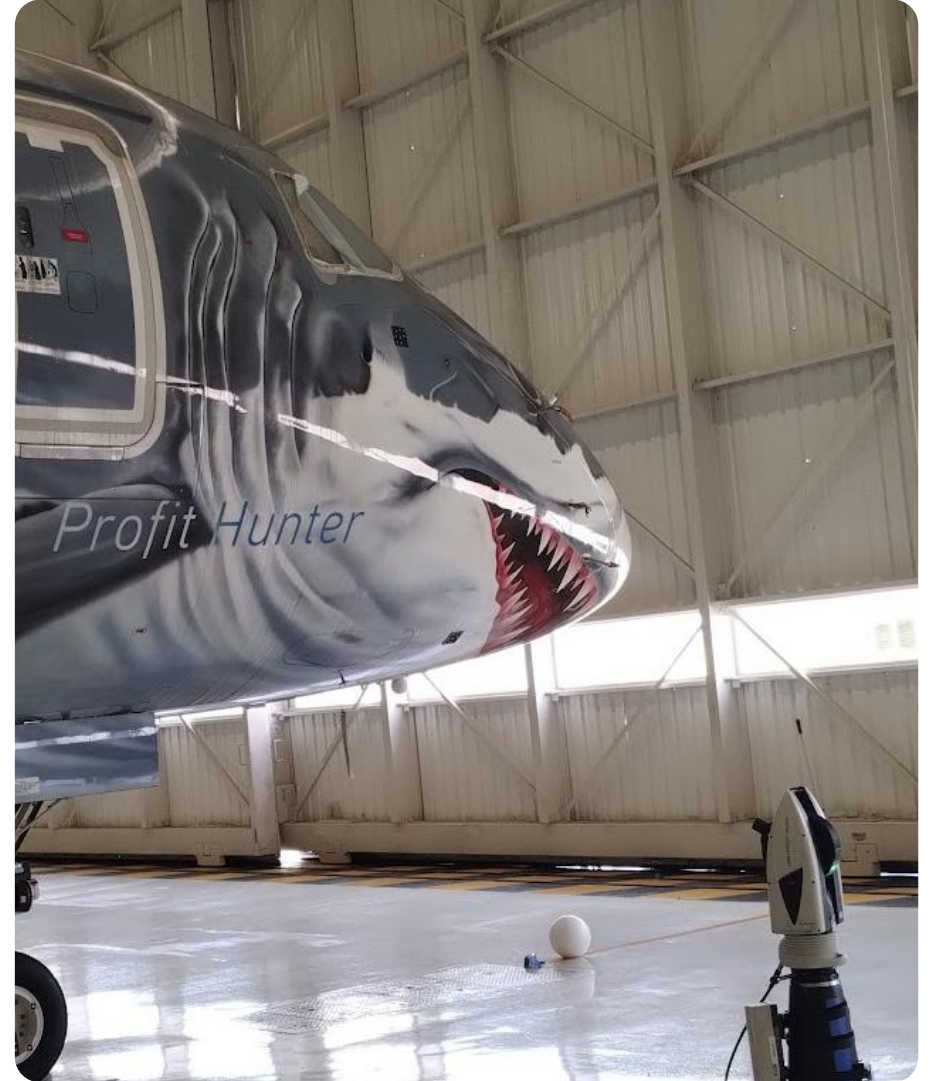
Focus scanner



Utilized methods

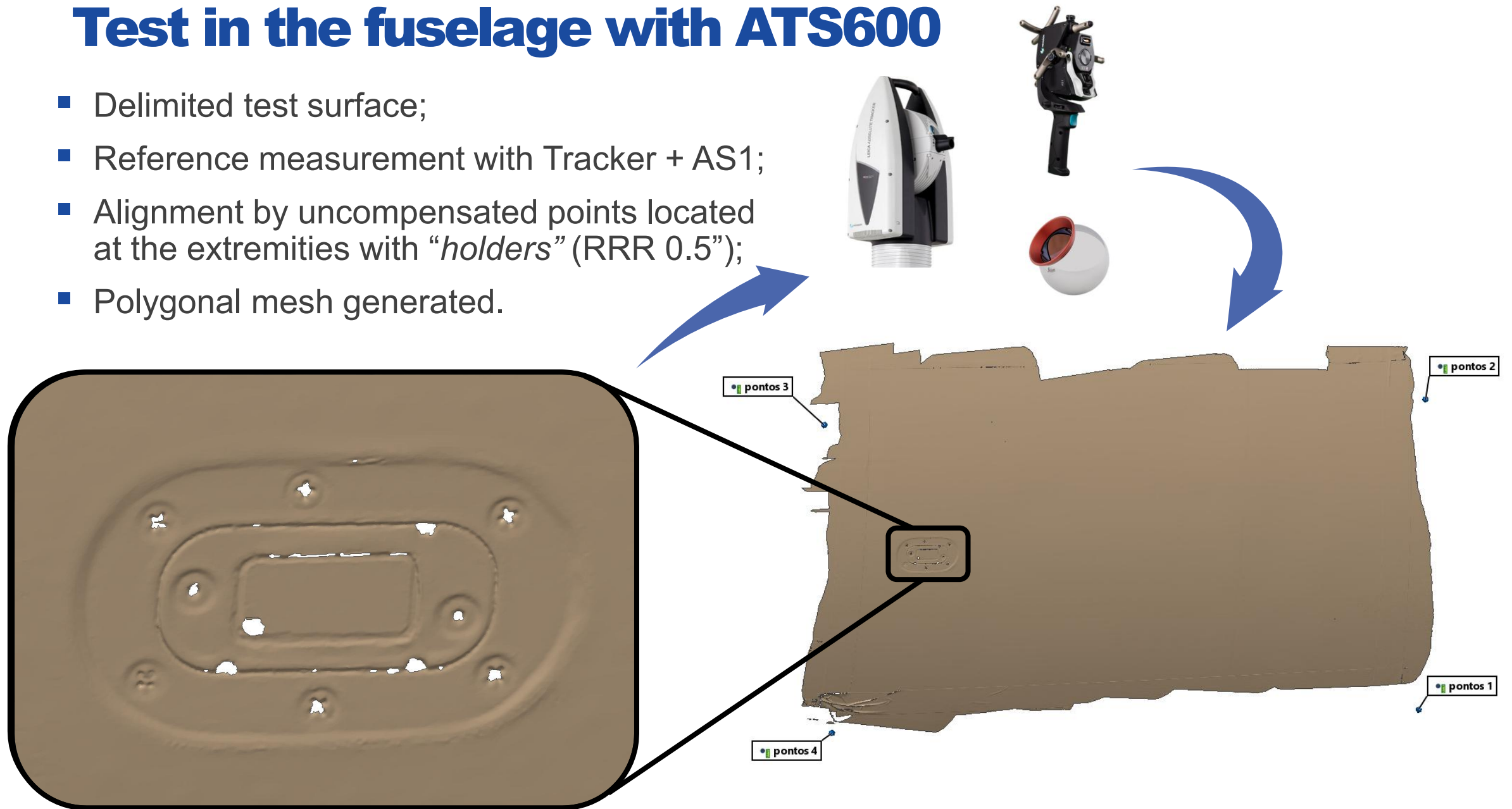


ATS 600



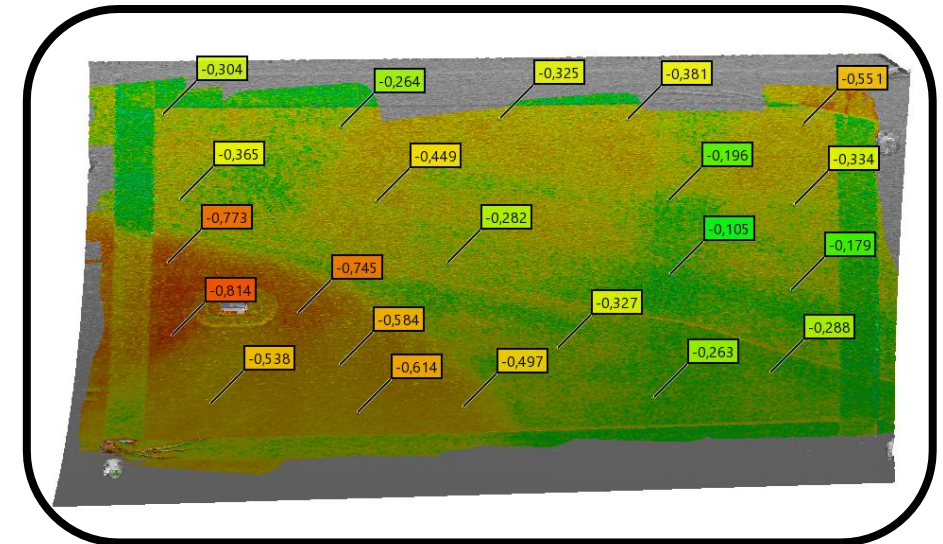
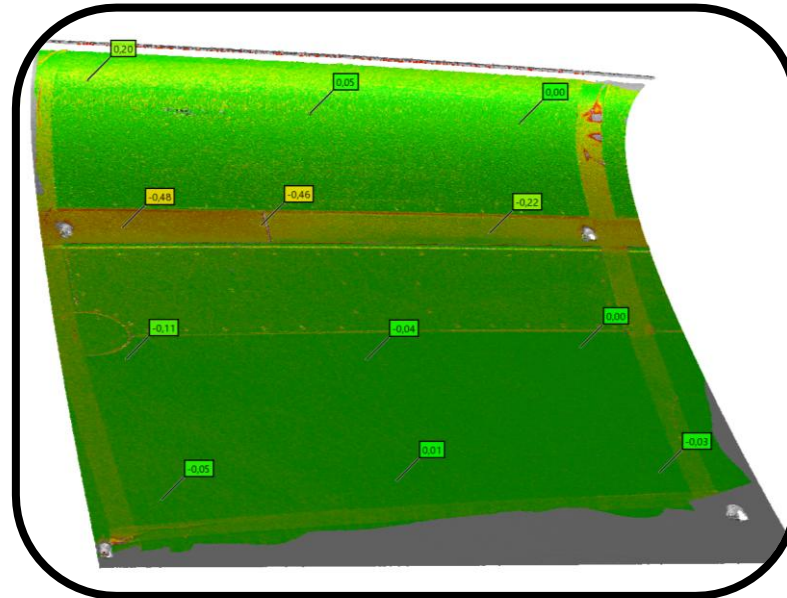
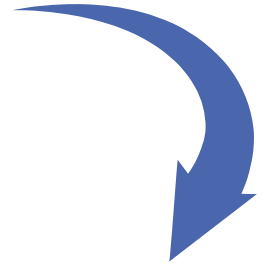
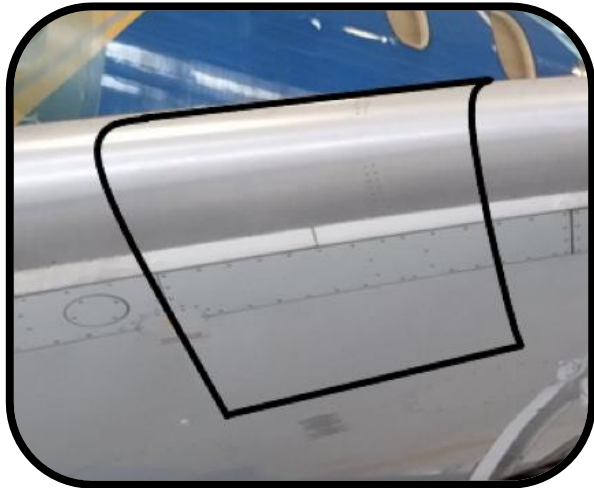
Test in the fuselage with ATS600

- Delimited test surface;
- Reference measurement with Tracker + AS1;
- Alignment by uncompensated points located at the extremities with “holders” (RRR 0.5”);
- Polygonal mesh generated.



Testes with ATS600

- The ATS600 is affected by the color of the part, causing measurement error in the distance-scanning (method non-contact measurement).

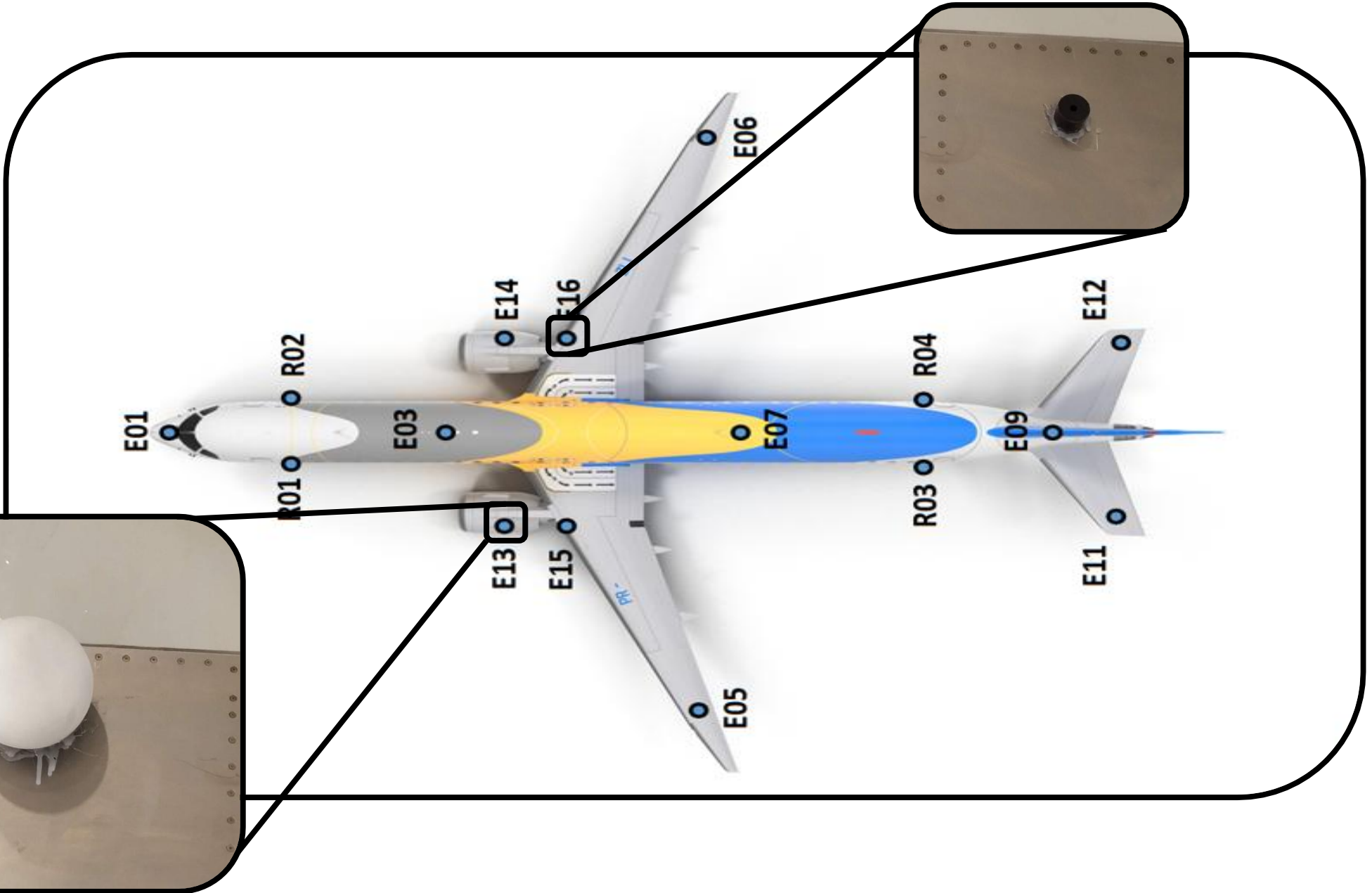


Tests in Industrial Environment

Object
E190-E2 (Profit-Hunter)

16 spheres

16 holders



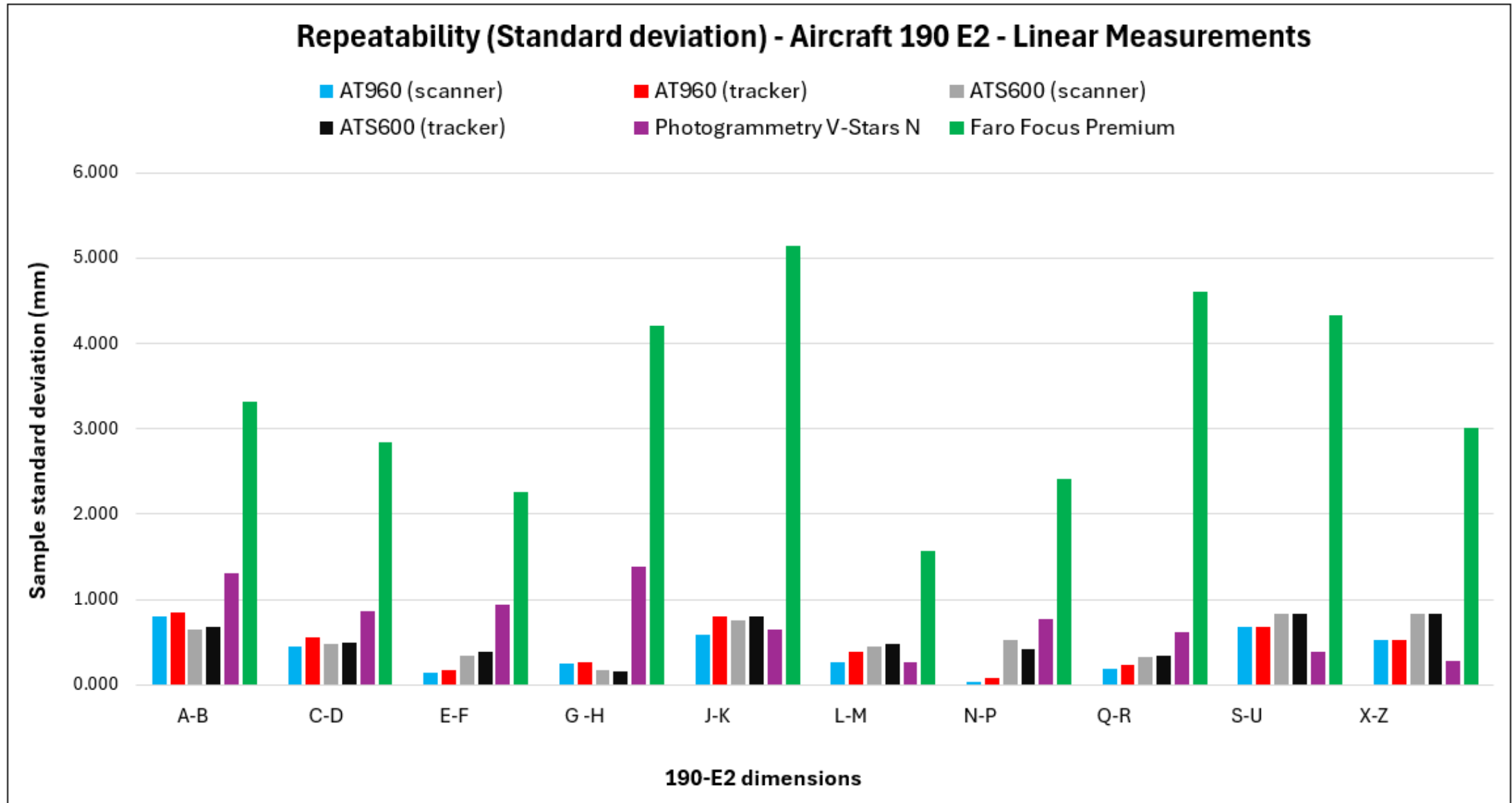


Results

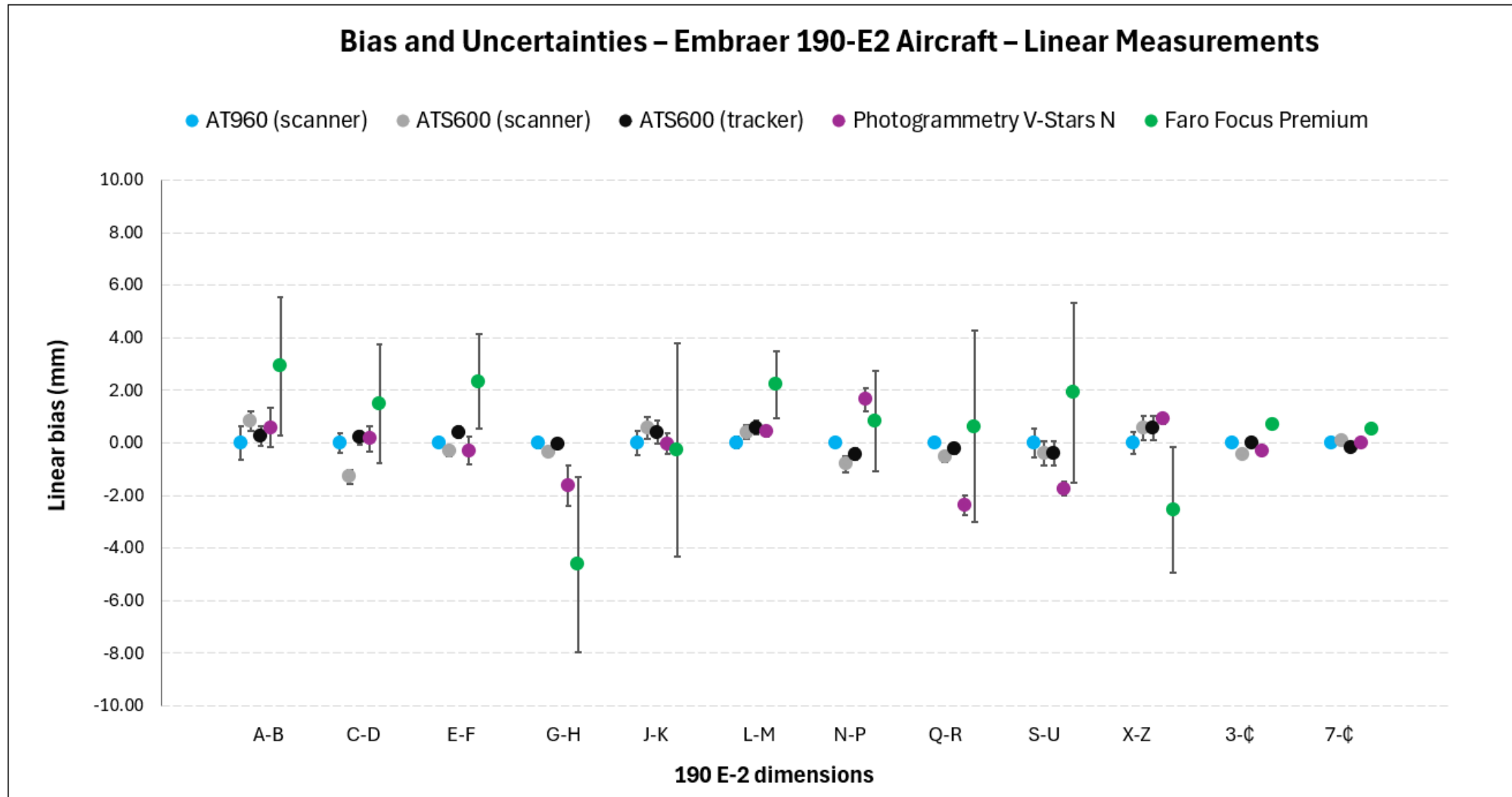
Results of linear measurements



Linear measurements on the 190-E2 aircraft



Linear measurements on the 190-E2 aircraft

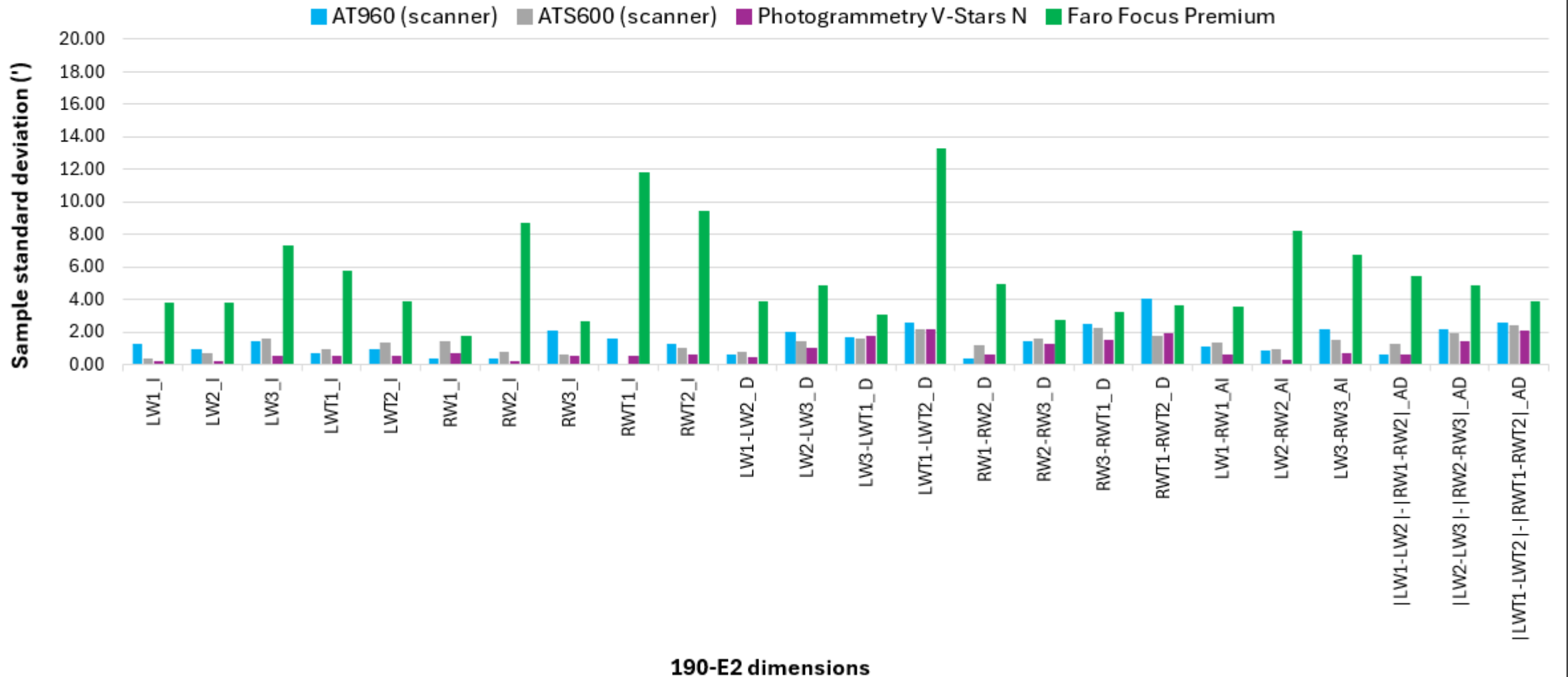


Results of angular measurements

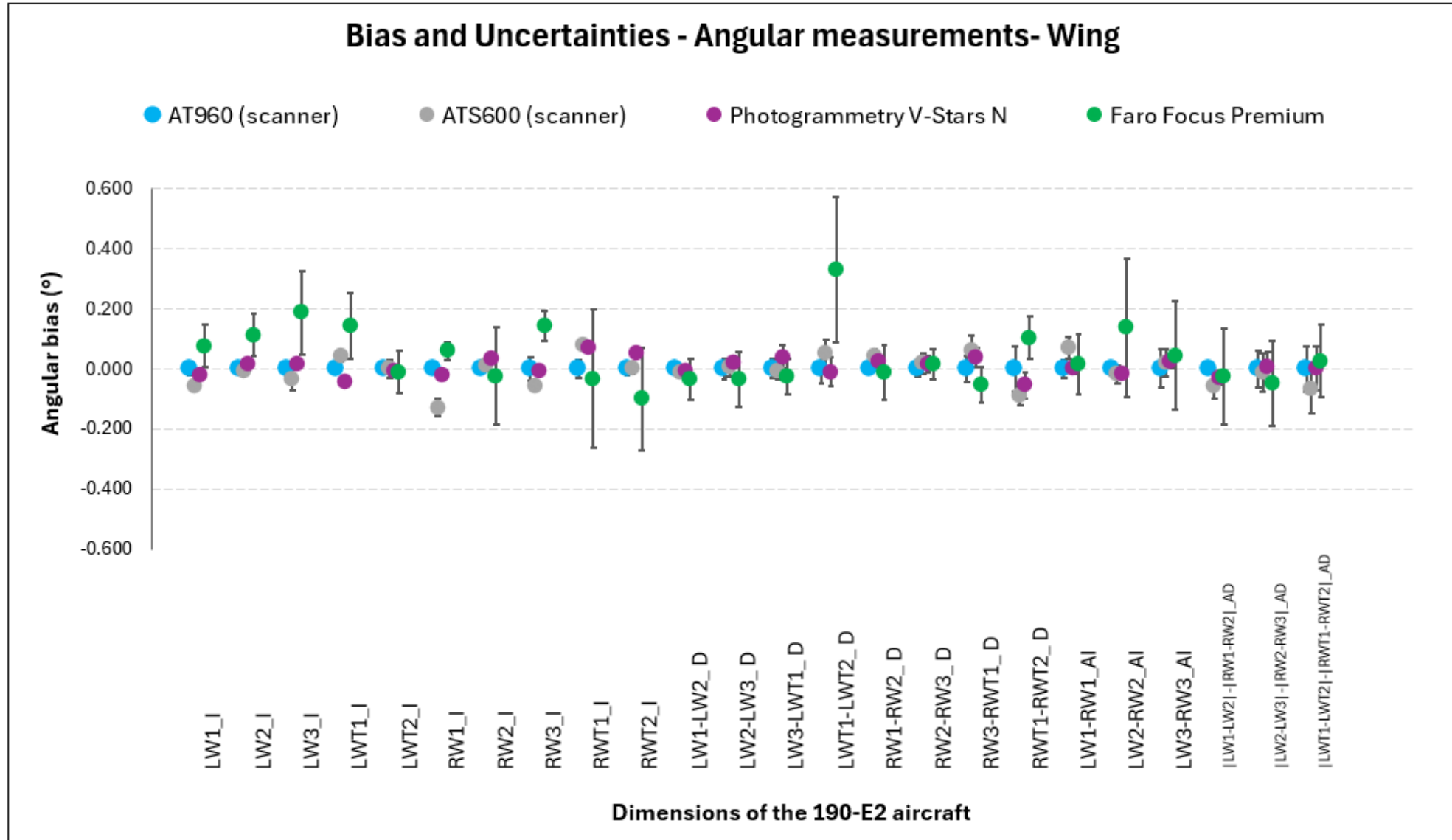


Angular measurements on the 190-E2 aircraft

Repeatability (Standard deviation) - Angular measurements - Wing

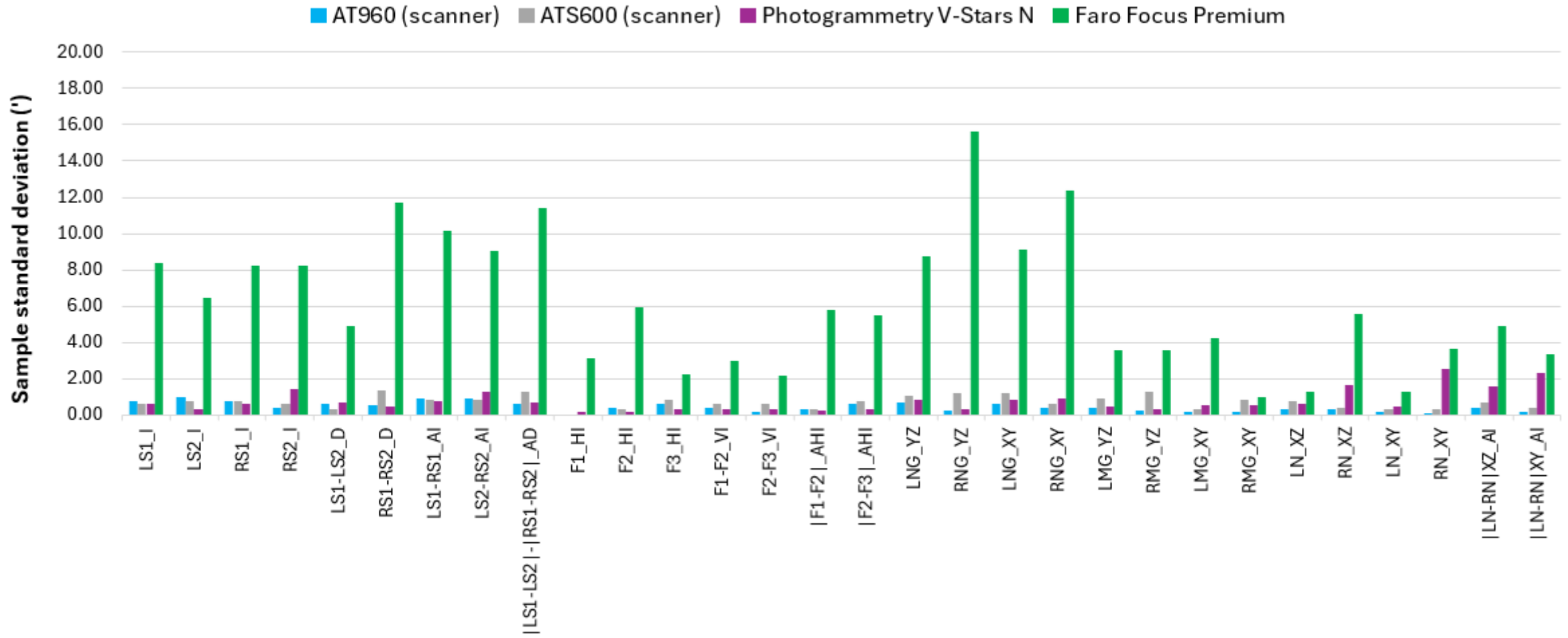


Angular measurements on the 190-E2 aircraft



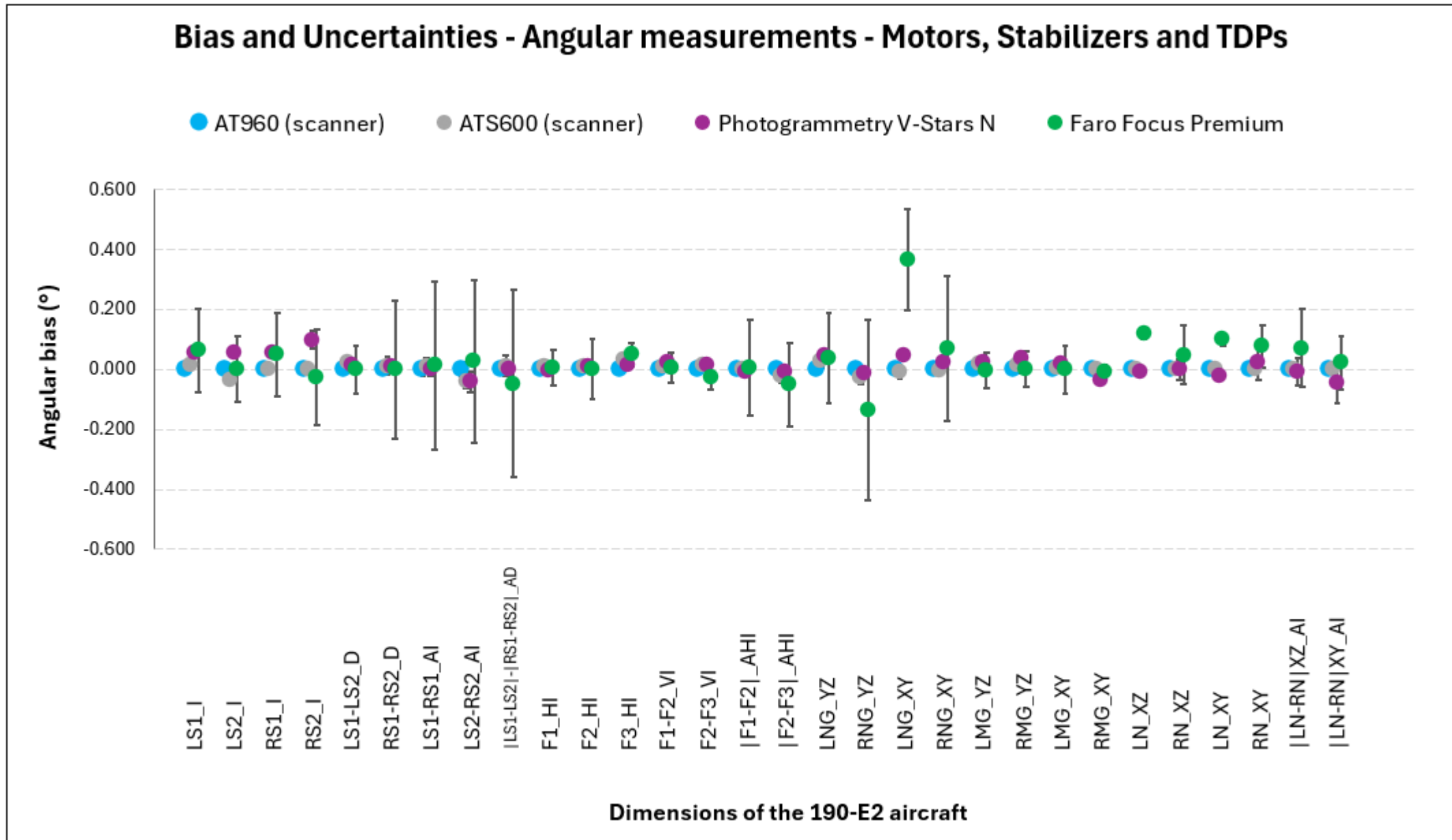
Angular measurements on the 190-E2 aircraft

Repeatability (Standard deviation) - Angular measurements - Motors, stabilizers and TDPs



190-E2 dimensions

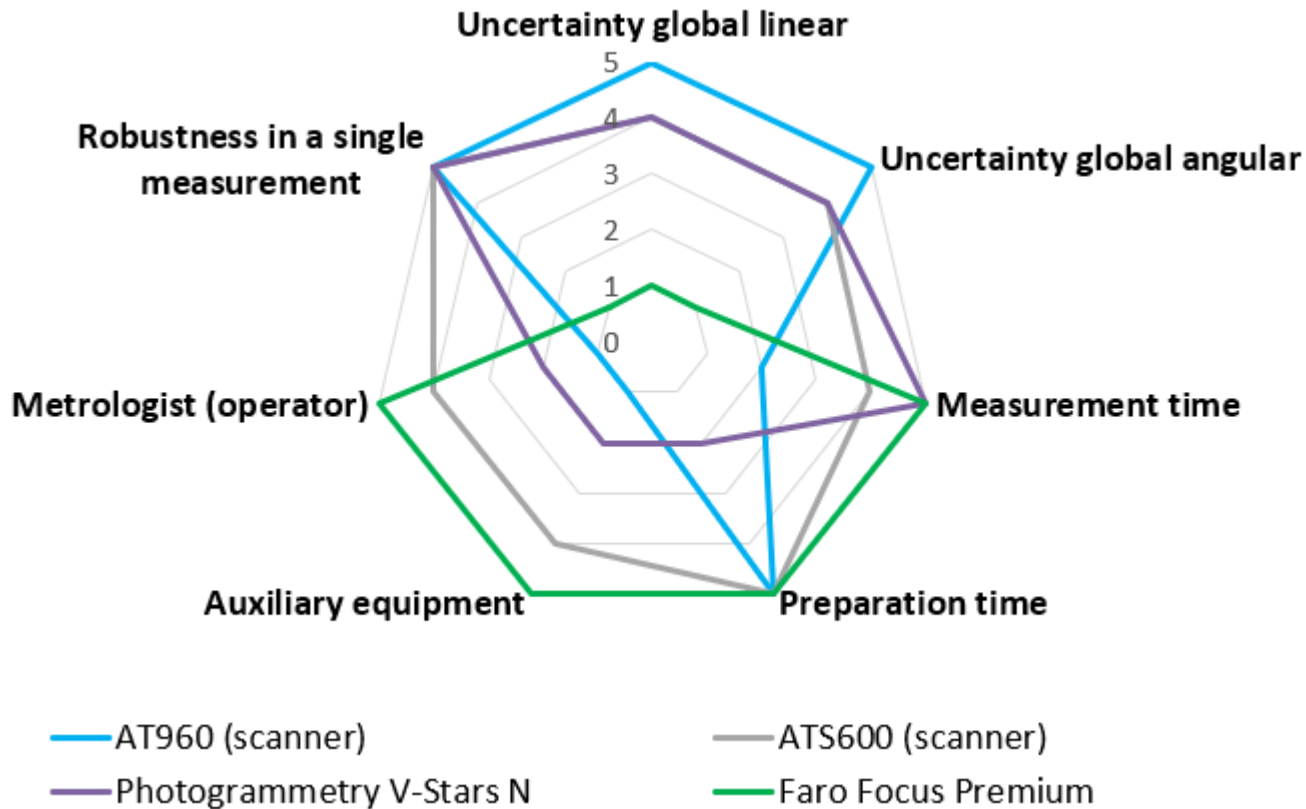
Angular measurements on the 190-E2 aircraft



Comparison of Measurement Methods



Comparison of Measurement Methods



Uncertainty global linear	Description
5	Minimum linear measurement uncertainty (U+E)
1	Maximum linear measurement uncertainty (U+E)

Uncertainty global angular	Descrição
5	Within the tolerance zone fo all types of dimensions
1	Outside the tolerance zone for all types of dimensions

Measurement time	Description
5	1 h a 1.5 h
1	4 h

Preparation time	Description
5	1 h
1	6 h

Auxiliary equipment	Description
5	No auxiliary equipment
1	Device kit, lifting platform, ladders, PolyWorks, alignment holders.

Metrologist (operator)	Description
5	Inexperienced operator
1	NR-35 compliant, proficiency in measurement techniques, ability to operate the lifting system, and the operator's influence on measurements

Robustness in a single measurement	Description
5	A single measurement is sufficient
1	Three to five measurements are required

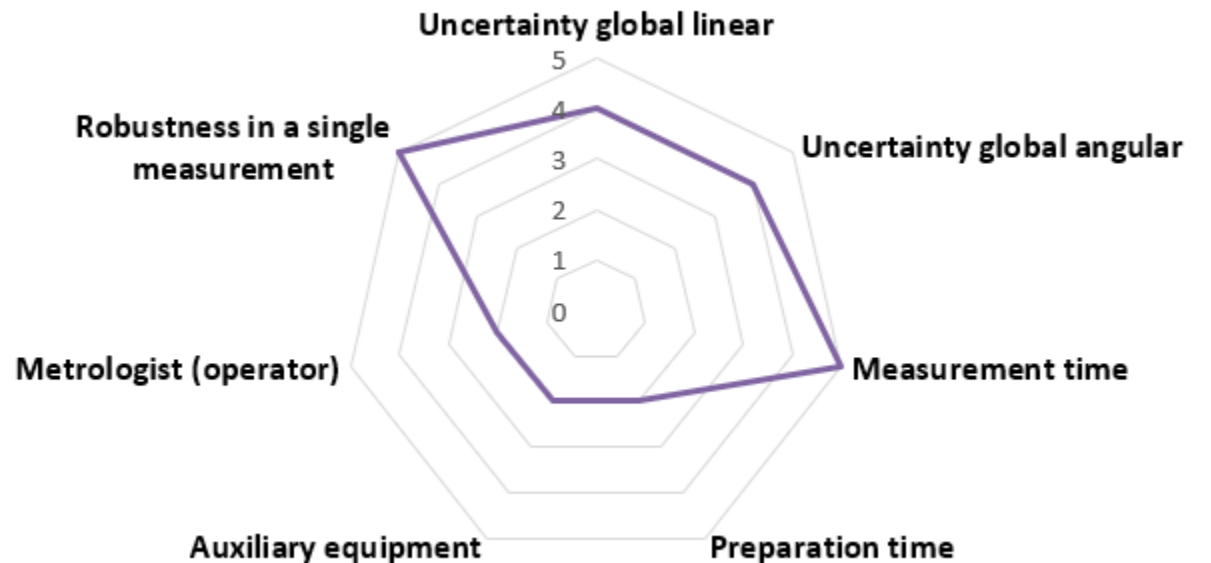
AT960 (scanner)	ATS600 (scanner)	Photogrammetry V-Stars N	Faro Focus Premium
24	30	24	23

Comparison of Measurement Methods

- **Current Method: V-Stars N Photogrammetry**
 - **Advantages**
 - Accuracy and precision suitable for the intended use;
 - Minimum measurement time (1 hour);
 - A robust single measurement.
 - **Disadvantages**
 - NR-35 compliant operator and Star 10 qualified.
 - Operator effect on measurements (photogrammetry experience).
 - Star 10 is required for measurements.
 - High preparation time \approx 4 hours (requires attaching and removing targets).
 - Cost of targets and accessories (wear and tear).



Photogrammetry



Comparison of Measurement Methods

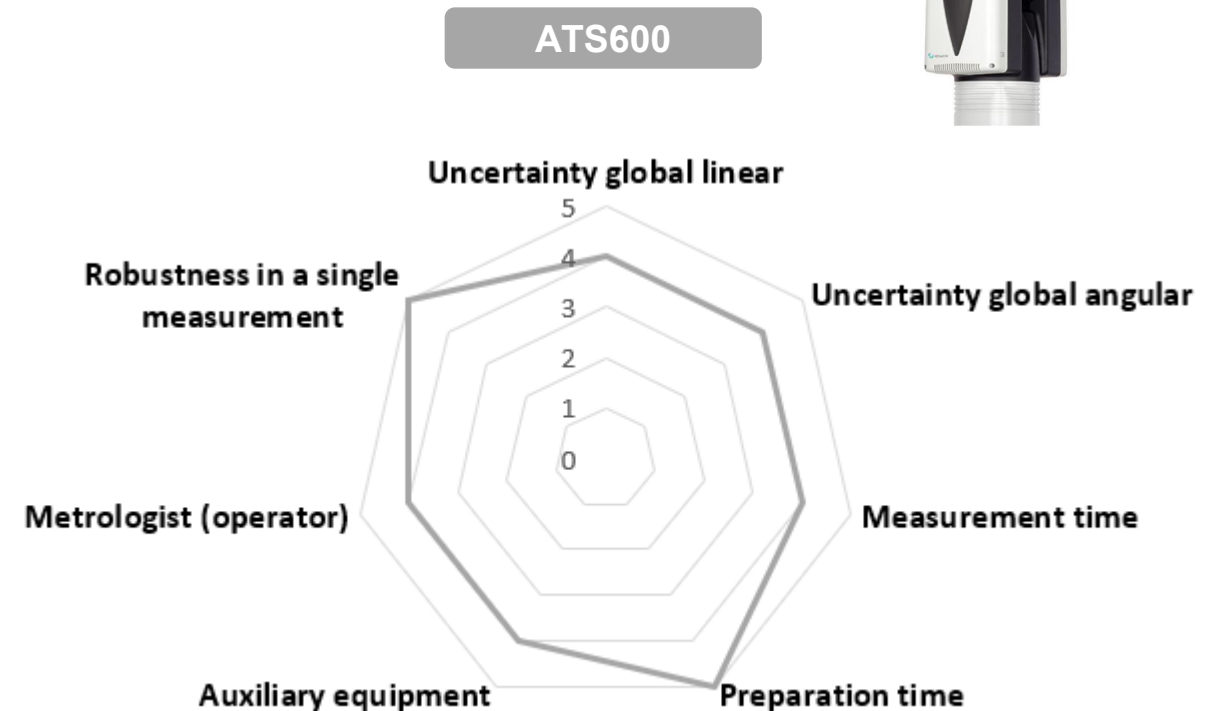
- Proposed Method: ATS600 (scanner)

- **Advantages**

- Accuracy and precision suitable for the intended use.
- Measurement time of 2 hours.
- Minimum preparation time (1 hour).
- Non-contact measurement and no targets (except triangulation points).
- NR-35 compliant operator not required and Star 10 qualified.
- Reduced operator effect on measurements.
- Robust single measurement.
- Possibility of remote measurement and automation.

- **Disadvantages**

- Cost of equipment.
- Operator with experience and mastery of PolyWorks.
- *Color is a source of measurement error (less than 1 mm).*



Concluding remarks

- ATS600 shows strong potential for industrial metrology
- Advantages:
 - Automation possibilities
 - Time optimization
 - Maintains result quality
- Limitations of Faro Focus Premium
 - High dispersion and uncertainty
 - Unsuitable for high-accuracy measurements in tested conditions
- Importance of choosing the right technology for specific environments
- ATS600 stands out as a promising solution for future applications

Thank you!

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