FUTURE-ORIENTED DIMENSIONAL MANAGEMENT AND PRODUCTION ENGINEERING METROLOGY

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MOTIVATION – QUESTIONS?

- ✓ **What is dimensional management and production engineering metrology?**
- ✓ **What is our vision and mission?**
- ✓ **Dimensional Management:**

  What are the current challenges and what is the next step in dimensional management?

- ✓ **Production Engineering Metrology**

  How will the future industrial metrology system be designed and constructed?

  How will the future industrial metrology system function in its working environments?

WHAT IS DIMENSIONAL MANAGEMENT AND PRODUCTION ENGINEERING METROLOGY?

Our definition is:

The applied science of reliable geometrical assurance, geometrical control and geometrical metrology in research and in the product realization process.

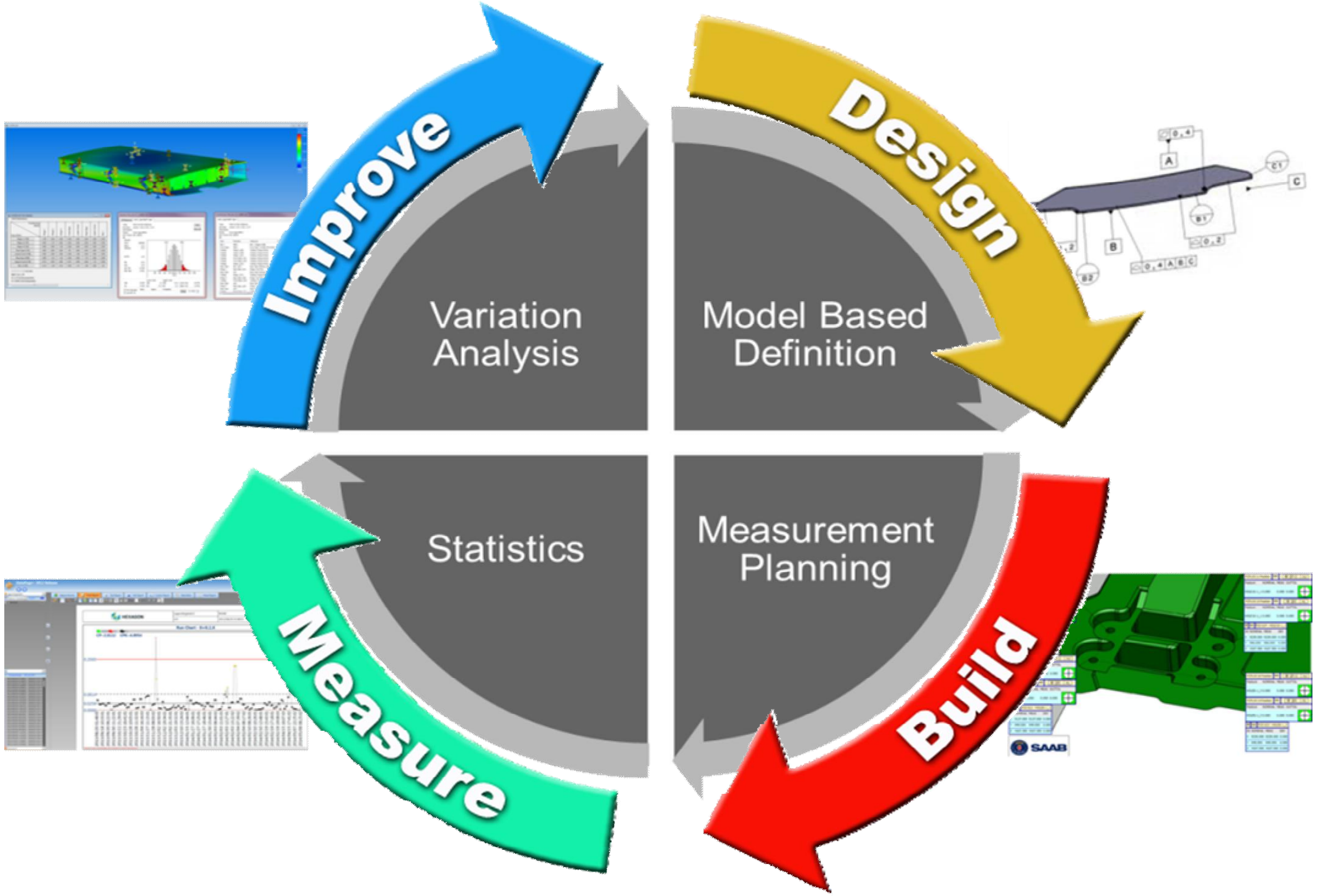
"From raw material to complete aircraft"

WHAT IS DIMENSIONAL MANAGEMENT AND PRODUCTION ENGINEERING METROLOGY?

Our vision and mission - challenges?

- ***One holistic approach, with a "Total Vehicle Integration" responsibility***
- ***Implement and ensure the use of our geometrical assurance process***
- ***Ensure that all geometrical requirements is met with economical variation***
- ***Add value through systematic use of geometrical knowledge***
- ***A closed interoperable and reliable geometrical information process loop***

THE VISION AND CONCEPT OF:
DIMENSIONAL MANAGEMENT AND PRODUCTION ENGINEERING METROLOGY



NEXT STEP IN DIMENSIONAL MANAGEMENT?

<u>Compliant tolerance analysis: Rigid body analysis v.s. non rigid body analysis:</u>

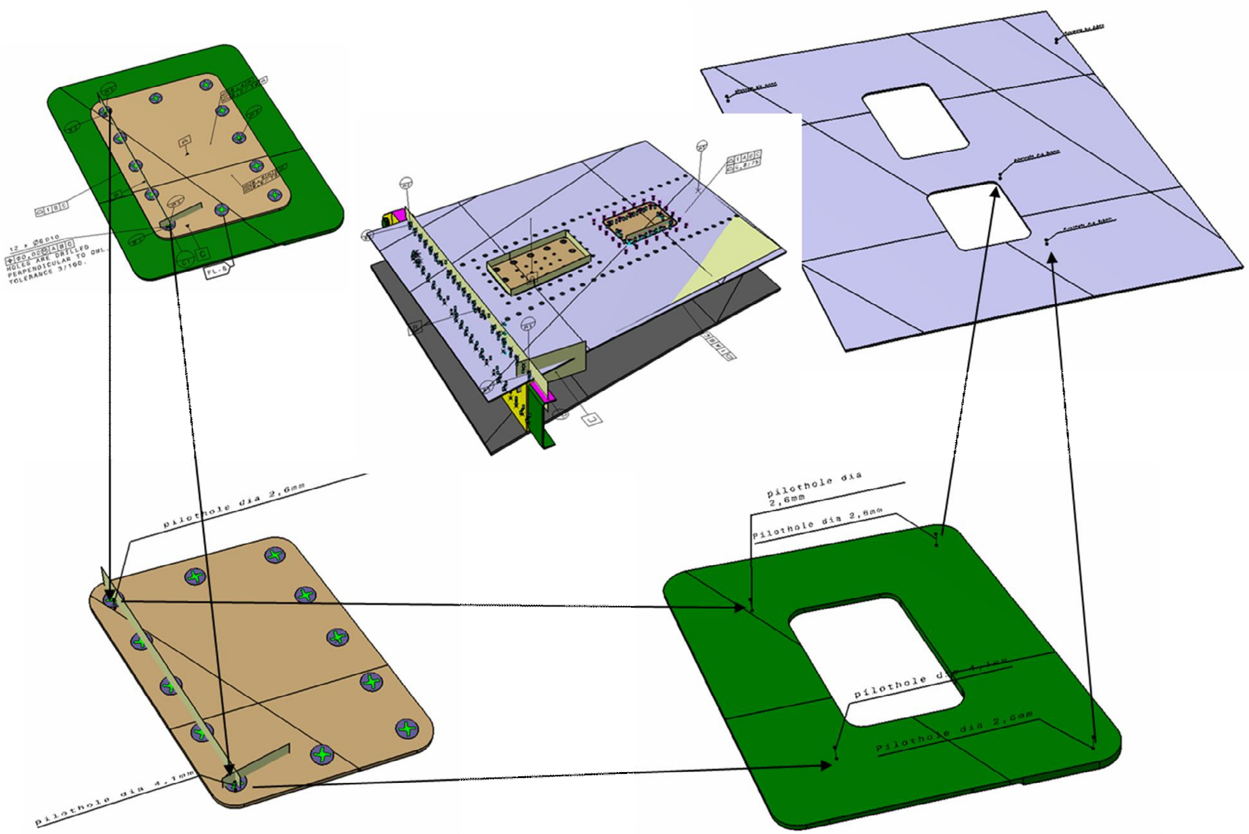
- ✓ According to our studies, there are cases of simulations where non-rigid body analysis could and should be applied. (Composite manufacturing, sheet metal manufacturing, and in some cases in metrology planning applications)
- ✓ Typically cases is where elastic parts such as sheet metal parts are used.
- ✓ However ***we could ”work around” those non rigid issues only using conventional rigid body analysis*** without compromising the result.
- ✓ To simulate non rigid bodies leads to other negative consequences and disadvantages such as increased complexity, considerably longer times for simulations, increased license fees, educational needs etc.

<u>Conclusions:</u>

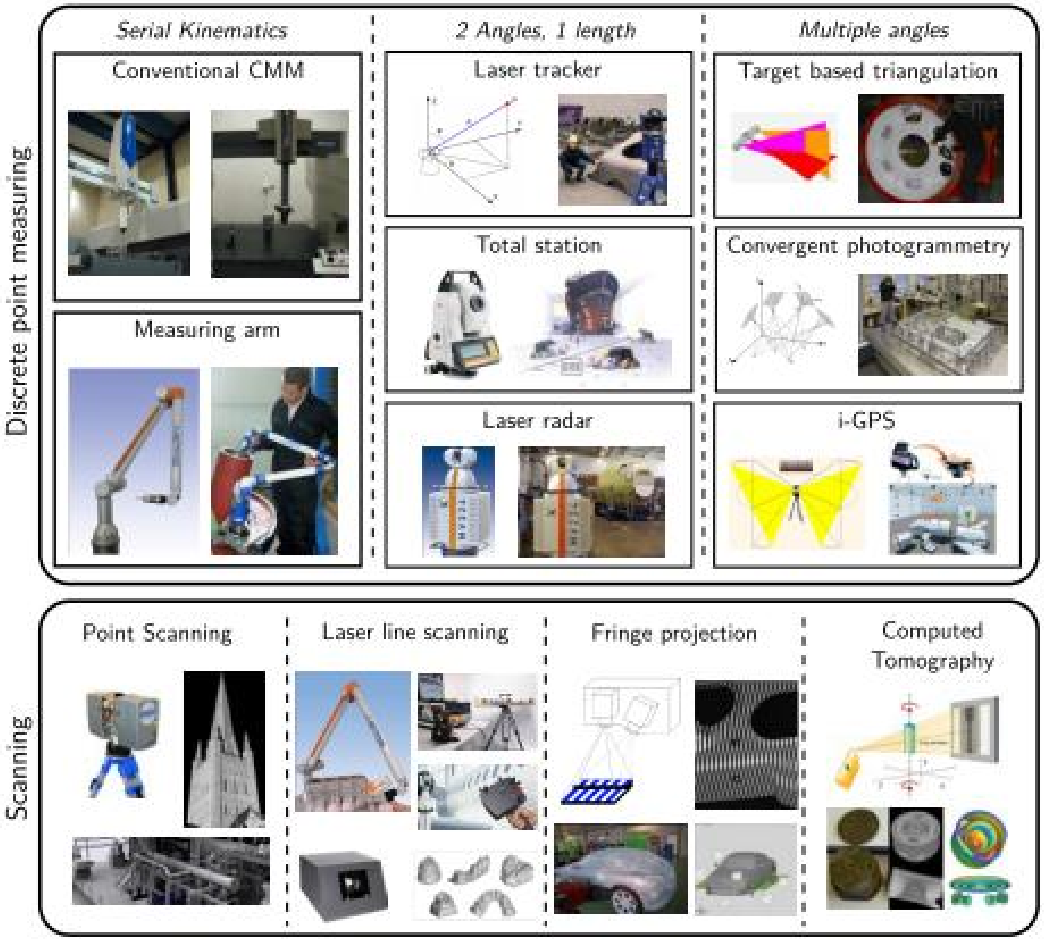
We have not found any particular simulation cases where the need for non rigid body simulation considers the disadvantages, as mentioned above.

WHAT DRIVES THE DEVELOPMENT TODAY? PART TO PART ASSEMBLY – AFFORDABILITY REQUIREMENTS

Part to part location and assembly means less tooling but requires more dimensional management and precision metrology integration…



COMMON COORDINATE MEASURING MACHINE SYSTEMS

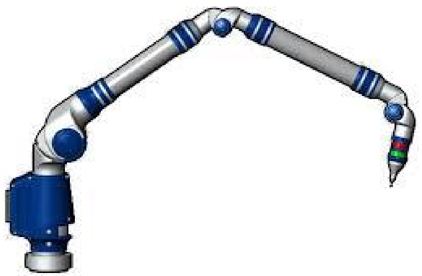


(Reference: Nick Van Gestel, 2011)

CURRENT GEOMETRICAL METROLOGY SYSTEMS USED AT SAAB AERONAUTICS/AEROSTRUCTURES

Portable CMM systems

Fixed CMM systems



Source: www.leica-geosystems.com, Hexagon Metrology, 2015. Metronor.com and Faro.com.

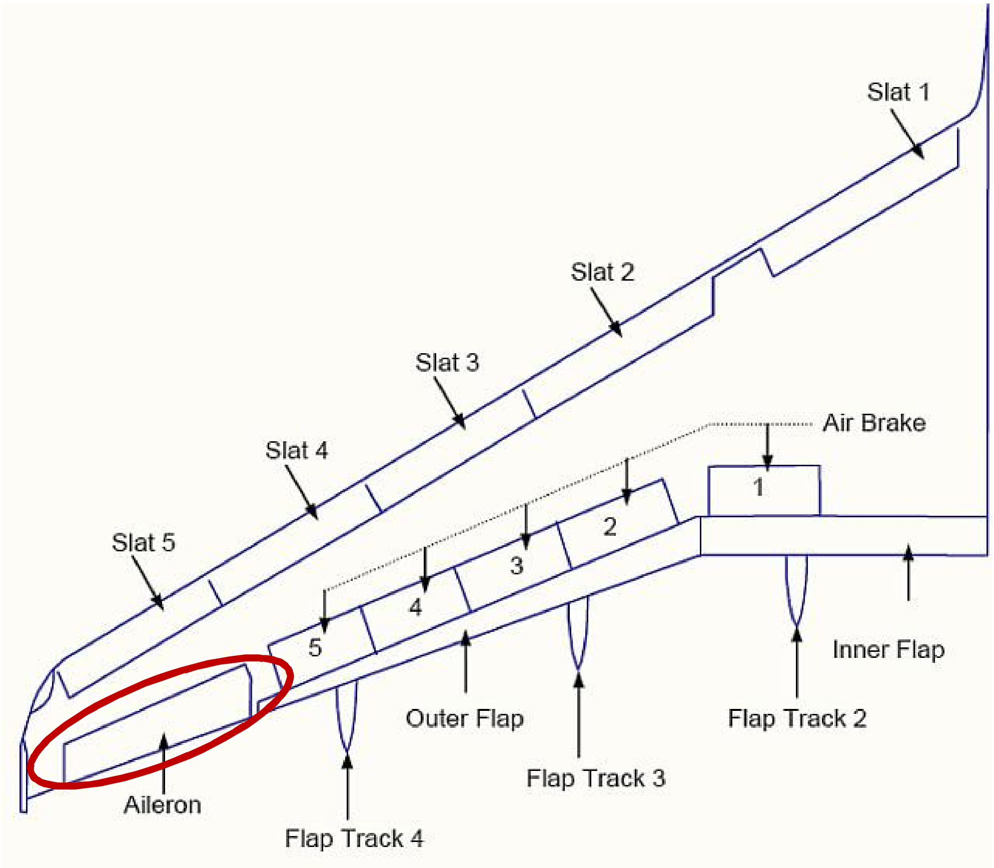
TREND:
IMAGE METROLOGY – A FAST GROWING METROLOGY…

Source: 8Tree.com, 8Tree GmbH.

- ✓ It is a quick technique
- ✓ Uses fast algorithms to compute and evaluate the results
- ✓ Reliable
- ✓ Affordable, cost effective
- ✓ User friendly
- ✓ Mainly based on fringe projection techniques

- ✓ Example: Fastcheck fringe projection system for measuring and inspecting flushness of fasteners and projects the results direct on the airframe structure.

TREND:
SCANNING - WHY SHOULD WE IMPLEMENT AND SCAN MORE?



Recent benchmark and internal casestudy:

Facts:

✓ Laserscanning compared to discrete point measurements (lasertracker v.s. Photogrammetry)

✓ Application: Manual measurement and inspection of Ailerons using 3D portable coordinate measuring machines

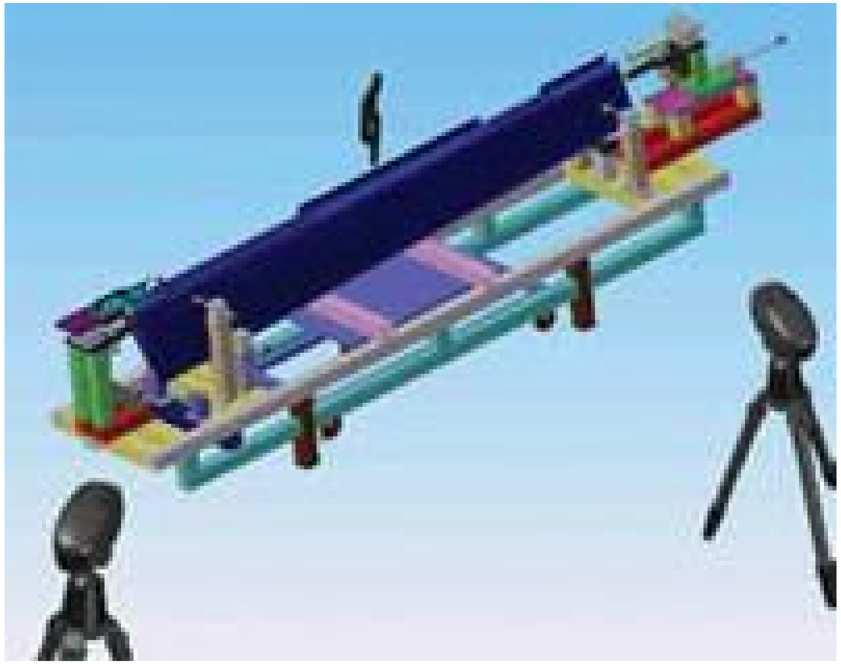
✓ High production rates → Minimize the time for measurement and inspection

✓ Equipment used: Absolute Tracker 901 with T-Scan 5 and Spatial Analyzer (measurement software)

TODAYS SOLUTION – PHOTOGRAMMETRY SYSTEM

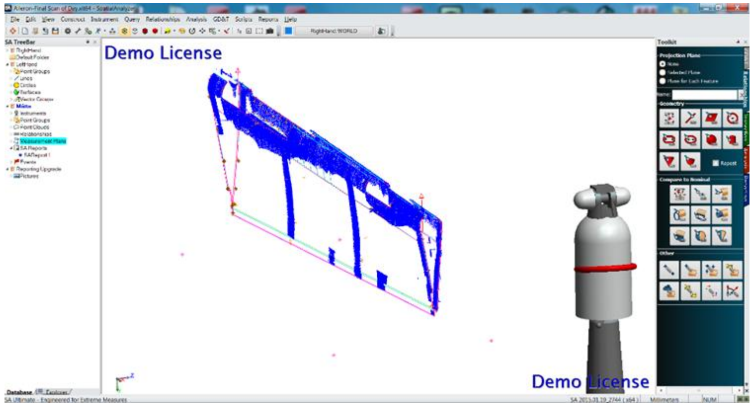
- ✓ One Metronor DUO photogrammetry (stereo camera based technique) system and Powerinspect measurement software is used.

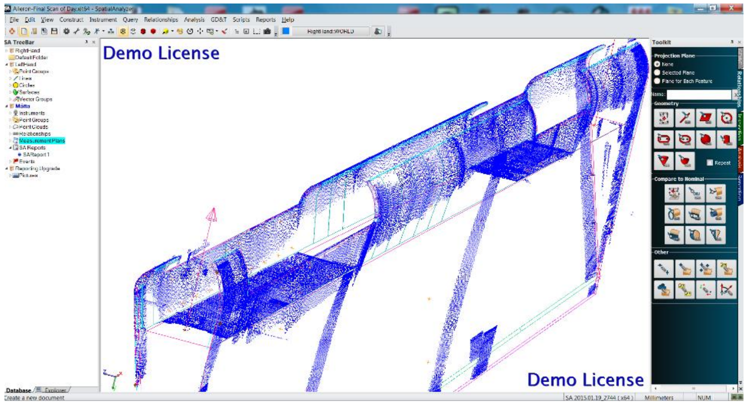
✓ The purpose is to measure, extract and filtering out 280 measurement datapoints, and use advanced best-fit calculations



Source: Metronor.com, Metronor A/S.

LASERSCANNING SOLUTION





- ✓ The measurement software Spatial Analyzer extracted the points of interest from the point cloud, did a relationship fitting (different tolerance on different points).
  The fixture was not ideal for the scanner so T-Probe was used in some areas.

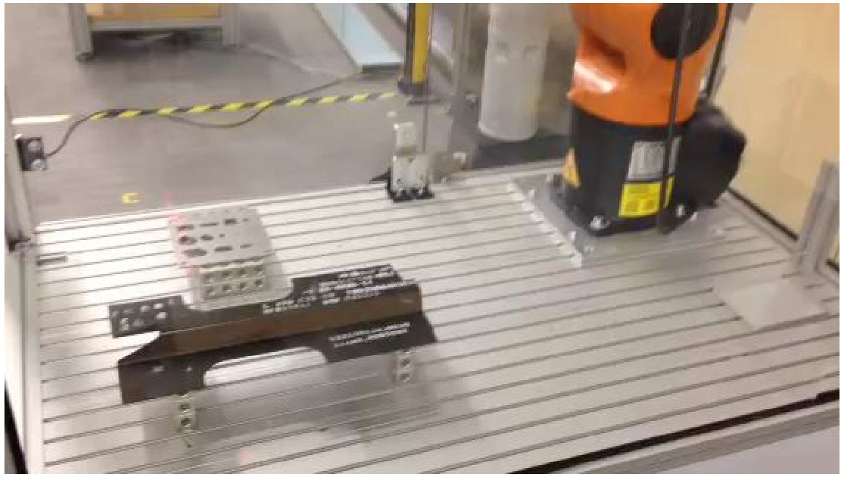
- ✓ If the measurement fixture is changed so only the T-Scan is used and a Measurement Plan is created in the measurement software, the measurement and inspection could be performed 6 to 8 times faster than the old photogrammetry method.

Conclusion:

- ✓ The current software has limitations in performing a bestfit calculation, using different tolerances and weightening on different points and on different surfaces. It is also more time consuming (6-8 times) to extract 280 measurement datapoints compared to using laserscanning

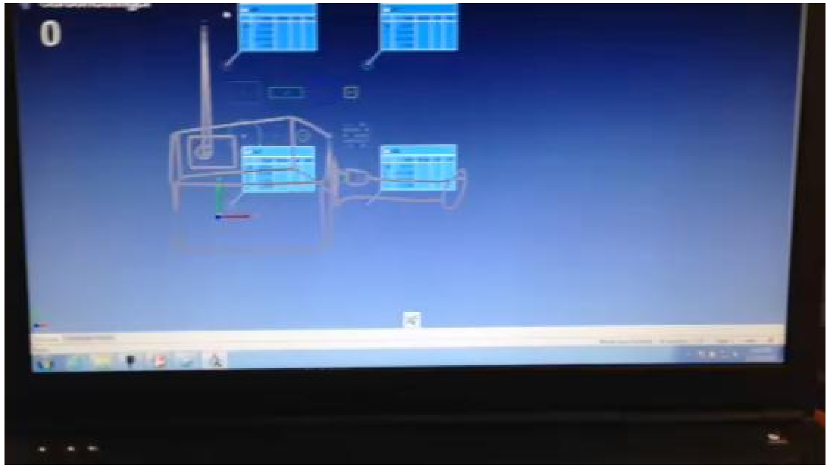
Source: Hexagon Manufacturing Intelligence, Per Uno Olsson and Zack Rogers.

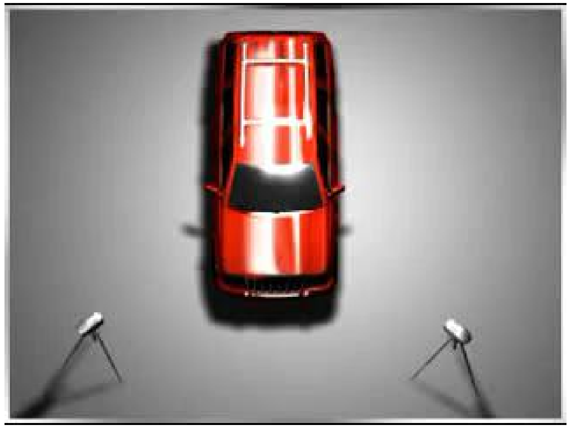
WHAT COULD IT LOOK LIKE IF WE MOUNTED THE SCANNER ON A STANDARD INDUSTRIAL ROBOT?



Source: Studytrip and test trials at Hexagon Manufacturing Intelligence and Leica in Switzerland, 2014-11-11,
Absolute Tracker 960 + T-Scan5 – KUKA KR6 Cell

Source:
http://www.metronor.com/industrial/products/duo/,
discrete point measurements.





SPC RESULTS FOR THE SHEET METAL SAMPLE PART

- ✓10 repetitive measurements
- ✓Alignment recomputed every time
- ✓0.07 mm point spacing
- ✓40% scan line width
- ✓0.5 ms exposure time
- ✓320 scan lines / sec
- ✓Robot speed 150-300 mm / sec

Object Control SPC Results

Control	# Pieces	Mean M...	Std Dev	3 Sigma	Min	Max	Range	Cp	Cpk
circle 1									
Diameter	10	29.909	0.003	0.010	29.903	29.913	0.010	101.163	91.661
X	10	25.049	0.015	0.045	25.032	25.076	0.044	23.501	22.340
Y	10	75.031	0.013	0.038	75.011	75.048	0.037	27.901	27.045
Z	10	3.008	0.005	0.014	3.002	3.014	0.011	89.817	89.064
circle 4									
Diameter	10	4.978	0.010	0.031	4.964	4.993	0.029	34.873	33.819
X	10	104.979	0.013	0.039	104.958	104.998	0.039	26.185	25.649
Y	10	75.032	0.012	0.035	75.010	75.046	0.036	28.365	27.463
Z	10	3.005	0.005	0.016	2.996	3.011	0.015	68.270	67.938
Pattern_C1									
Diameter	10	2.244	0.017	0.051	2.224	2.274	0.051	20.273	15.398
X	10	119.950	0.017	0.052	119.923	119.974	0.051	20.140	19.135
Y	10	85.016	0.015	0.044	84.990	85.040	0.050	20.560	20.231
Z	10	3.021	0.005	0.015	3.014	3.030	0.016	65.221	63.851
slot 4									
Length	10	9.968	0.032	0.097	9.908	10.020	0.112	9.122	8.828
Width	10	3.006	0.011	0.033	2.987	3.024	0.036	28.358	28.189
X	10	134.965	0.024	0.071	134.933	134.999	0.066	15.583	15.037
Y	10	35.056	0.013	0.038	35.041	35.075	0.034	30.052	28.368
Z	10	3.028	0.005	0.014	3.023	3.037	0.014	71.264	69.259
A1									
Diameter	10	7.981	0.011	0.033	7.965	7.993	0.028	36.761	35.565
X	10	139.985	0.011	0.034	139.962	140.002	0.040	25.925	25.542
Y	10	139.978	0.006	0.019	139.970	139.991	0.021	49.647	48.540
Z	10	3.007	0.002	0.005	3.006	3.010	0.005	215.293	213.696
A2									
Diameter	10	7.968	0.008	0.023	7.958	7.982	0.024	43.602	41.621
X	10	140.006	0.011	0.034	139.993	140.025	0.032	32.565	32.355
Y	10	9.980	0.008	0.025	9.971	9.996	0.025	41.002	40.194
Z	10	2.993	0.002	0.005	2.990	2.994	0.005	215.293	213.696
A3									
Diameter	10	7.966	0.011	0.032	7.950	7.985	0.035	29.455	28.057
X	10	10.036	0.008	0.025	10.025	10.048	0.023	44.432	42.852
Y	10	10.011	0.006	0.018	10.001	10.019	0.019	55.216	54.588
Z	10	3.007	0.002	0.005	3.006	3.010	0.005	215.293	213.696

Statistics | Values per piece | Trend chart

Source: Studytrip and test trials at Hexagon Leica in Switzerland, 2014-11-11, AT960 + T-Scan5 – KUKA KR6 Cell

LEVEL OF METROLOGY AUTOMATION?

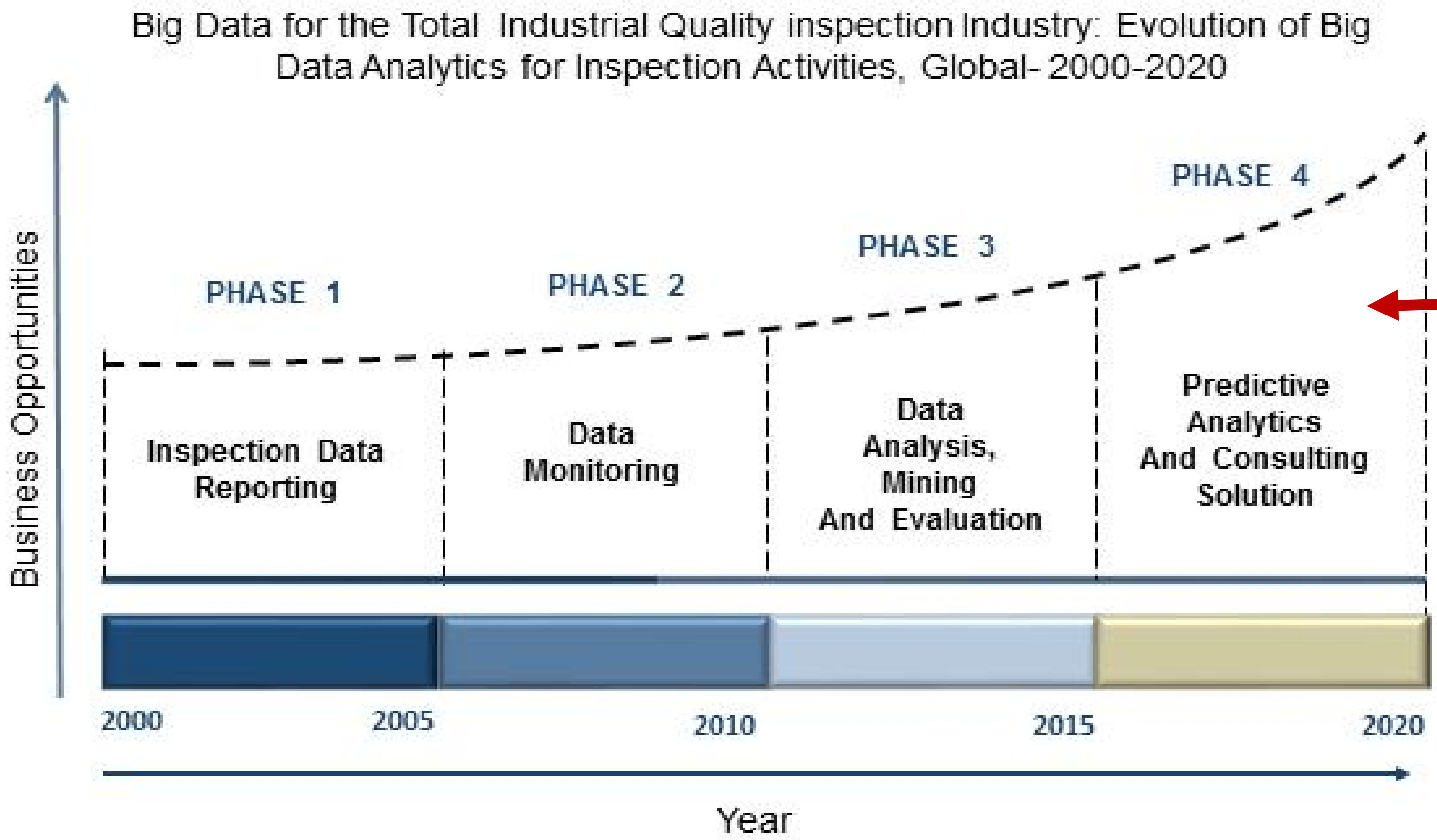
Trend: Going from manual measurements to more fully automated and in-line metrology systems. ***”Measure at the source”***

Where should one measure?

- To measure ***in confined*** and environmental controled spaces or
- To measure ***in non confined*** and ***non environmentally controled*** spaces, ref. ISO 1 – reference temperature 20 °C, such as:
  - In-line, in-process and in close range to the machine tools in part manufacturing or at the jigs, fixtures and automation cells in airframe assembly?

TREND:
IN-LINE GEOMETRICAL METROLOGY SYSTEMS

TREND:
BIG DATA - ANALYTICS TOWARDS ARTIFICIAL INTELLIGENCE?



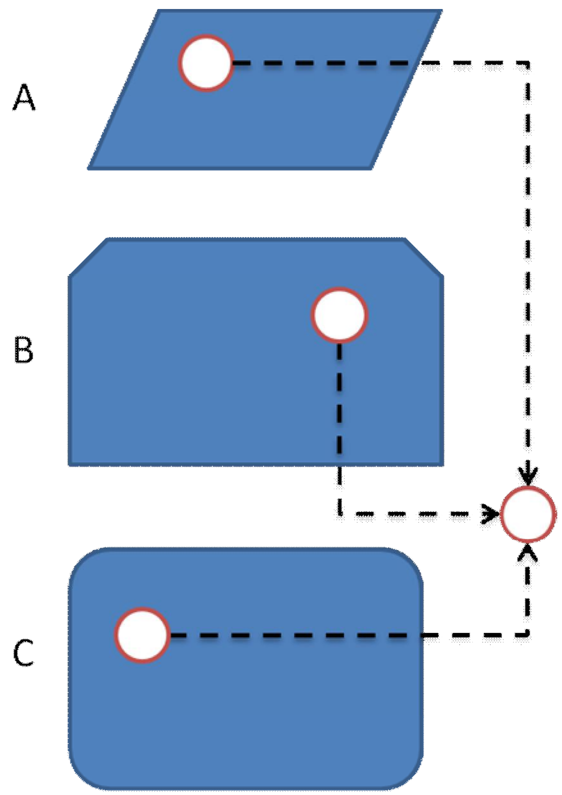
<u>Example - realtime analysis:</u>
- ✓ Predict tool wear
- ✓ Virtual assembly verification

Reference: Frost and Sullivan, 2016-01-11, webinar, “Understanding Industry 4.0 and its Impact on Inline Metrology Market”.

TREND:
DATA MANAGEMENT / SPC - THE SAAB WAY

Concentrate on the geometrical features rather than the specific part.

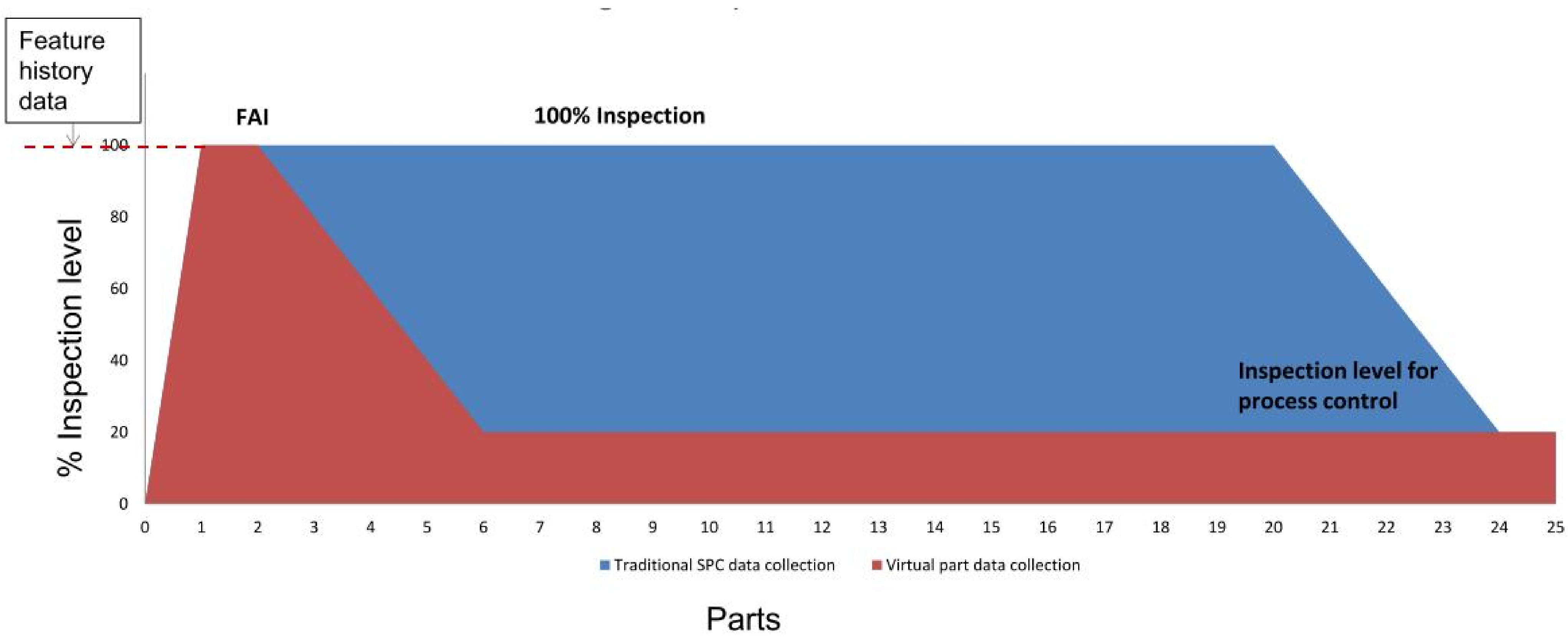
Store as a virtual features, geometrical "phantom features"



Virtual parts are a part with one feature for example a hole.

That virtual part collects the hole data from a number of physical parts produced in one and the same machine tool.

SPC – THE SAAB WAY
A FASTER WAY TO MEASUREMENT AND INSPECTION REDUCTION?

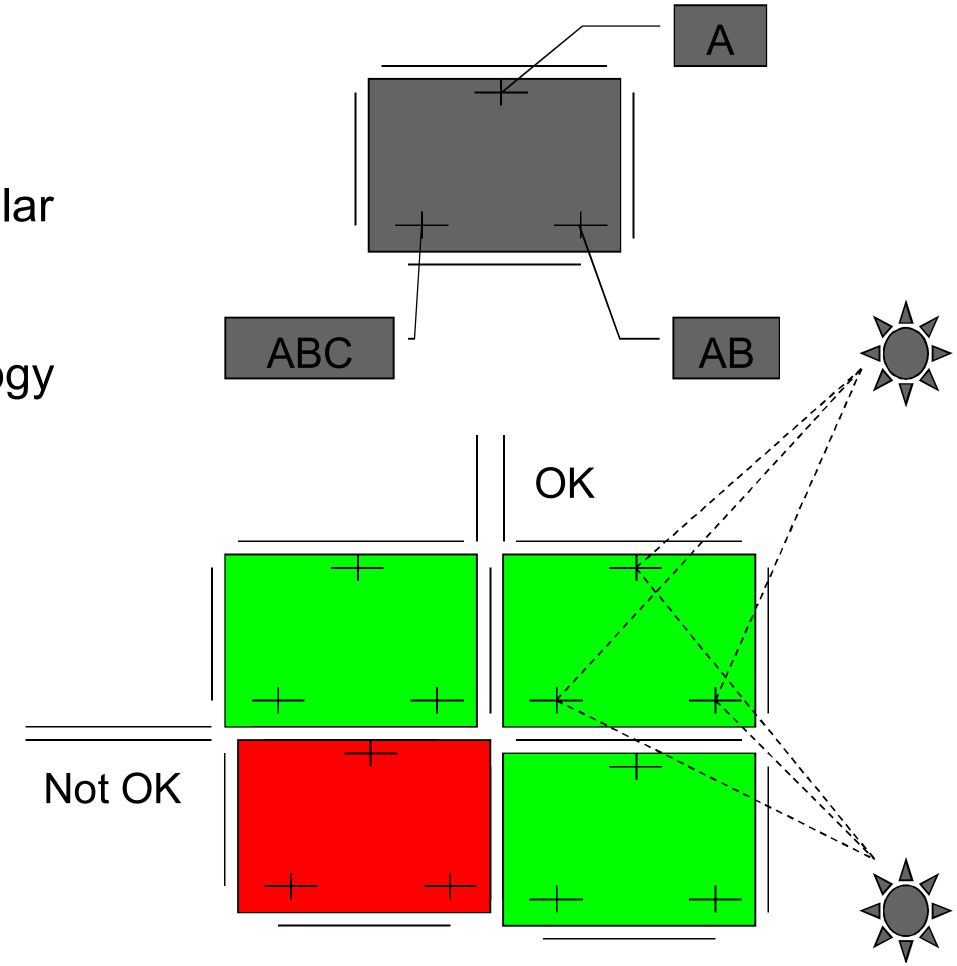


FUTURE: REAL TIME VERIFICATION OF ASSEMBLIES AND TOOLING

Conceptual description:

- ✓ Part picked and verified by barcode or RFID tag or similar
- ✓ Part installed by the operator, with assistance from a metrology system
- ✓ Part item and position verified and accepted by metrology system.
- ✓ System deliver an as-built report of item and position.

- ✓ Applicable on airframe parts and tooling (drill jigs).
- ✓ Applicable on jig pickup positions.




THANK YOU!