Digital Clamping – A cost-Efficient Approach for Quality Control in BiW Applications



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Expert Product Manager
AutoForm Group

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Webinar Content

1

Inspection

Relevance and impact on the total Cost of Quality

2

Car Body Parts Inspection

Car Drives – The two approaches at comparison

3

Digital Clamping

The NEW measurement process and how it applies to two applications

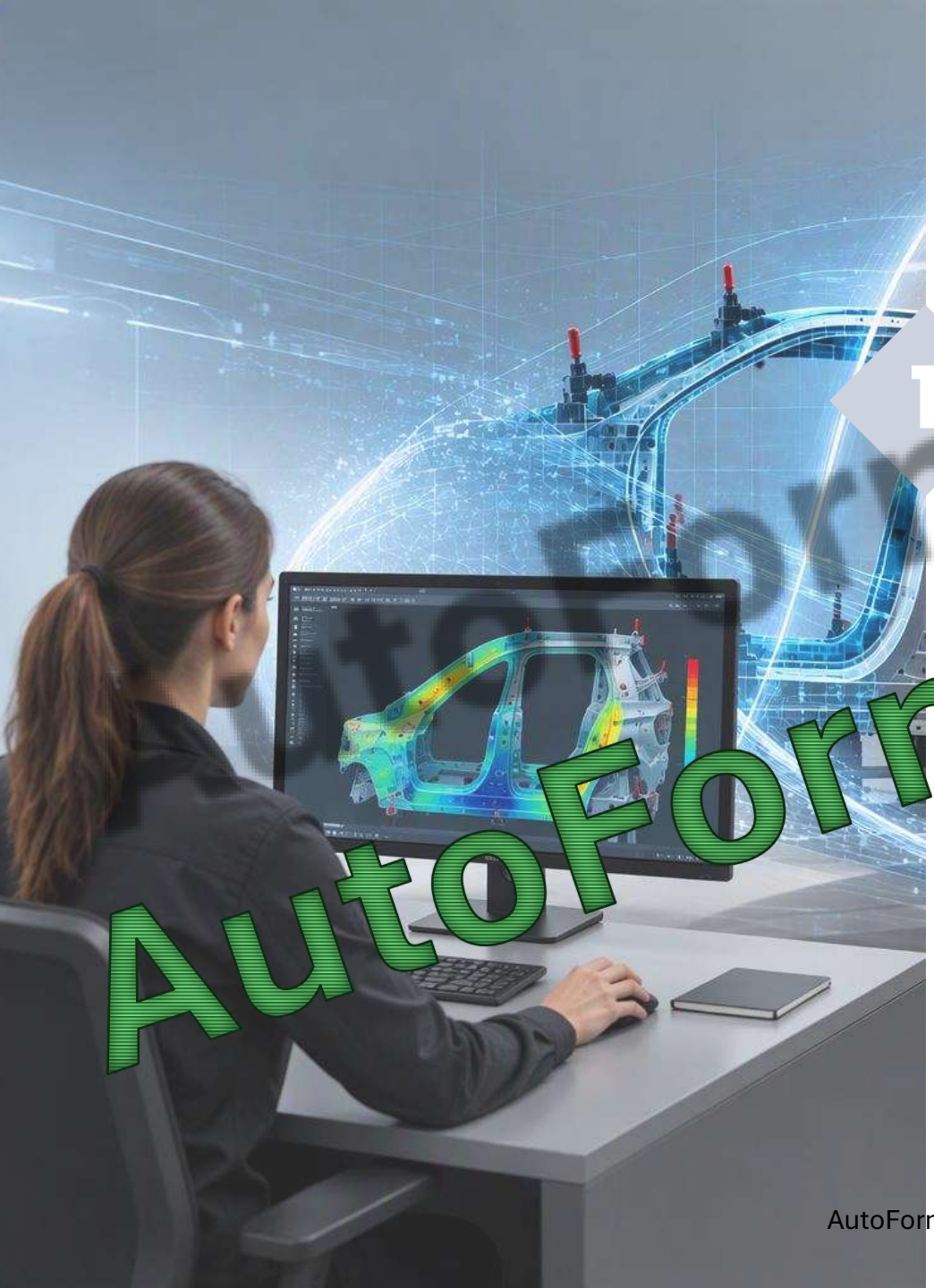
4

Conclusions

Takeaways and Next steps

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Webinar Content

1

Inspection

Relevance and impact on the total cost of Quality

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Inspection



Is the process of verifying that a manufactured product meets specific requirements through examination and measurement of relevant characteristics

- Surface quality
- Defects
- Dimensional characteristics
- Geometry and tolerances
- …

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Cost of Quality

Cost of **Good** Quality

- Design - Product Specs
- QMS (APQP – DFMEA – PFMEA)
- Process Engineering
  - Assessment Criteria
  - Process Variation Reduction
- Continuous Process Improvement (PPAP)
- *Trainings…*



- Quality Audit
- Incoming inspection (i.e.Material)
- Measure & Monitoring (In-Process & Final Inspection)
- MSA & SPC
  Fixtures Manufacturing, Measurements
- ….

Prevention

Appraisal

Cost of **Poor** Quality

- Scrap
- Unplanned Downtime
- Reworking (tools & products)
- Analysis of issues (failure)

Internal Failures

- Warranty claims
- Repair & Servicing
- Product Return
- Loss of image

External Failures

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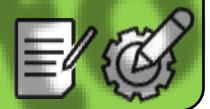
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Cost of Quality - Drivers

Cost of Quality in the BiW Manufacturing Process

Cost of Good Quality

- Design - Product Specs
- QMS (APQP – DFMEA – PFMEA)
- Process Engineering
  - Assessment Criteria
  - Process Variation Reduction
- Continuous Process Improvement (PPAP)
- *Trainings…*



- Quality Audit
- Incoming inspection (i.e.Material)
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- MSA & SPC
  Fixtures Manufacturing, Measurements
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Cost of Poor Quality

- Scrap
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- Warr ty ai s
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- Product Return
- Loss of image

Prevention | **Appraisal** | **Internal Failures** | **External Failures**

€	€€€	€€€	€€€€€
Low	High	High	Extremely High

Impact on Total CoQ

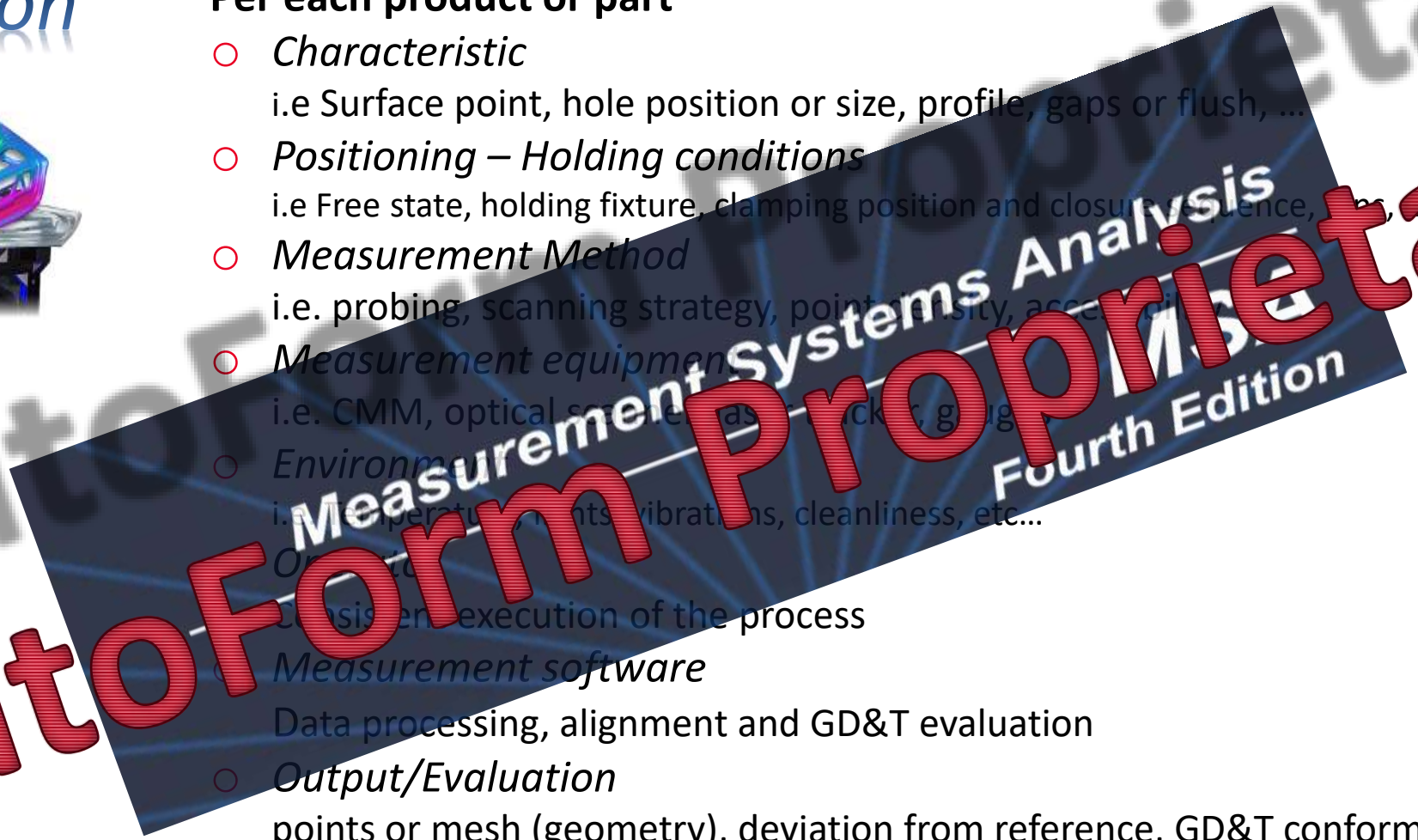
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Inspection



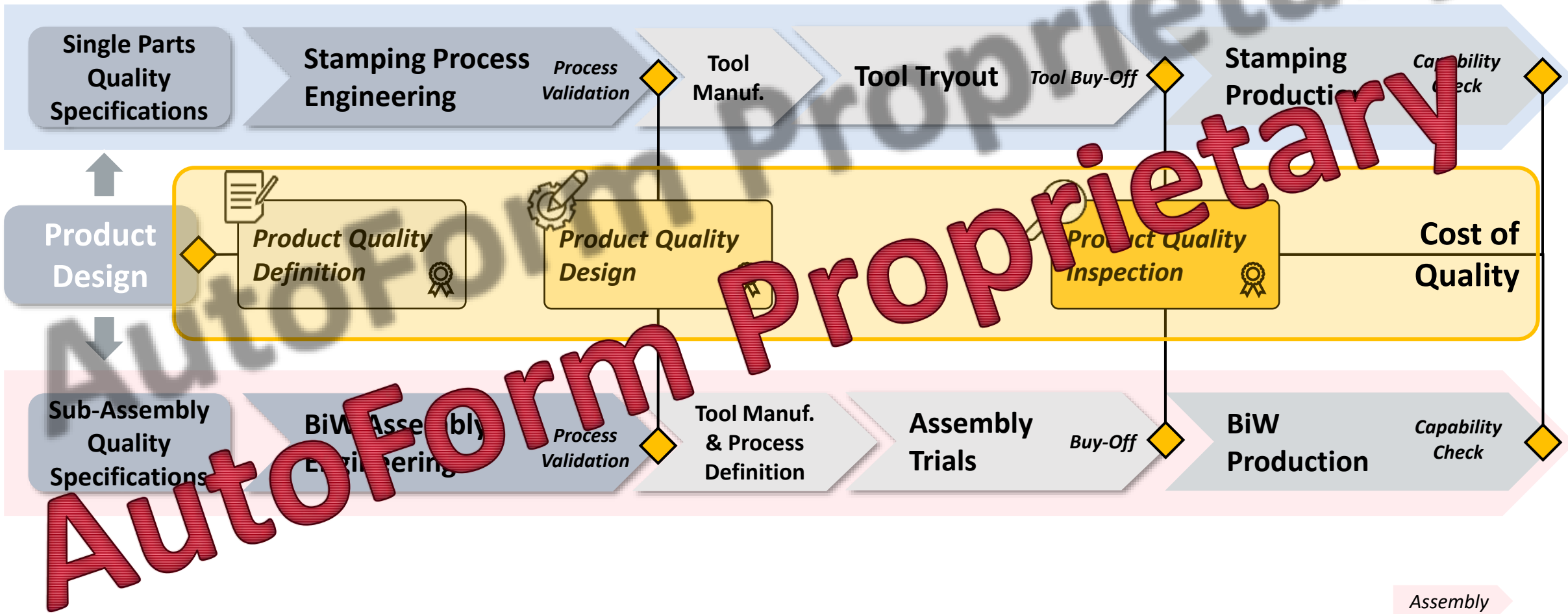
Per each product or part

- *Characteristic*
  i.e Surface point, hole position or size, profile, gaps or flush, …
- *Positioning – Holding conditions*
  i.e Free state, holding fixture, clamping position and closure sequence, [illegible] alignment procedure
- *Measurement Method*
  i.e. probing, scanning strategy, point density, acce[illegible]
- *Measurement equipment*
  i.e. CMM, optical scanner, [illegible]
- *Environment*
  i.e. temperature, [illegible] vibrations, cleanliness, etc…
- *Operator*
  Consistent execution of the process
- *Measurement software*
  Data processing, alignment and GD&T evaluation
- *Output/Evaluation*
  points or mesh (geometry), deviation from reference, GD&T conformity assessment



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From Dimensional Quality Definition to Inspection



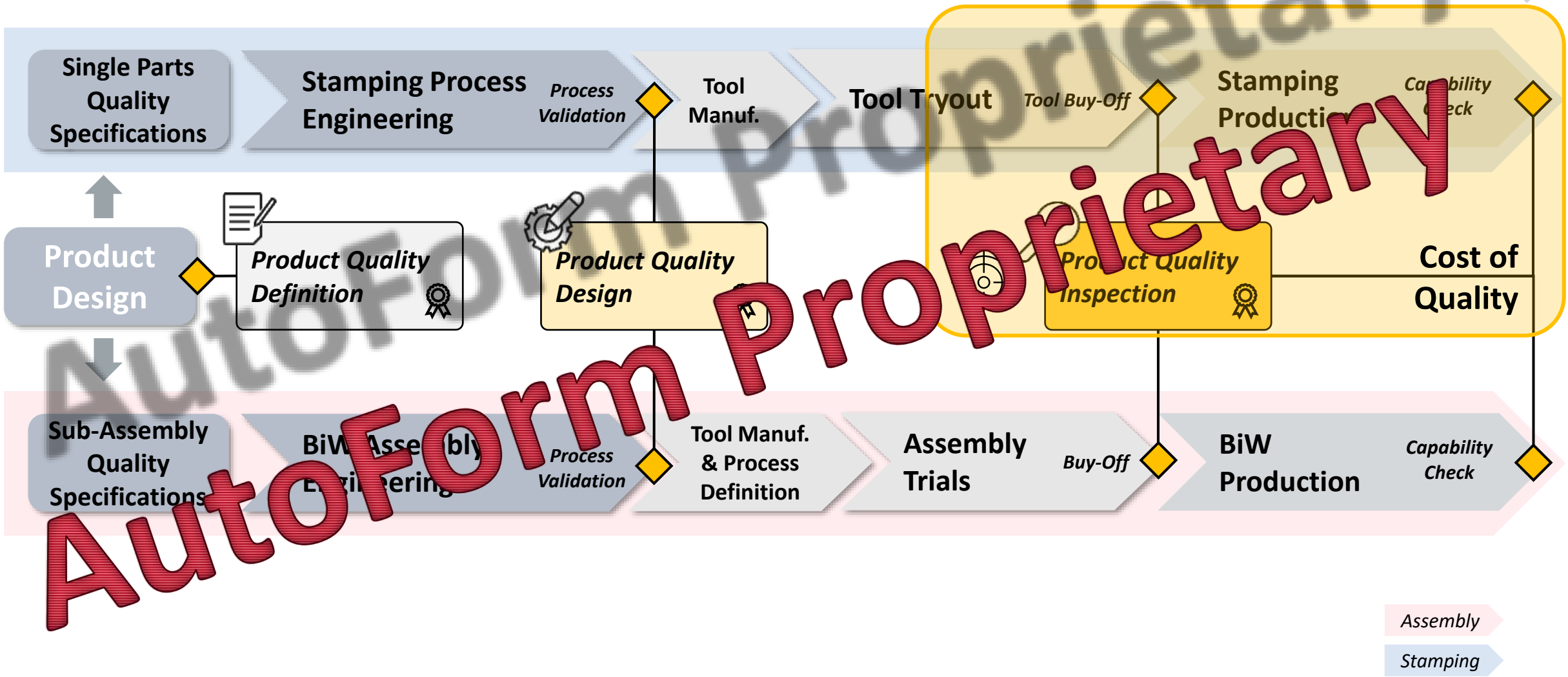
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From Dimensional Quality Definition to Inspection



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Webinar Content

1 Inspection

Relevance and impact on the tria[illegible] Quality

2 Car Body Parts Inspection

Car Drives – The two approaches at comparison

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Inspection Activities – As Is vs To Be

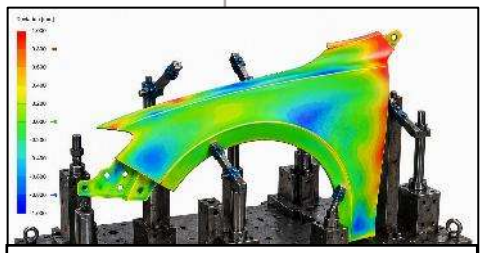
Physical Clamping



Part-tailored Clamping Fixture



Part Physically Clamped



Inspection

STANDARDS



- Measurement process definition
- Equipment calibration and certification
- Accuracy and precision evaluation
- ….



OEM Std.
(*agreed with supplier*)

- Orientation: vehicle position
- Fixturing method – Free vs Clamped
- Clamp positioning and closure sequence
- Part Preparation & Loading
- Operator training

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Physical Clamping



Costs are covered by OEM



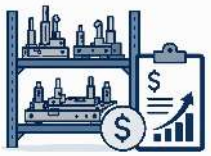
Engineering & Design

$



Manufacturing & Certification

$ $ $ $



Storage

$ $ $ $ $

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Digital Clamping Definitions



It is the simulation of the deformation of a non-rigid physical part when it is clamped on the inspection fixture (under constraints)

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Inspection Activities – As Is vs To Be

Physical Clamping



Part-tailored Clamping Fixture

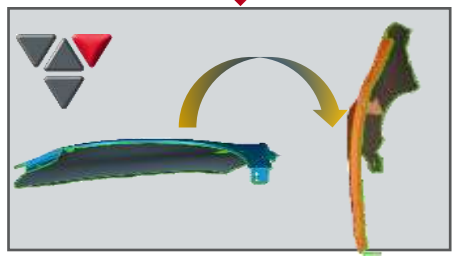


Part Physically Clamped

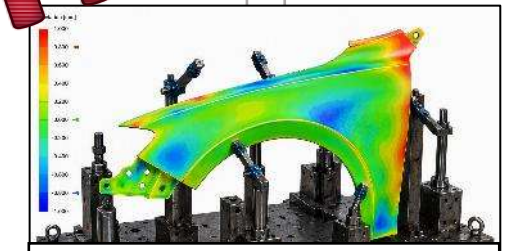
Digital Clamping

Universal Fixture





Part Digitally Clamped



Inspection

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Physical Fixture Cost Drivers & Digital Clamping Impact

Physical Clamping



Costs are covered by OEM



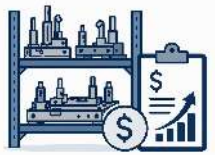
Engineering & Design

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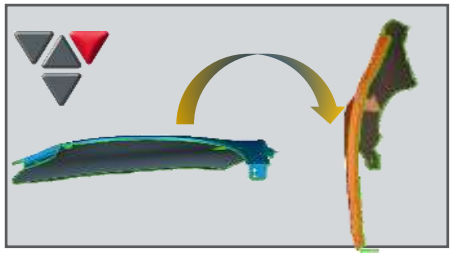


Storage

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Digital Clamping





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Webinar Content

1 **Inspection**
Relevance and impact on the tria[illegible]

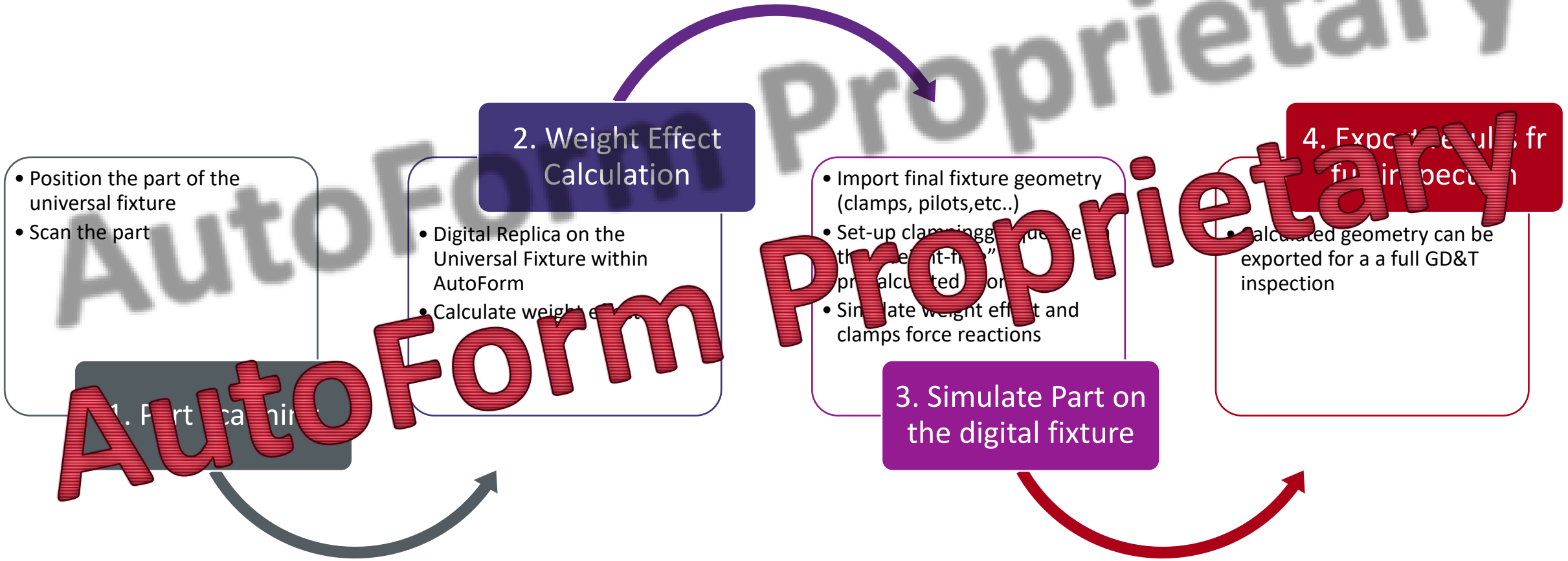
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Cl[illegible]Drivers – The two approaches at comparison

3 **Digital Clamping**
The NEW measurement process and how it applies to two applications

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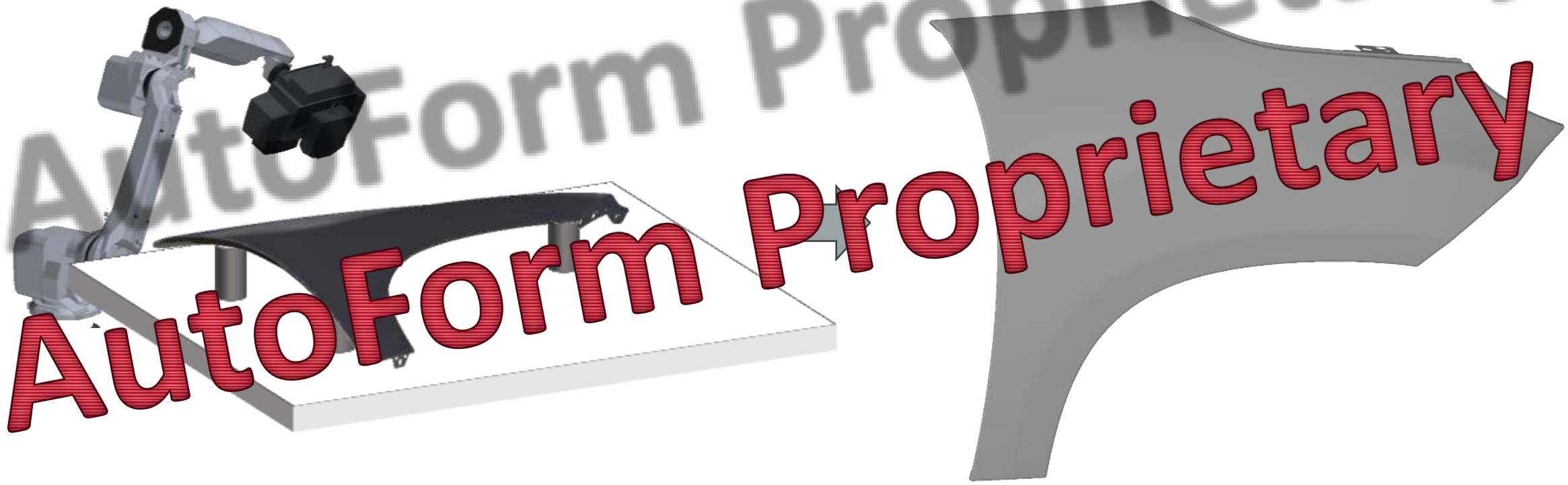
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Comprehensive Measurement Process



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Step 1 – Part Geometry Scanning in “Free” State



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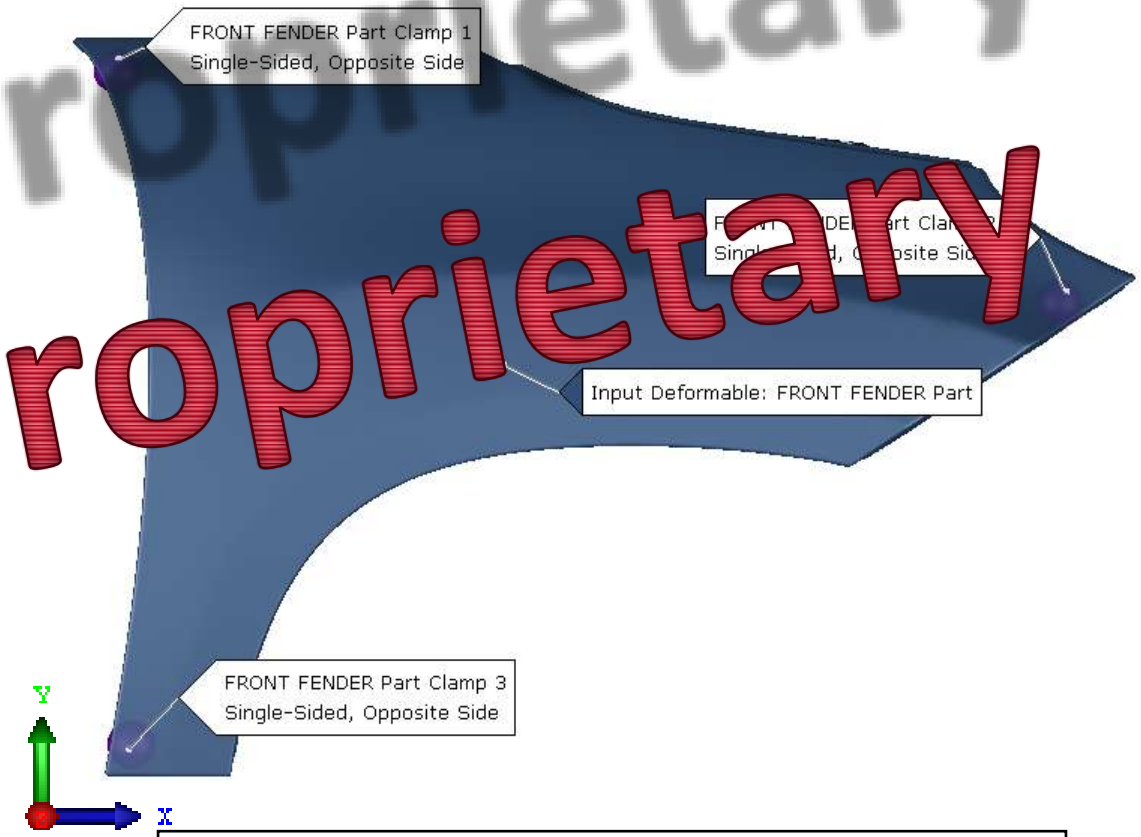
Physical part positioned on supports

Scanned Part – STL Format

Step 2 – Weight Effect Calculation



Scanned geometry and support setup within AutoForm

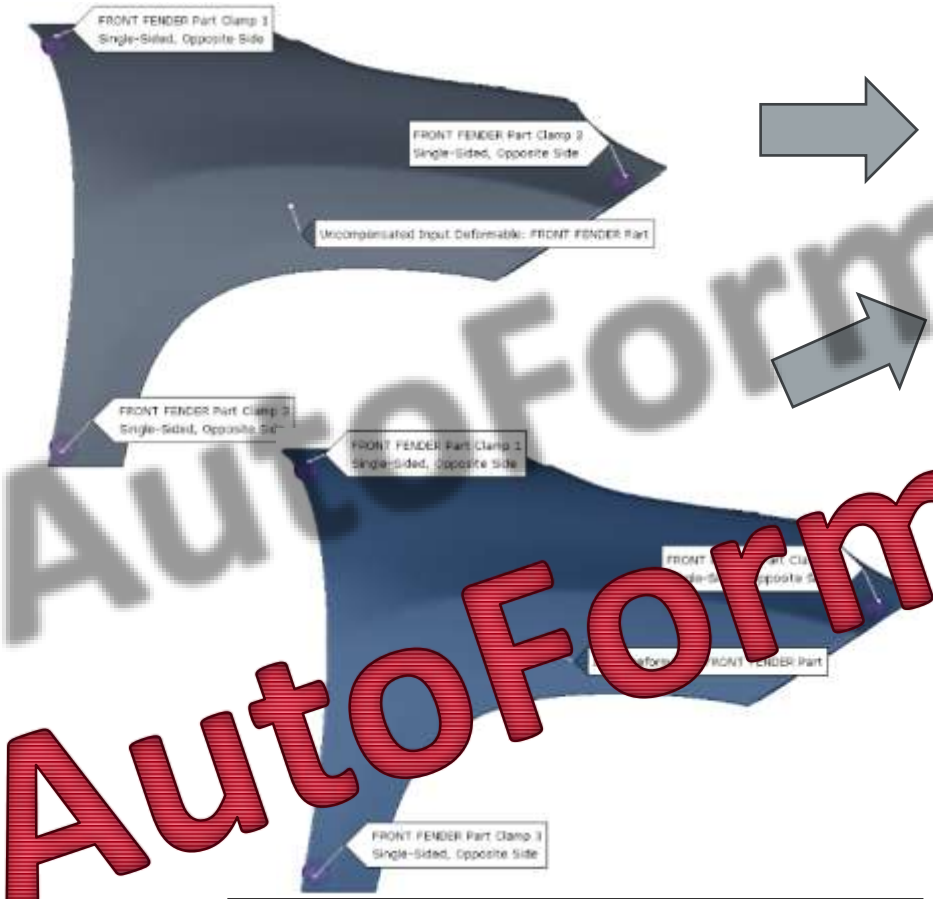


Scanned geometry without weight effect

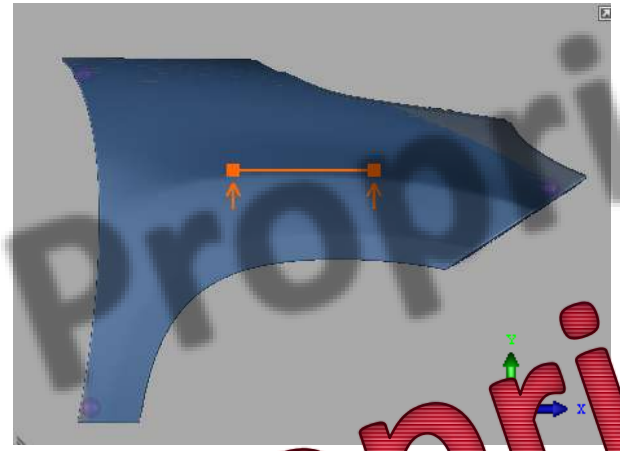
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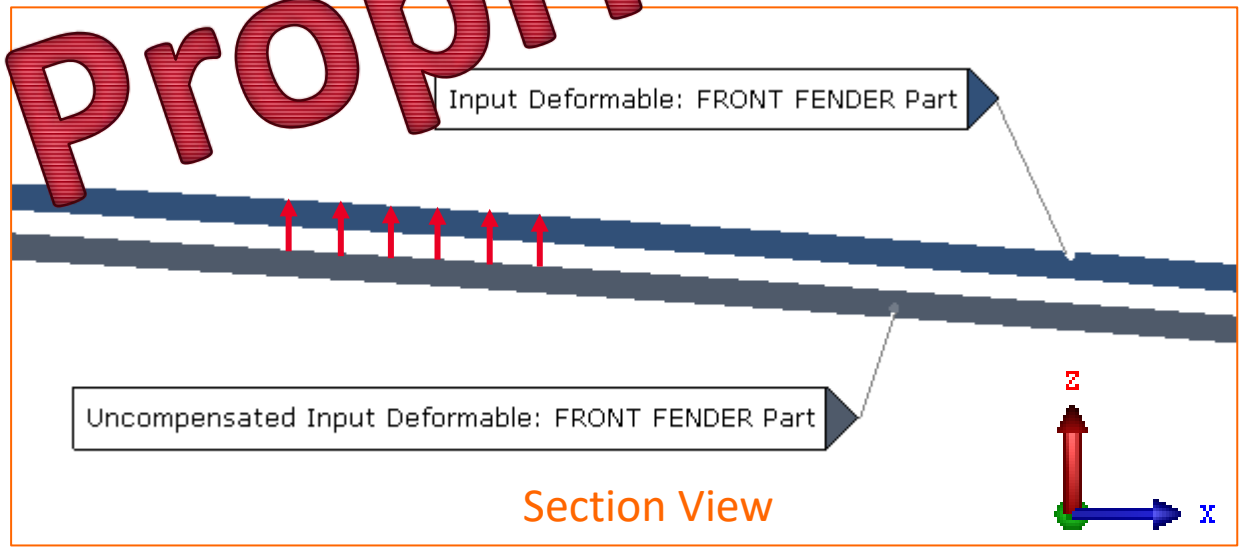
Step 2 – Geometries at comparison - With & Without Weight Effect

As Scanned Geometry



Geometry without Weight Effect





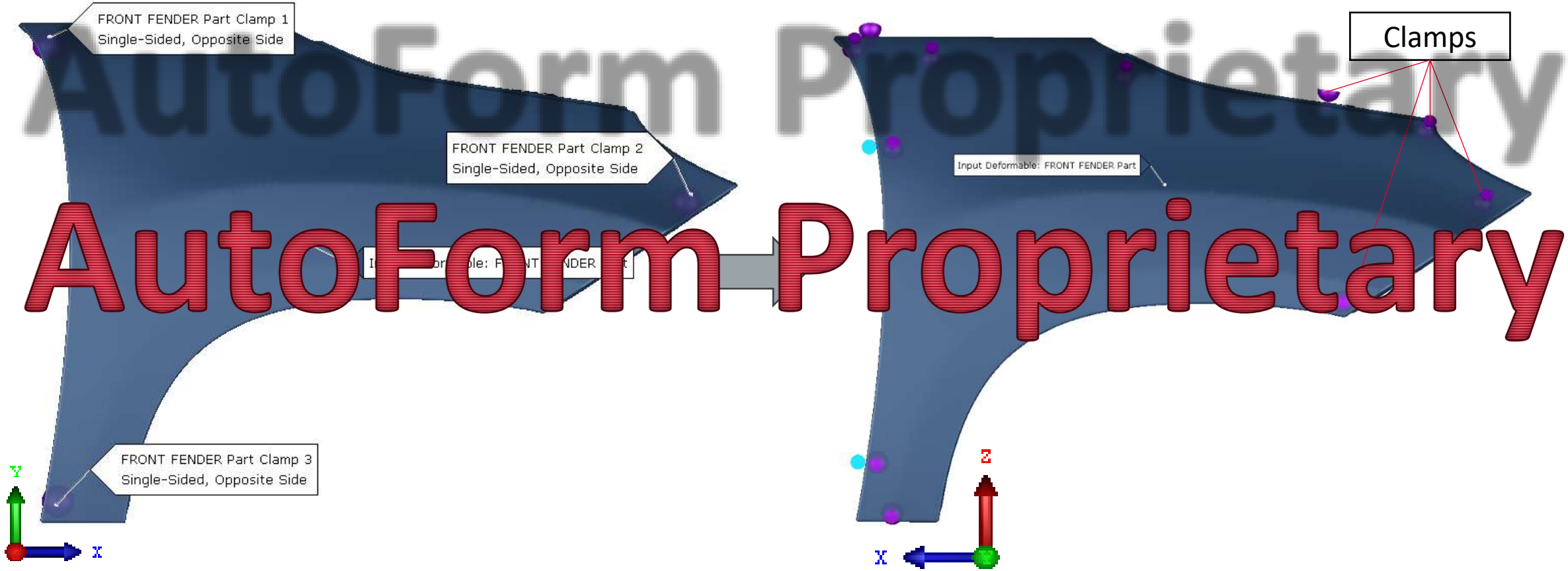
Weight effect analysis

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Step 3 – Digital Clamping Setup within AutoForm

Geometry without Gravity Effect

Digital Clamping Setup



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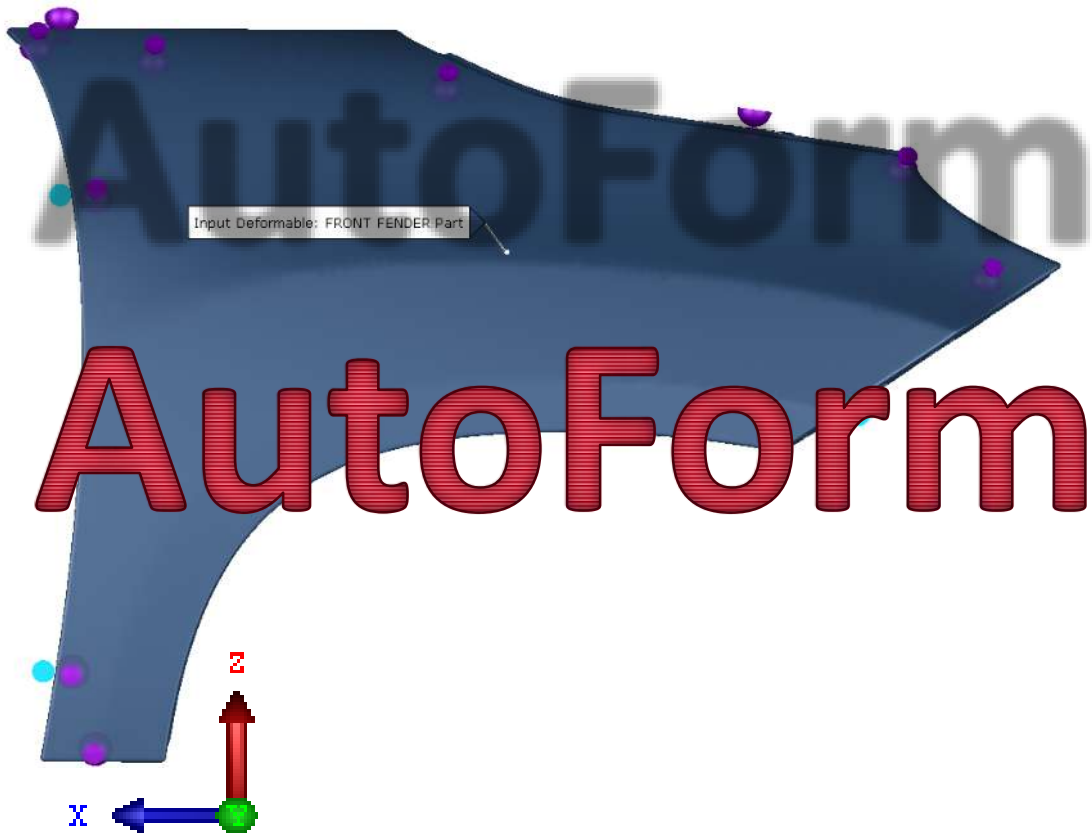
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Clamps and pilots are the digital replica on the physical fixture

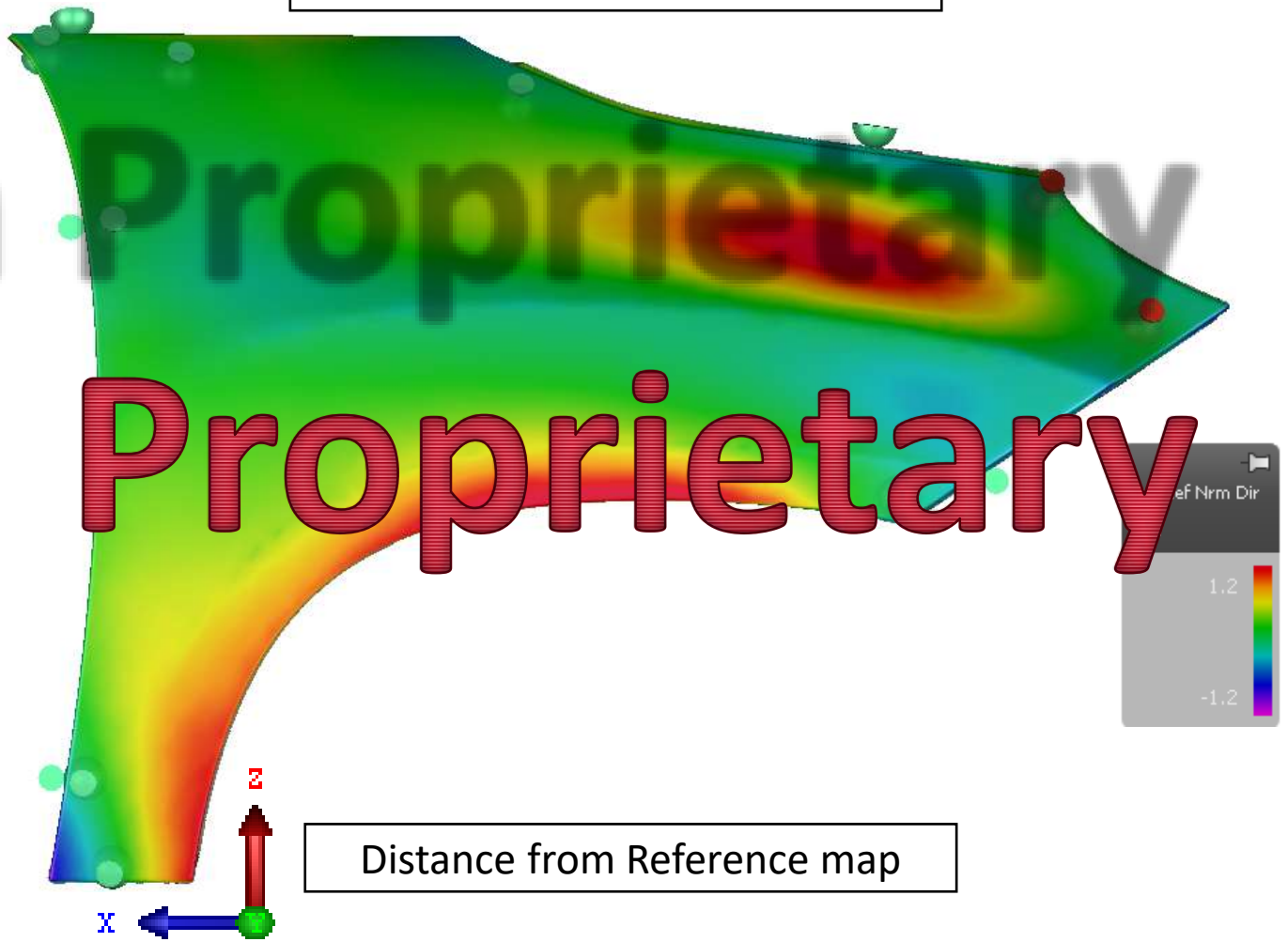
Step 3 – Digital Clamping Simulation

3

Part deformation simulation



Inspection - Springback



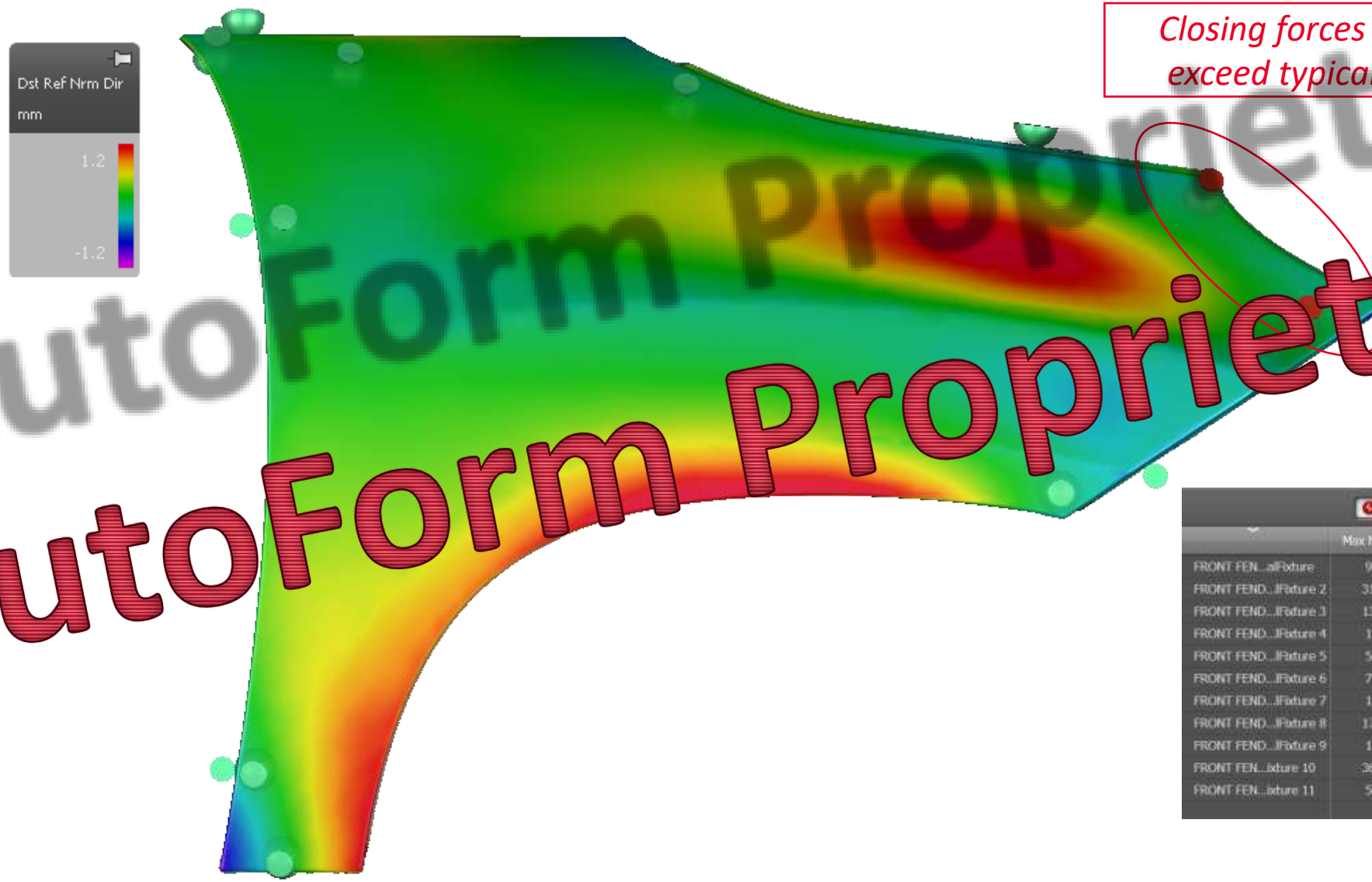
Distance from Reference map

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Step 4 – Springback Analysis

3

Closing forces on the Clamps exceed typical limit of 30kN



Forces | Distances

	Max Norm F	Max Clos F	Max Sup F	Max Tang F
FRONT FEN...alFixture	9 N	0 N	9 N	0 N
FRONT FEND...lFixture 2	31 N	0 N	31 N	0 N
FRONT FEND...lFixture 3	13 N	0 N	13 N	0 N
FRONT FEND...lFixture 4	1 N	0 N	1 N	0 N
FRONT FEND...lFixture 5	5 N	0 N	5 N	0 N
FRONT FEND...lFixture 6	7 N	0 N	7 N	0 N
FRONT FEND...lFixture 7	1 N	0 N	1 N	0 N
FRONT FEND...lFixture 8	17 N	17 N	0 N	0 N
FRONT FEND...lFixture 9	1 N	0 N	1 N	0 N
FRONT FEN...ixture 10	36 N	36 N	0 N	0 N
FRONT FEN...ixture 11	5 N	5 N	-1 N	0 N

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Export the simulated geometry to perform a full GD&T inspection in a deviation product

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Digital Clamping for Assembly Process optimization

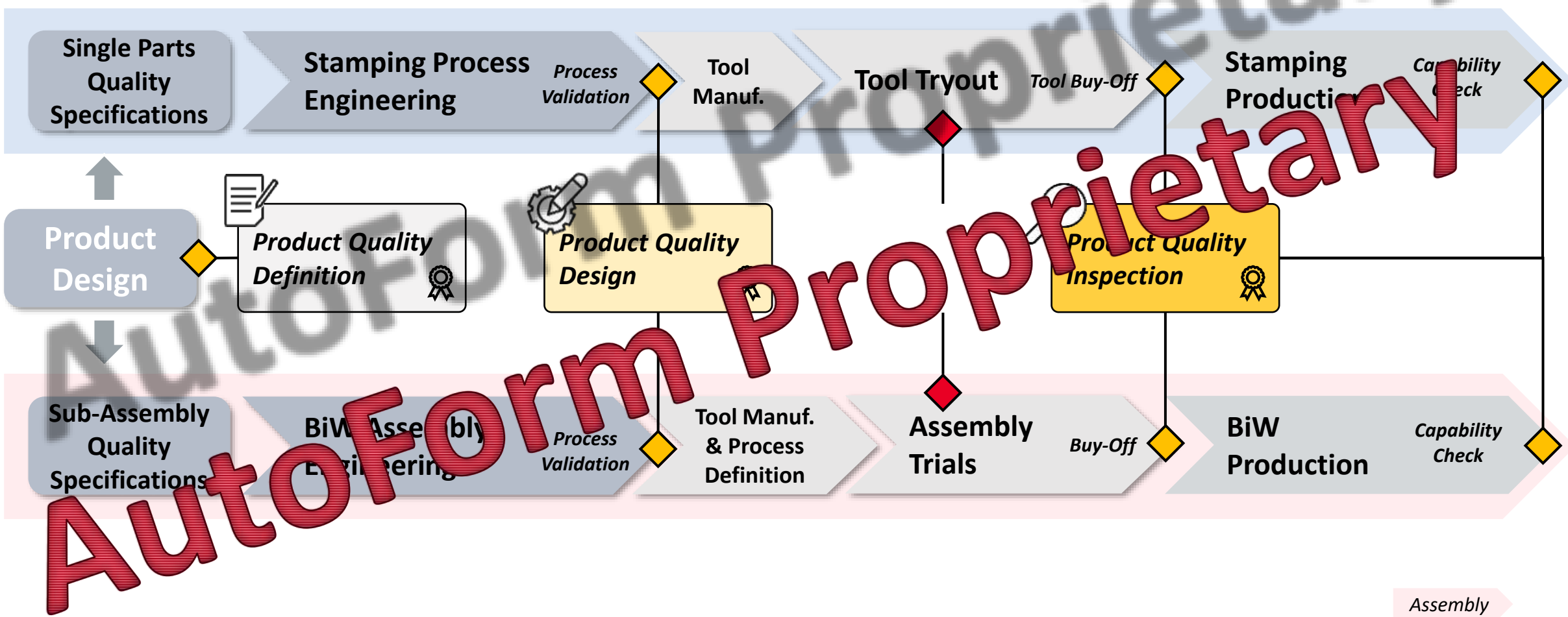
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From Dimensional Quality Definition to Inspection



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Digital Clamping vs Assembly



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Inner Door Example

Parts
Reinforcement Hinge
Reinforcement Lock
Door Inner Panel
Window Frame
Side Impact Beam
Reinforcement-WindowFrame



Scanning of individual parts

Digital Clamping of individual parts → Measurement Report

Virtual Sub-Assembly Simulation Clamping state → Measurement Report

Virtual Sub-Assembly Simulation Joining state → Measurement Report

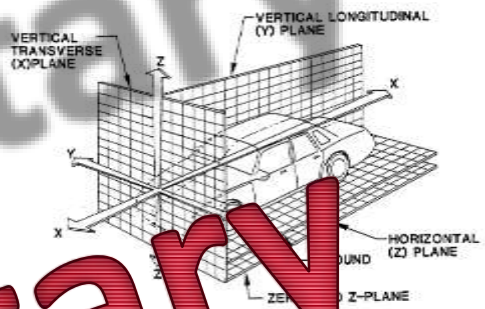


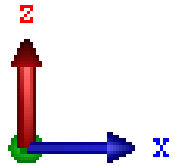
Source: Arcetool.com

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Inner Door located in Vehicle Coordinate System







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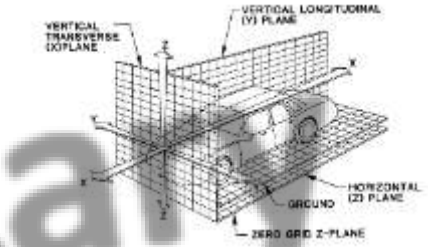
Key points

- Input of all necessary RPS points, pilots & clamps
- Referential: Vehicle Coordinate System

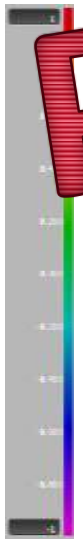
Inner Door: Measurement report

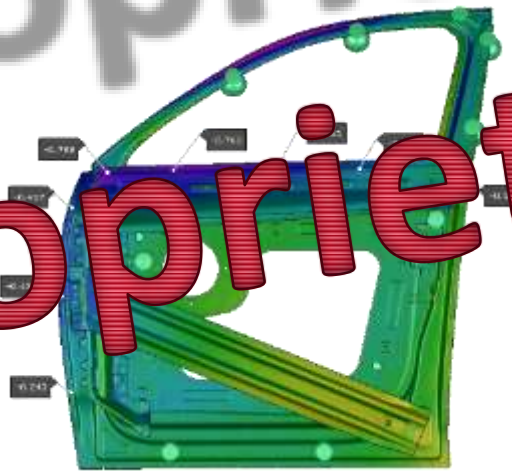
- Deviations to nominal CAD-0 geometry
- Check impact of RPS & Clamping conditions

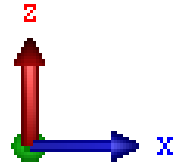












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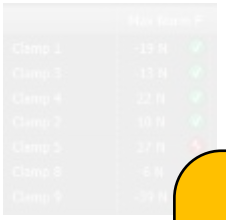
Trial #1 **Trial #2**

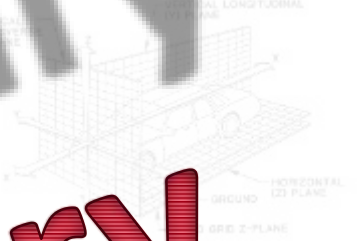
Locating & Clamped conditions

Inner Door: Measurement report

- Deviations to nominal CAD-0 geometry
- Check impact of RPS & Clamping conditions

Export the simulated geometry to perform a full GD&T inspection in a deviated product





Trial #1

Trial #2

Locating & Clamped conditions

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CAD Driven – The two approaches at comparison

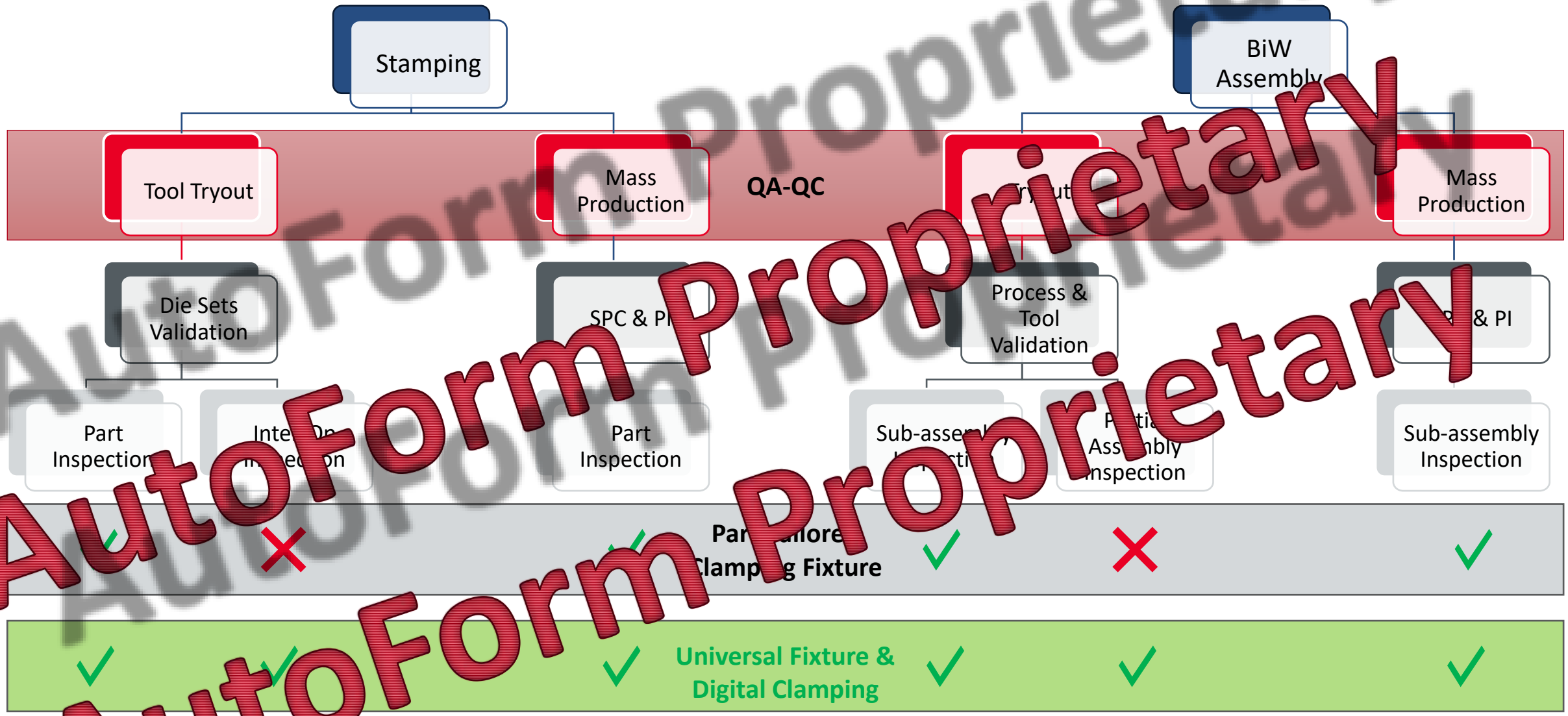
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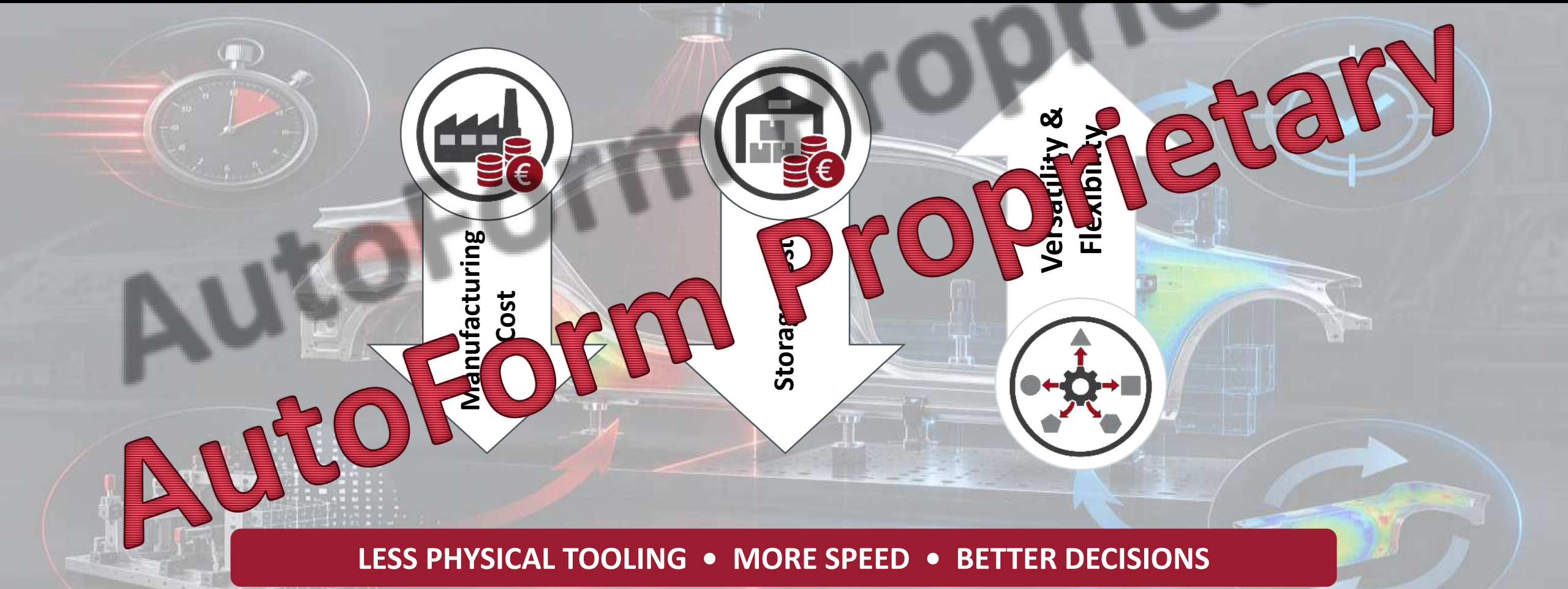
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Part Tailored vs Digital Clamping Versatility



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Digital Clamping turns inspection into a faster, flexible digital workflow



Questions & Answers



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Digital Clamping – A cost-Efficient Approach for Quality Control in BiW

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