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Volunteering for the future – Geospatial excellence for a better living

Quality in Engineering Geodesy - an introduction to the topic and to the workshop

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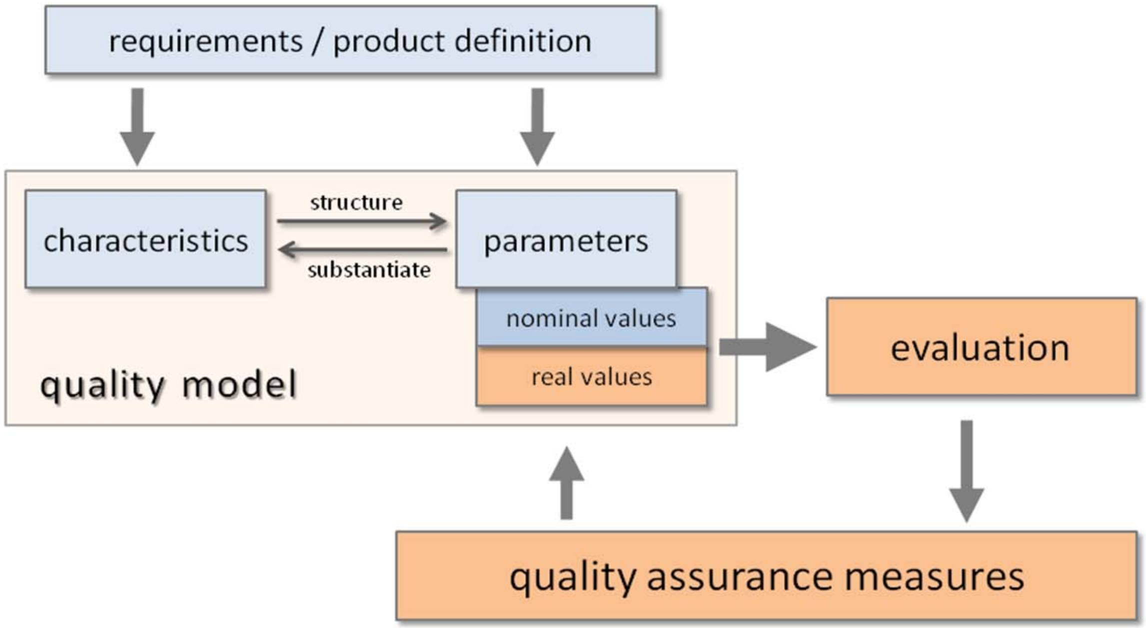
Outline

- Definitions
- Quality Models
  - Charcteristics, parameters, criteria
  - Control and decision points
- Quality Models in Geodesy
- Holistic Quality Model for IntCDC
  - Structure and interrelations
  - Quality control for graded concrete
  - Quality control for fibre composites
- Workshop
  - Objectives and content

Definitions

- Engineering Geodesy
  „Engineering geodesy is the discipline of reality capture, setting-out and monitoring of local and regional geometry related phenomena, paying particular attention to **quality assessment**, sensor systems and reference frames“
  (Kuhlmann et al. 2014)
- Quality
  „degree to which a set of inherent characteristics fulfils requirements”
  (DIN EN ISO 9000)

Quality model (1) and assessment



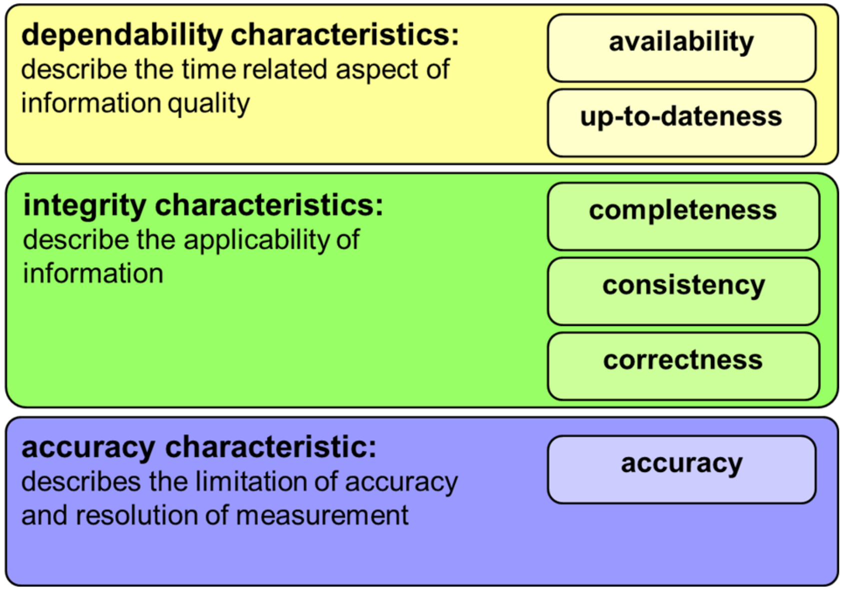
Schweitzer, Kochine, Schwieger, Berner (2012)

Quality model (2) and assessment

- Characteristics
  ..present the structure of the quality model qualitatively e.g. accuracy
- Parameters
  …concretize the quality characteristics, e.g. standard deviation
- Criteria
  …define a optimization target for a parameter (or characteristic)
  e.g. 5 mm or simply as small as possible
  (based e.g. on requirements)

Always application-related defined!

Qality model for transport telematics



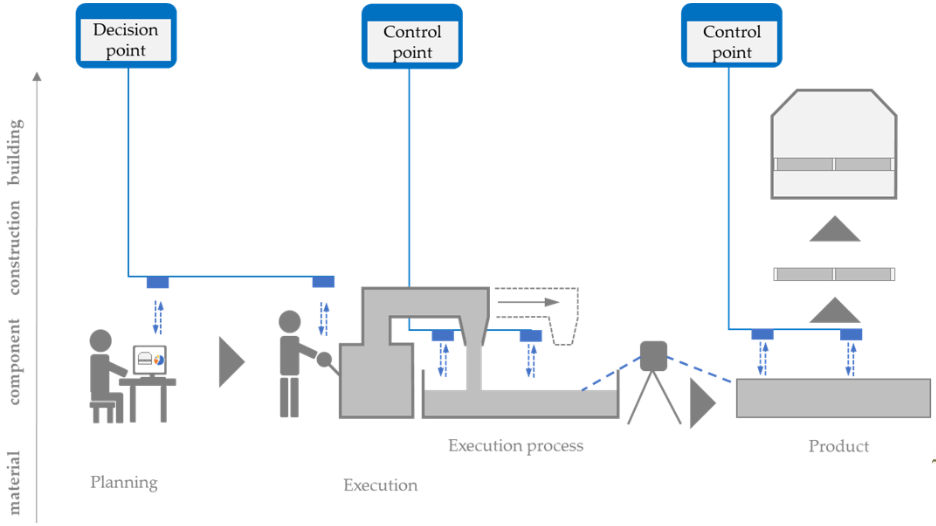
Wiltschko (2004)

Quality model (3) and assessment

- Control points
  …specify process situations where certain quality characteristics and parameters of processes or products can be defined, measured and assessed with respect to quality requirements
- Decision points
  …are process situations where a decision with relevant influence on future process or product quality is made either by humans or by algorithms

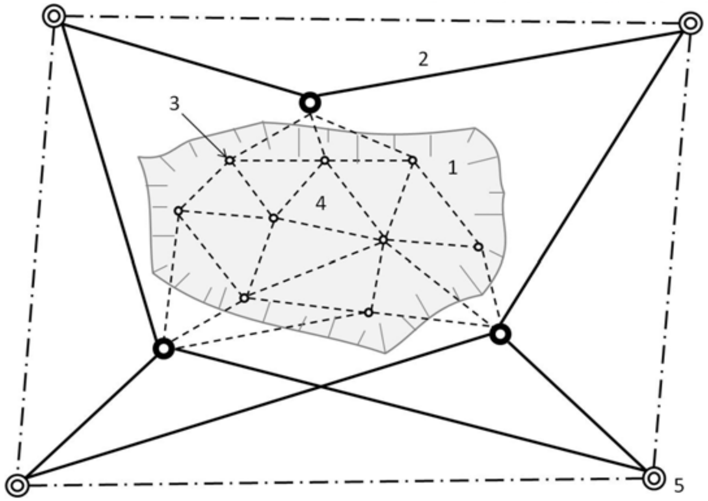
Needed in processes!

Characteristics, parameters and criteria may be process- and/0r product-related.

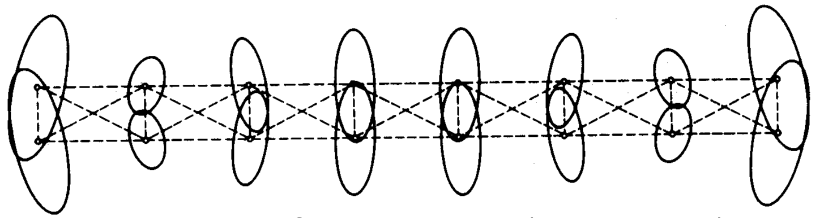


Quality model for geodetic (monitoring) networks

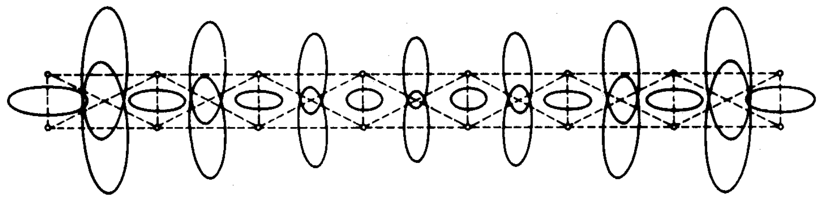
Characterictic	Examples for parameters
Accuracy	standard deviation, confidence ellipsoid, trace of the covariance matrix
Reliability	redundancy number, condition density, minimal detectable error.
Sensitivity	minimal detectable deformation
Seperability	minimal seperable deformation



monitoring network



abolute confidence ellipses (point-related)

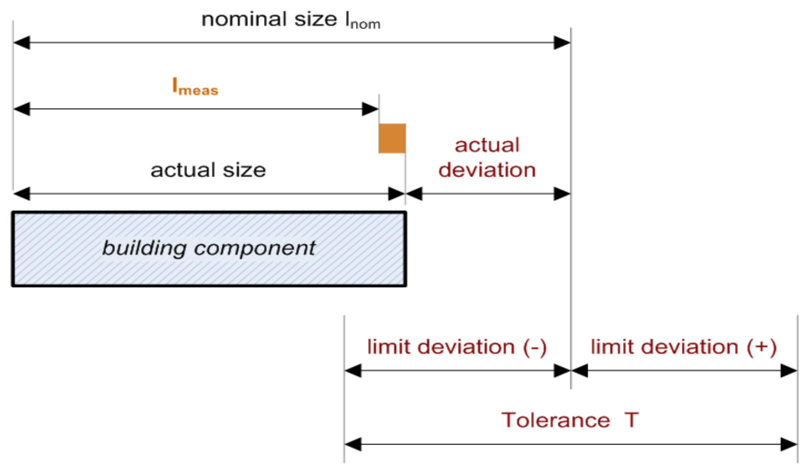


relative confidence ellipses (between neighboured points)

Quality model for geodetic processes

Characteristics	Parameters
Accuracy	Standard deviation
Correctness	Tolerance correctness
	Topological correctness
Completeness	Number of missing/ odd elements
	Adherence to the plan
Reliability	Condition density
	Minimal detectable error (mde)
	Impact of mde on parameters
	Vulnerability to failures
Timeliness	Time delay

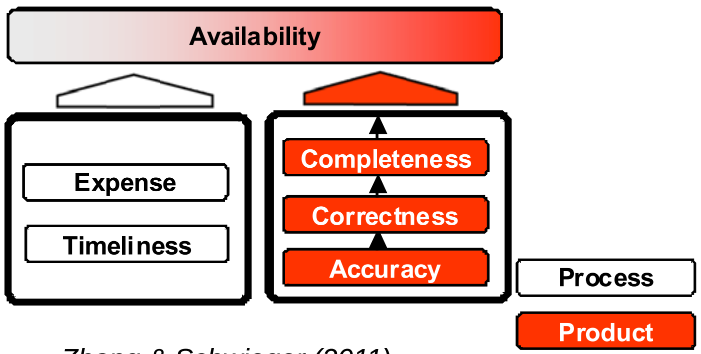
Schweitzer & Schwieger (2011)



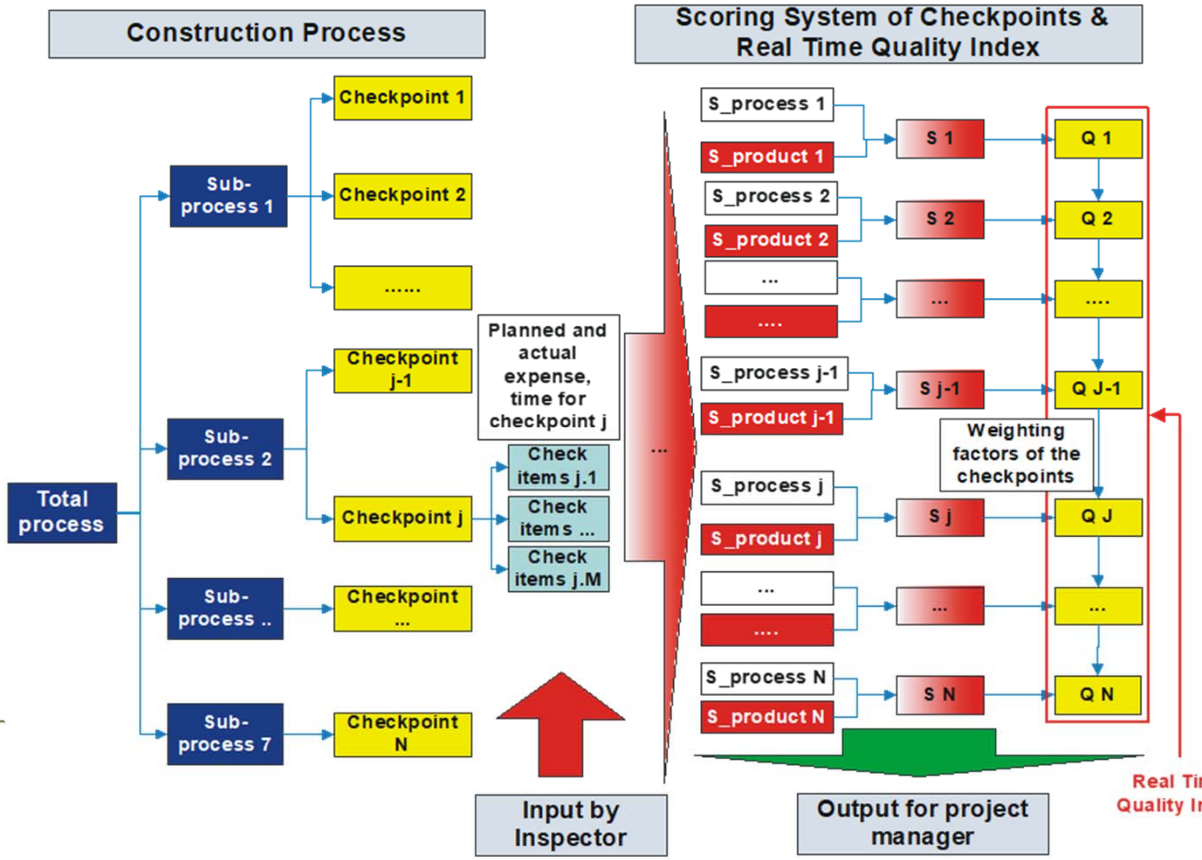
$$t_c = 0.5\sqrt{T^2 - T_M^2} - |l_{meas} - l_{nom}|$$

tolerance correctness

Quality model for construction processes

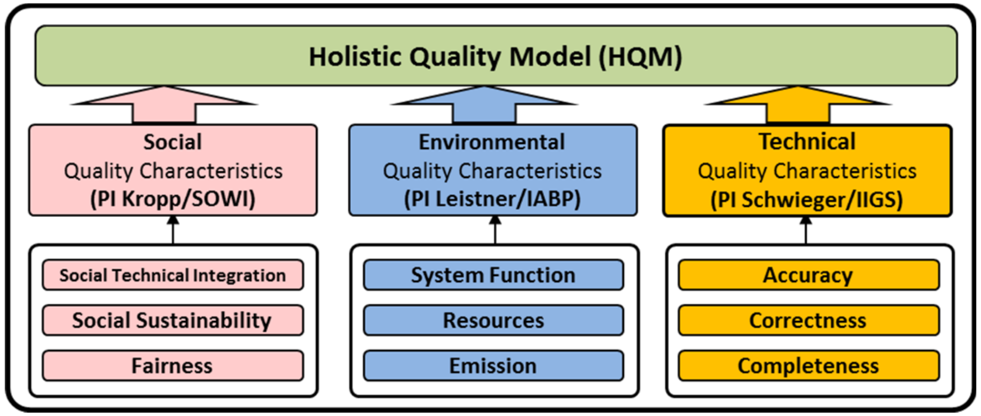


Zhang & Schwieger (2011)



Holistic Quality Model - General Structure

- **Institute of Engineering Geodesy**
- **Institute for Acoustics and Building Physics**
- **Institute for Social Science**

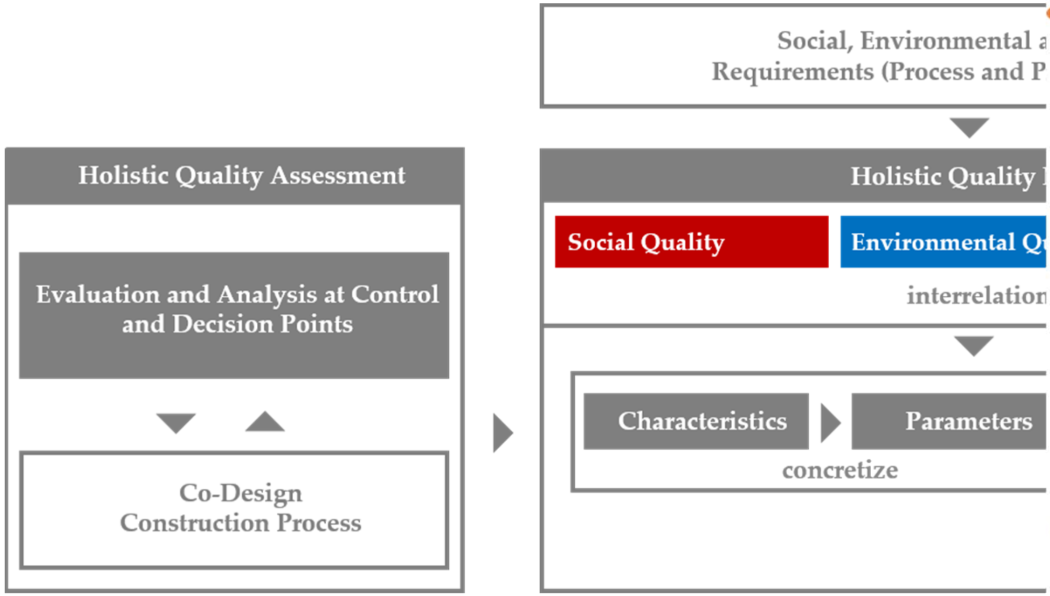


- Project Description
  HQM defines the base for IntCDC (requirements and their assurance)
- Concept
  - Framework HQM (published in Sustainability)
    - Requirements;
    - Characteristics;
    - Parameters;
    - Criteria.
- Quality assessment
  - Control points
  - Decision points

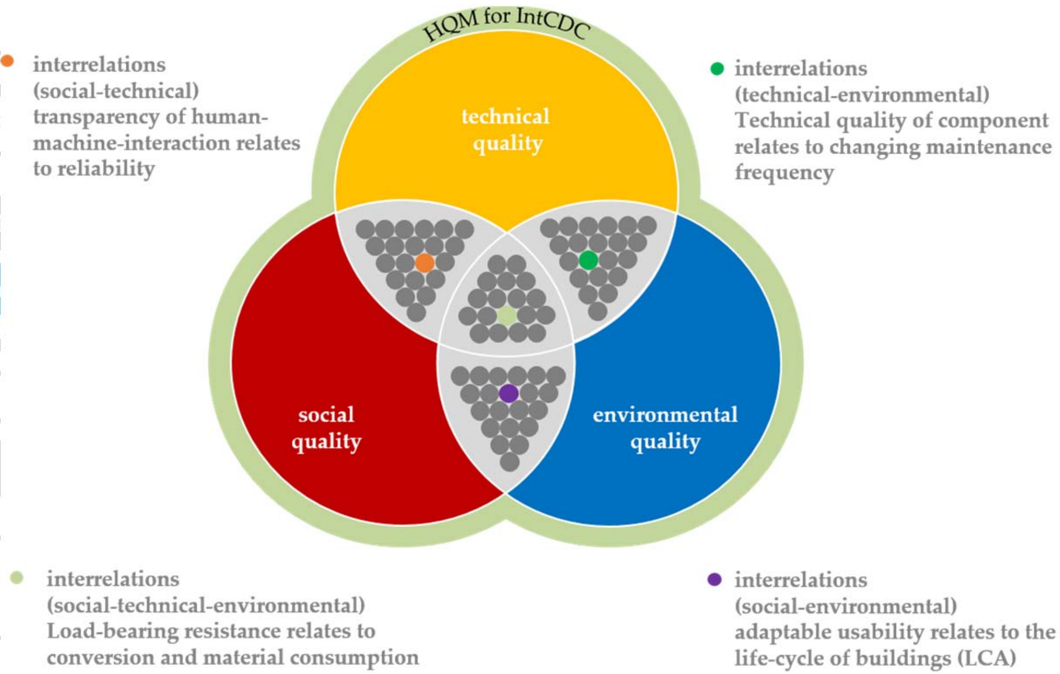
Economical Characteristics to be integarted in the coming years!

Zhang et al. (2020)

Holistic Quality Model - General Structure



Interrelations



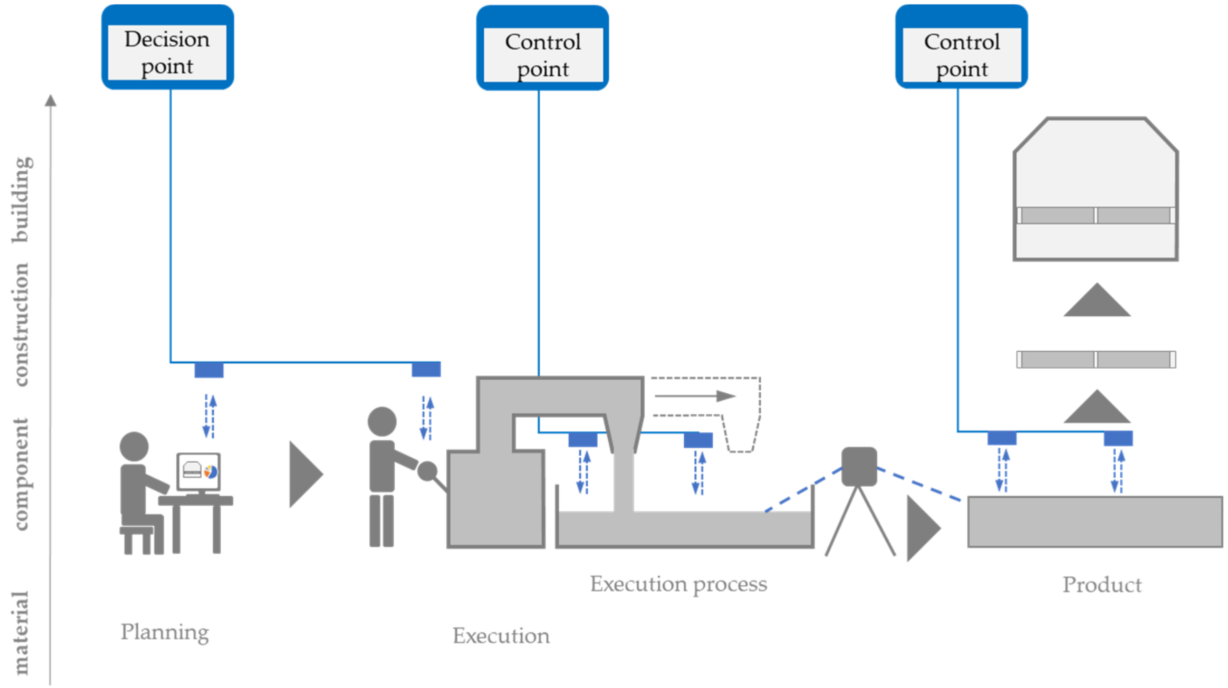
Zhang et al. (2020)

Holistic Quality Model – Characteristics and Parameters

	Requirement	Quality Characteristics	Exemplary Parameter	
Environmental Quality	Climate stability	Climate Change total (CC tot)	GHG emissions in kg CO_2 eq.	
	Resource efficiency	Total Material	Mass in kg	
		Non-renewable resources savings (NRM)	Percentage of NRM	
	Anthropocene activity efficiency	Recycling rate	Percentage of recyclable resources	
		Primary Energy Total (PEtot)	Total primary Energy in MJ	
		Primary Energy Non-Renewable (PENRT)	Total non-renewable energy in MJ	
		Share of Renewable Energy (PERT/PEtot)	Percentage of consumed renewable energy	
Social Quality	Decent Work	Control (Contr)	Influence on work	Likert-Scale (Given? In what form?)
		Safety (Safe)	Physically hard work	
		Work Intensity (WorkInt)	Requirements to reconcile	
		Job Security (JobSec)	Creation of jobs	
	Well Being	Building physics characteristics (BuiPhy)	Indoor Air quality Acoustic comfort	
	Socio-technical Robustness	Competences (Comp)	Manual takeover	
		Digital accessibility (DigAcc)	Screen Elements	
		Transparency (Transp)	Documentation	
		Human Agency (Hagen)	Human activity level Feedback loops	
	Process Quality	Process Quality of Design (PQDes)	Stakeholder participation Quality assurance concept	
Technical Quality	Eurocode 2 [63]	Load-Bearing Behavior (SLS)	stresses in N/mm2 and component deflection in mm	
	Eurocode 2-2 [55]	Fire insulation (FR)	slab thickness in mm	
	DIN 4109-1 [54,64]	Sound insulation (SI)	Sound reduction index and standardized impact sound pressure level in dB	

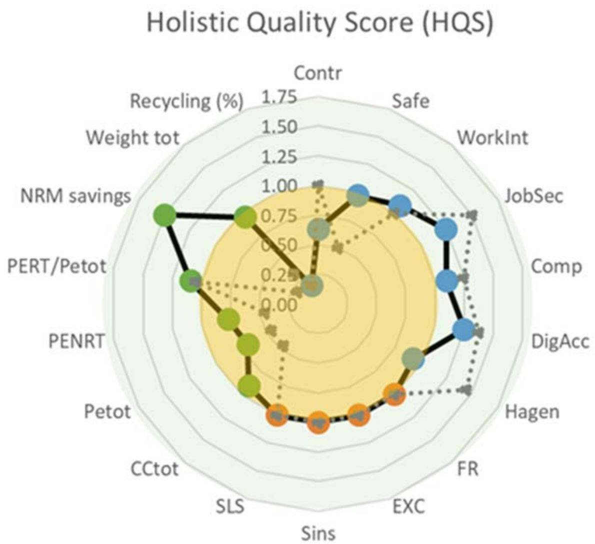
Zhang et al. (2020)

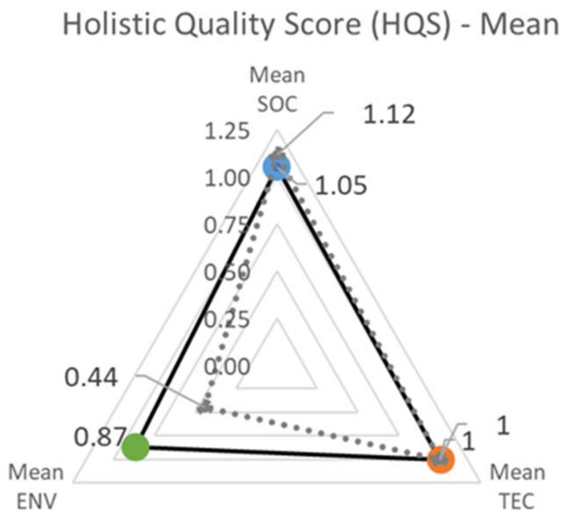
Holistic Quality Model – Process Example



Zhang et al. (2020)

Holistic Quality Model – Assessment





Frost et al. (2022)

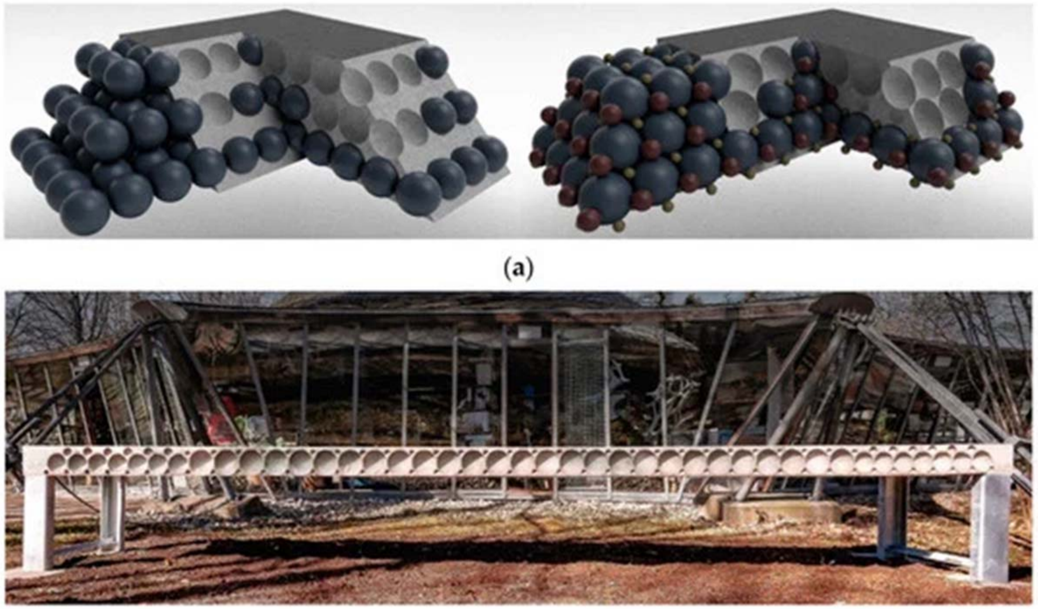
Quality Assessment - Graded Concrete

Graded Concrete

- Less material due to hollow spheres within the concrete (Sustainability Issue!)
- Typical pre-fabricated components are visible in (a) and (b)
- Typical sphere diameter: 10 cm,
  but different diameters are possible and visible in (b)
- During fabrication the concrete is casted between the hollow spheres

Quality assurance challenges and solutions

- Is the position of the hollow spheres stable during f abrication process?
- What is the concrete level after each casting step?
- Monitoring of the sphere position
- Investigation of concrete level and flatness of the concrete

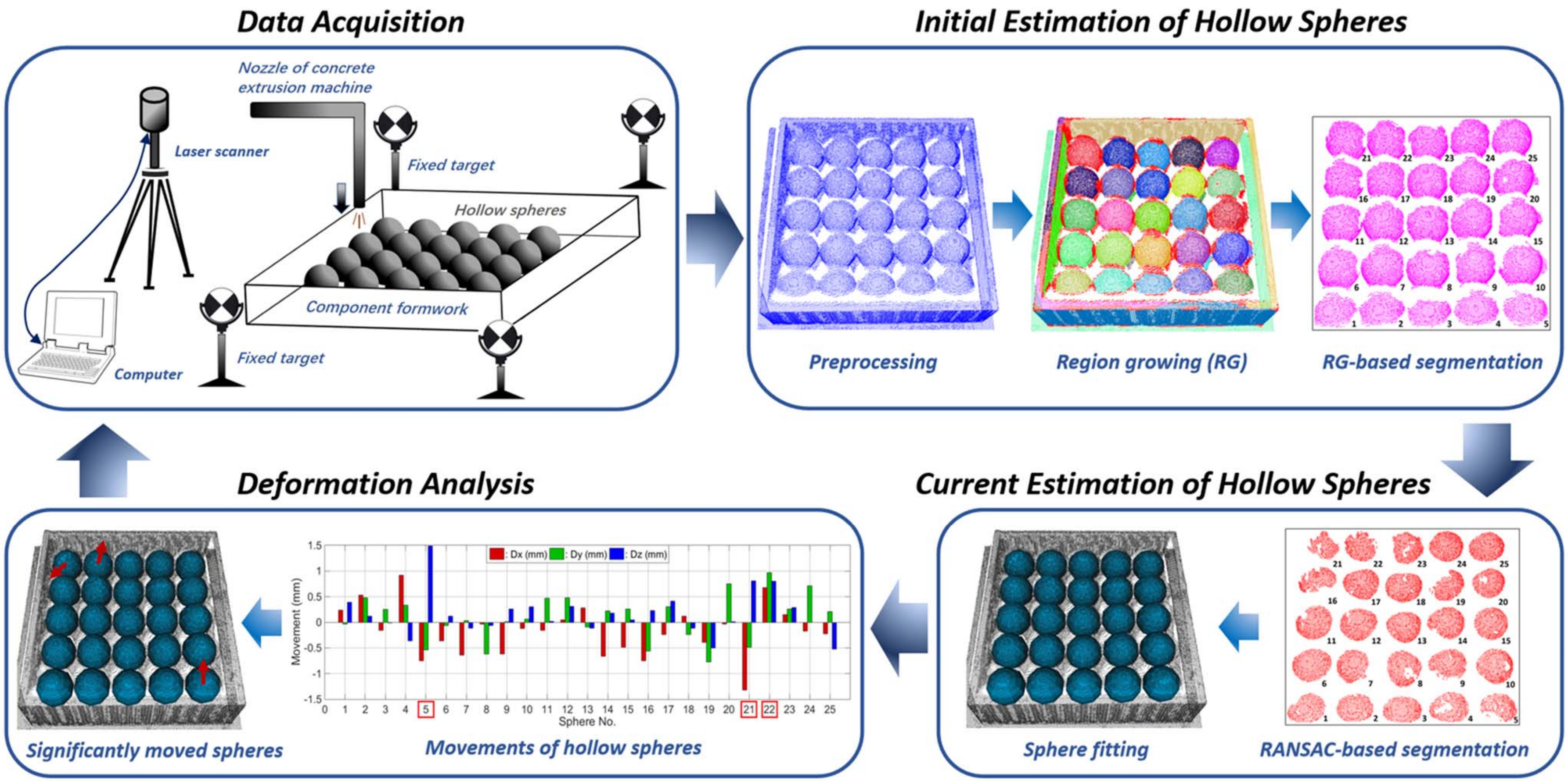


(a)

(b)

Yang et al. (2021)

Quality Assessment - Graded Concrete



Yang et al. (2021)

Quality Assessment - Graded Concrete

Yang et al. (2021)

(a)

(b)

(c)

(d)

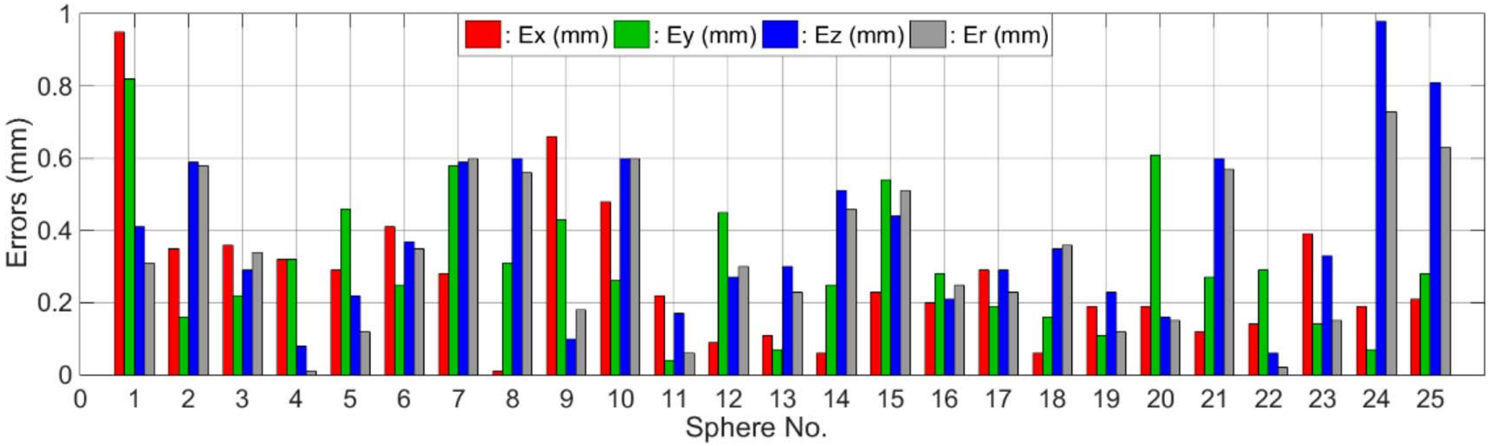
(e)

(f)

Quality Assessment - Graded Concrete

Results

- Correct sphere detection: 100 % for all epochs
- Accuracy of sphere estimation: < 1 mm



- Realtime capability – caculation time: < 3 s for 1st epoch, < 1 s for other epochs
- Movements: < 1,5 mm (non significant for almost all spheres)

Yang et al. (2021)

Quality Assessment – Filament Fibre Winding

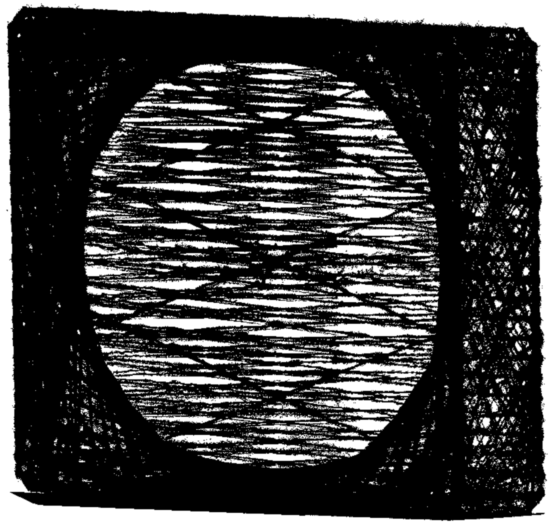
Menges 2021

How can quality control for objects like “La Maison fibre” could look like?

Challenges , caused by completely new fabrication and construction processes

- No CAD model (no explicit geometry) available
- Line model without thickness

1. Monitoring of the fiber interaction during the winding / fabrication process by TLS
2. Determination of the real shape (position and cross section) of components by tachymeter and TLS

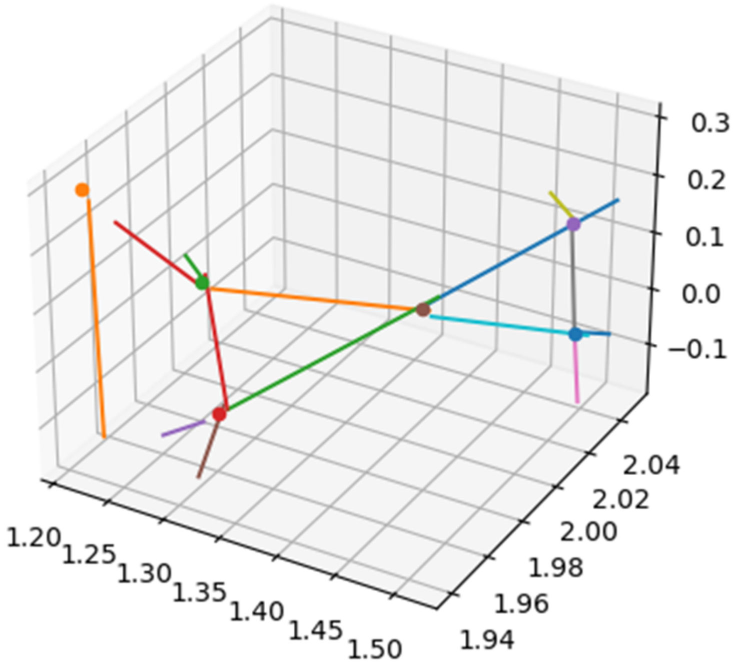


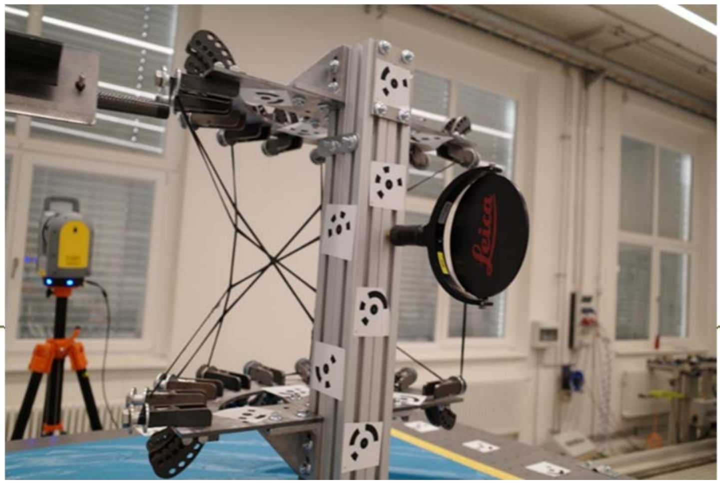
Quality Assessment – Filament Fibre Winding

Slicing of intersection points after each winding step

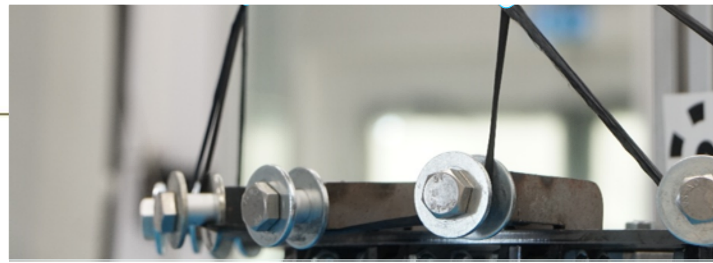
Tasks

- Line segmentation from the point cloud by Hough transformation
- Estimation of intersection points: finally least-square adjustment
- Find corresponding points in the previous epoch: Ungarian algorithm to find new intersection points based on minimal costs, no 1:1 assignment



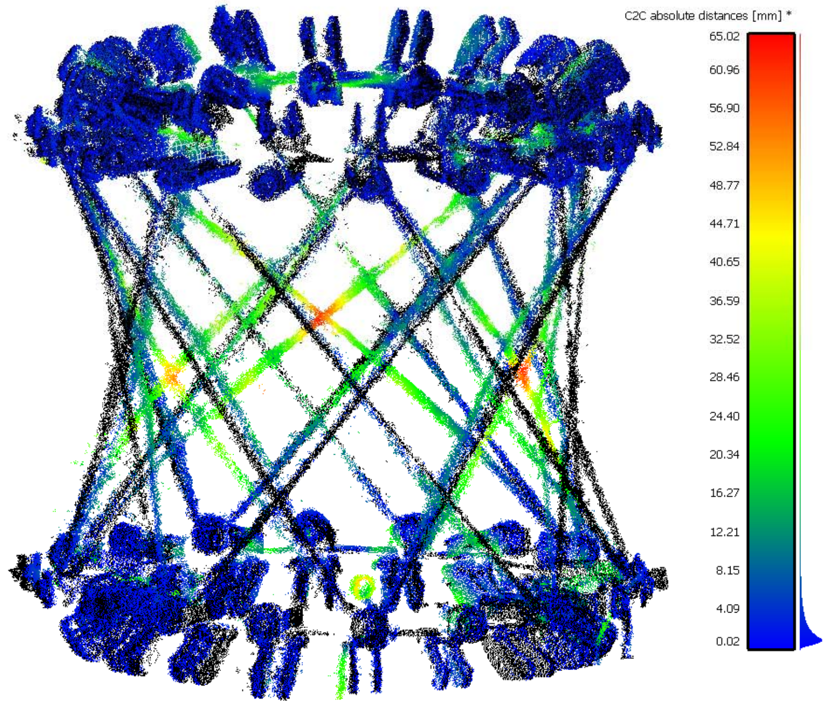


Composite wet thread: diameter appr. 0.5 cm

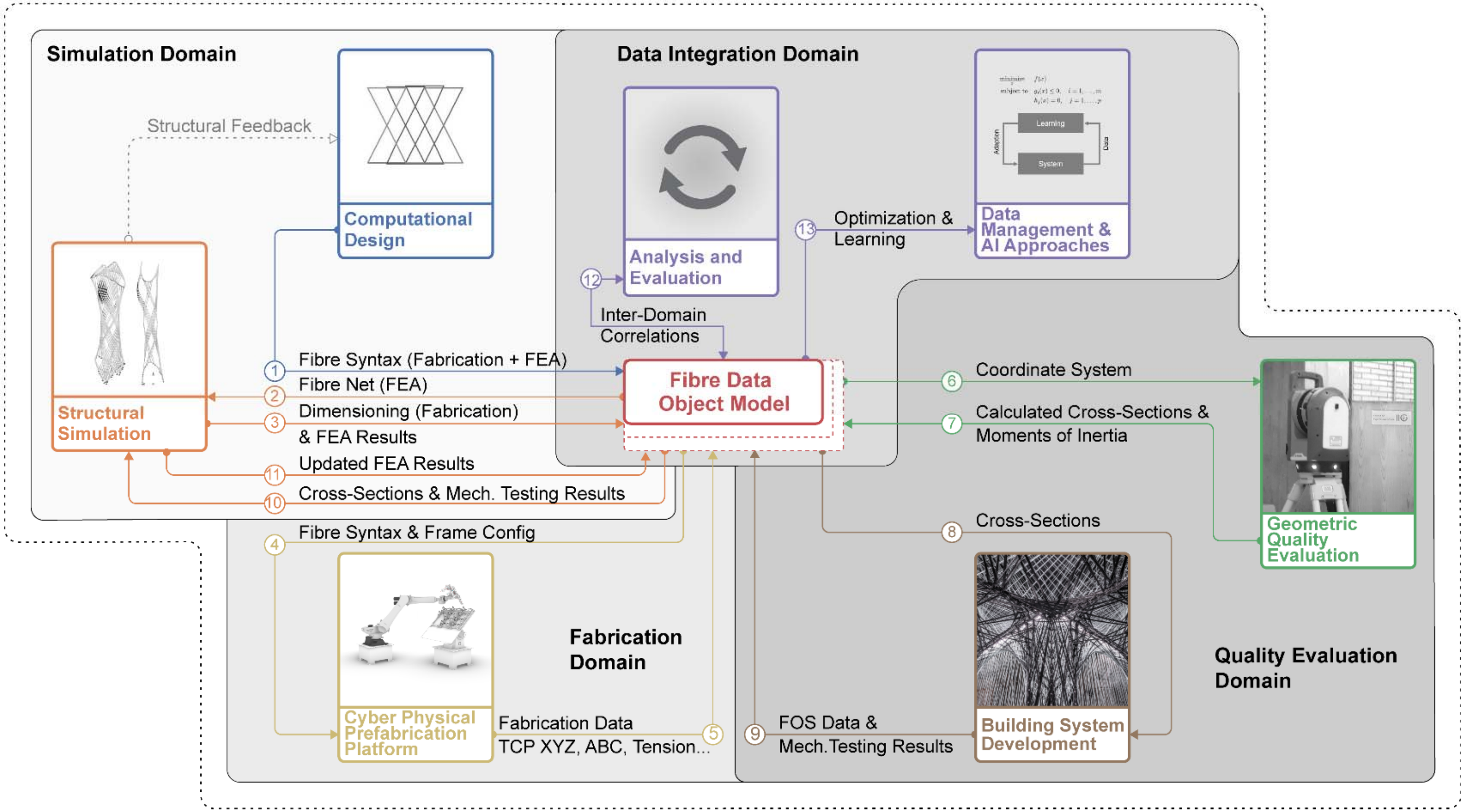


Quality Assessment – Filament Fibre Winding

- three scans per winding step
- registration using black-white targets
- Point-to-point comparison:
  basic structure versus last winding step (right)
- Slicing of of intersection points: < 2 cm
- Number of intersection points:
  given versus estimated (tbd)
- Problem:
  effects where laser beam hits wet fibre composites / rasin to be investigated



Quality Assessment – Filament Fibre Winding



Computational Co-Design Framework

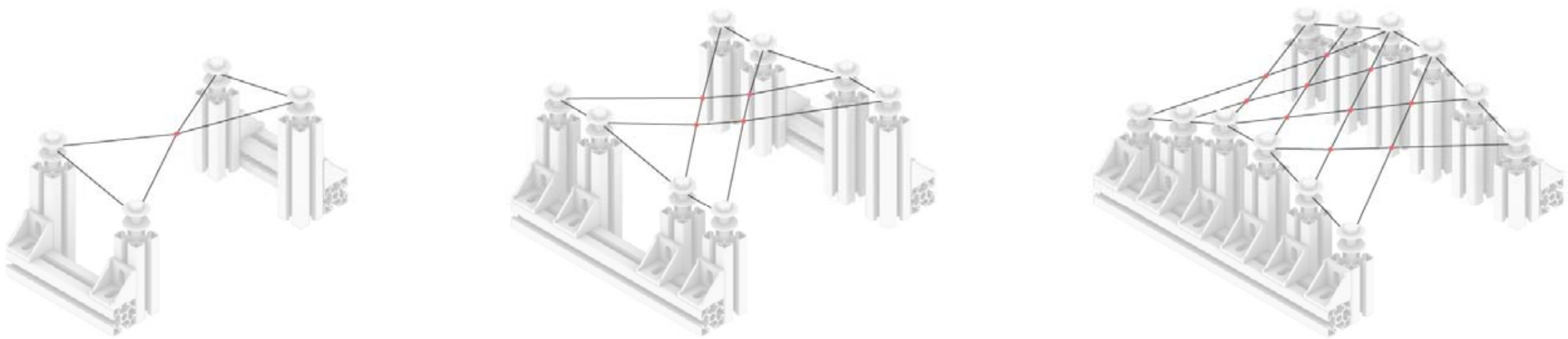
Gil Pérez et al. (2021)

Quality Assessment – Filament Fibre Winding

Tasks

- **Line segmentation** from the point cloud by Hough transformation
- **Calculation of fibre cross section areas**

Six composite dry threads: diameter appr. 1.5 to 2 cm



S1 cross | **S2** double cross | **S3** lattice

The three specimen types in their winding frames with desired fibre interaction points (n): S1 – cross (n = 1), S2 – double cross (n = 4), S3 – lattice (n = 10). Dimensions: h = 315mm, w1 = 80mm, w2 = 160mm, d = 32.5mm. *(full page width: 190mm (height = 55mm))*

Gil Pérez et al. (2021)

Quality Assessment – Filament Fibre Winding

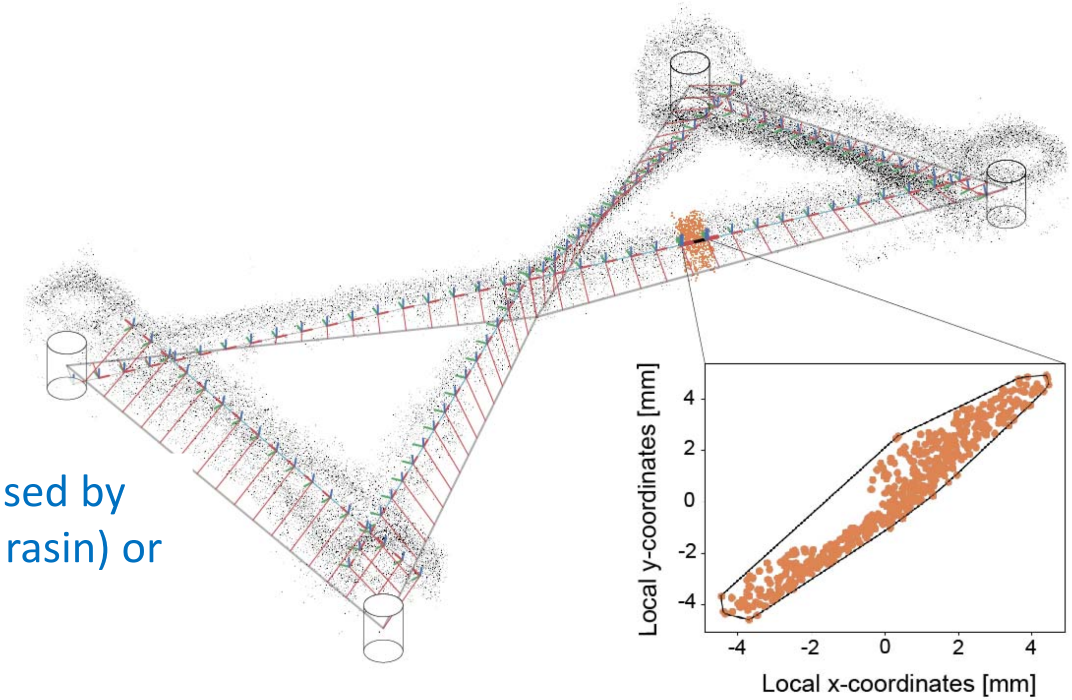
Gil Pérez et al. (2021)

Measurements of S1 by tachymeter and TLS

Quality Assessment – Filament Fibre Winding

- line/fibre is decritized in 1 cm bars,
- projection of all points within one bar on normal surface of the bar,
- forming a convex hull,
- surface estimation within this normal surface by arbitrary polyline
- cross section surface:
  between 50 mm^2 and 300 mm^2, average 150 mm^2

Open questions: All cross section surfaces are to small caused by
a) Interaction of laser beam and new materials (fibres and rasin) or
b) Calculation using covex hull?



Gil Pérez et al. (2021)

Scientific Workshop on Uncertainty and Quality of Multi-Sensor Systems

Announcement

- Combination of different sensors in static (e.g. monitoring) and dynamic (e.g. kinematic data acquisition) environments
  - sensors combined in one instrument (e.g. in terrestrial laser scanners or total stations)
  - measurement systems combing different sensors or instruments for integrated solutions
- Need for new sensor models and calibration procedures to reduce or even eliminate errors and influences
- Typical uncertainty modelling approaches are variance-covariance propagation, Monte Carlo simulation, Bayesian statistics, Fuzzy approaches or interval mathematics
- Quality characteristics as correctness, reliability, completeness, robustness, integrity or availability play a role

Scientific Workshop on Uncertainty and Quality of Multi-Sensor Systems

Contributions

- Applications: Waterresource Engineering, Transport Engineering, Deformation and Displacement Monitoring, Calibration, Kinematic Positioning,…
- Sensor Systems: Laser Scanning, IMU/GNSS Integration, IMU/Laser Integration, Photogrammetry, Laser Distance, Strain Measurements,..
- Precision, Accuracy, Quality,..

Program of the Workshop