

HYTAZER – ENTWURF, FERTIGUNG UND ZERTIFIZIERUNG VON WASSERSTOFFTANKS

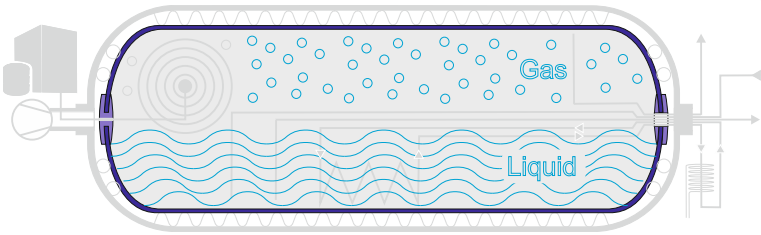
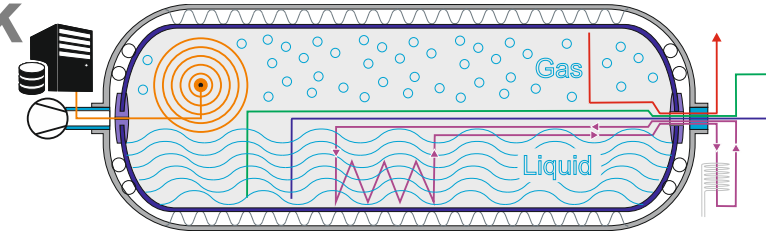
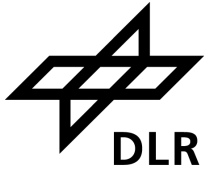
DLR/FA Wissenschaftstag

Dr. Sebastian Freund

06.10.2022



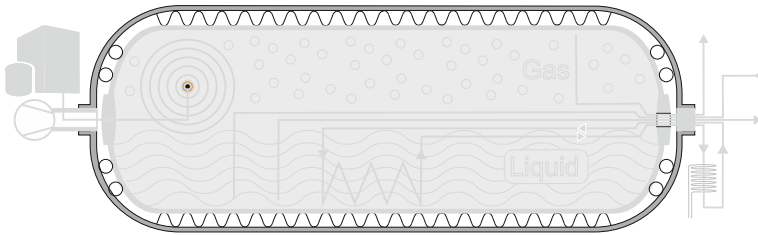
Challenges of an aircraft LH2 Tank



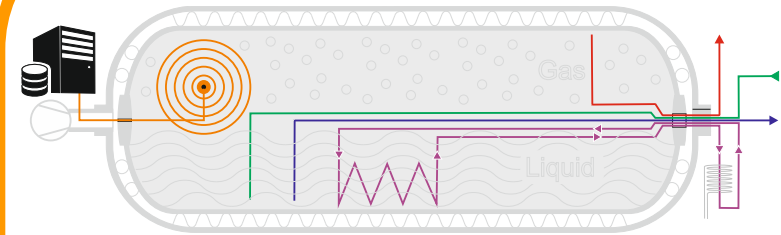
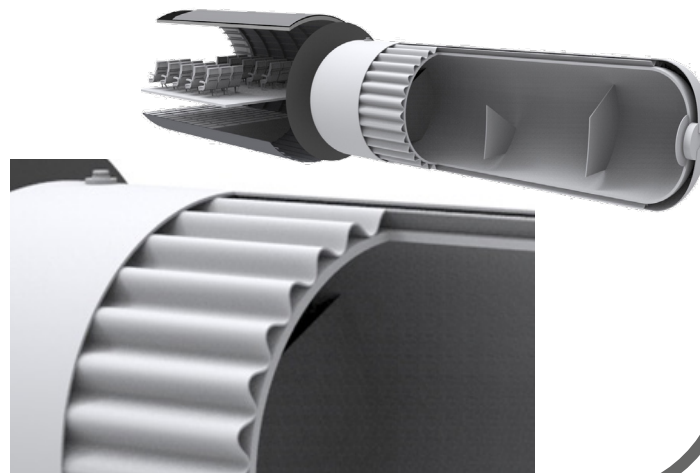
“LH₂-Cryo-Tank“



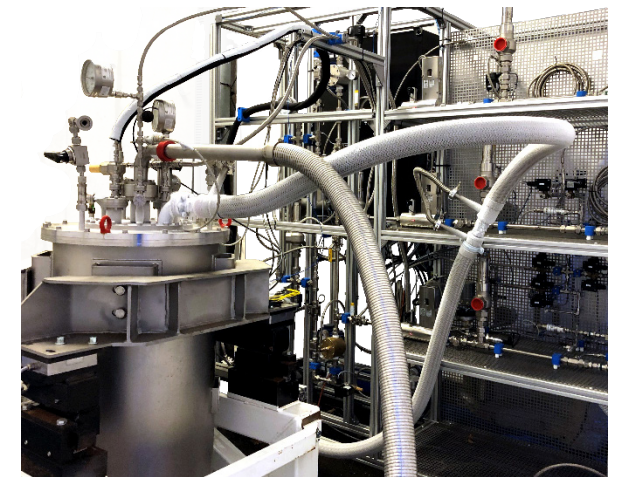
“CHATT”
150kg Tank



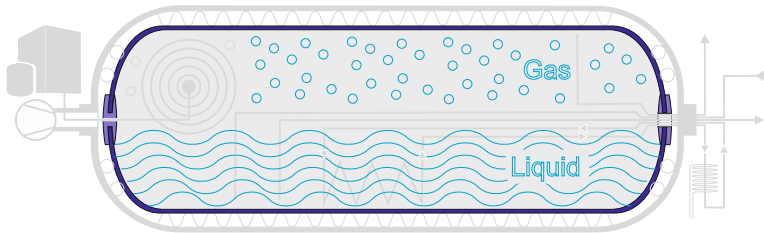
“Tank Integration/Insulation“



„Hydrogen System“



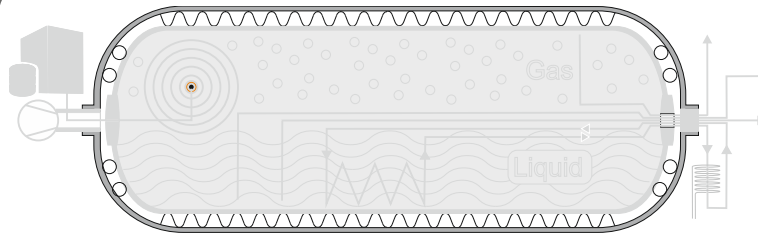
Challenges of an aircraft LH2 Tank



“LH₂-Cryo-Tank“

Completely New Challenge

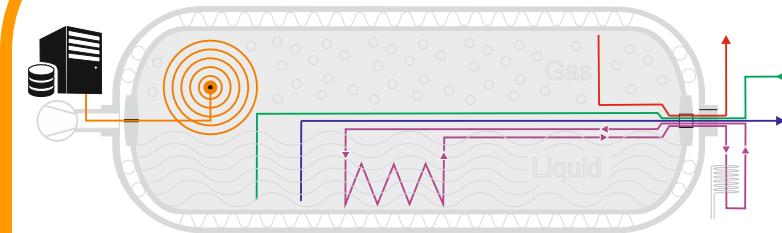
- Inner Pressure Driven Structure
- Cryogenic Environment
- Multiple Thermal effects
- Sealings / H₂ Permeability
- Weight / Cost / Production Rate



“Tank Integration/Insulation“

CS 25 Based Approach

- Stability Driven Structure
- Structural Interaction / Interfaces
- Classic Impact Scenario
- Extended Temperature Range
- Weight / Cost / Production Rate



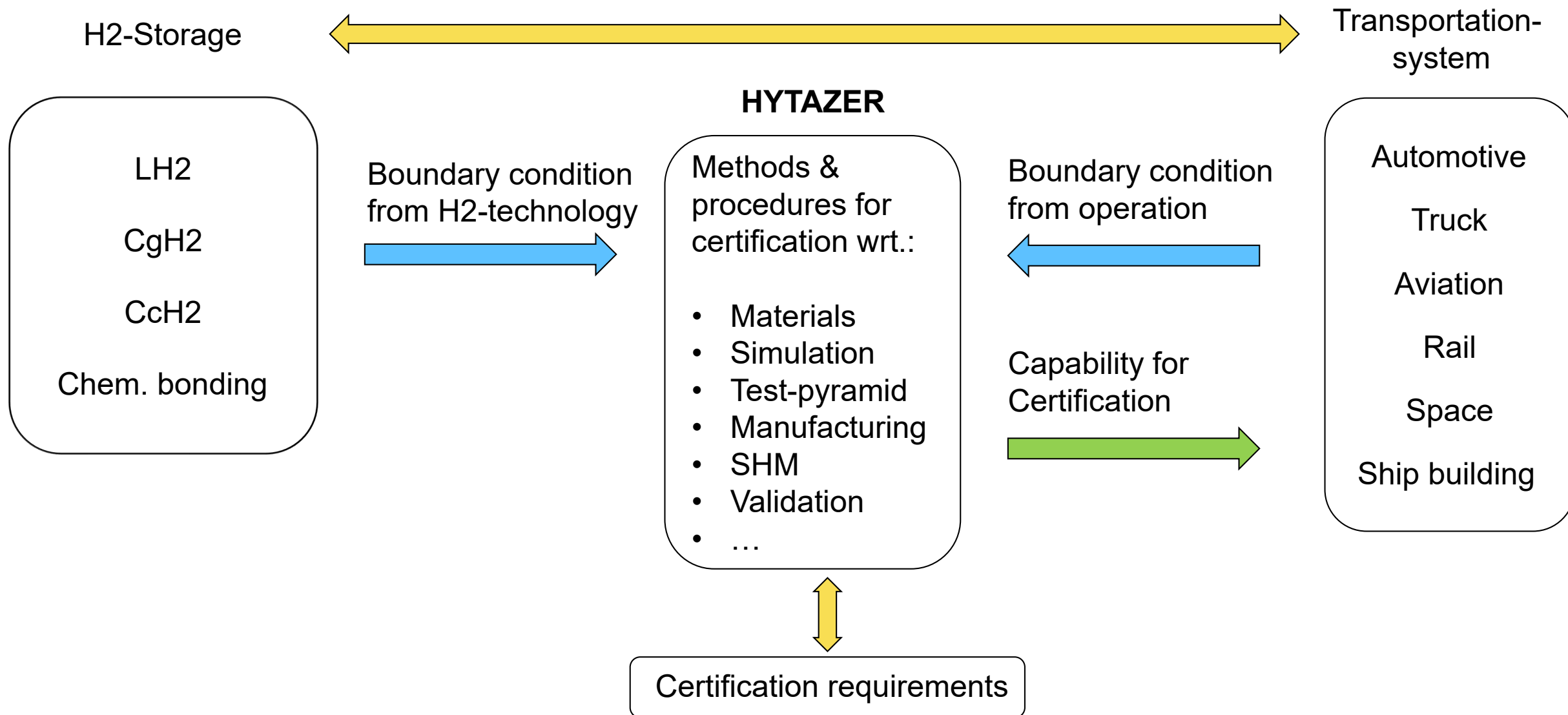
„Hydrogen System“

Multi ATA Approach

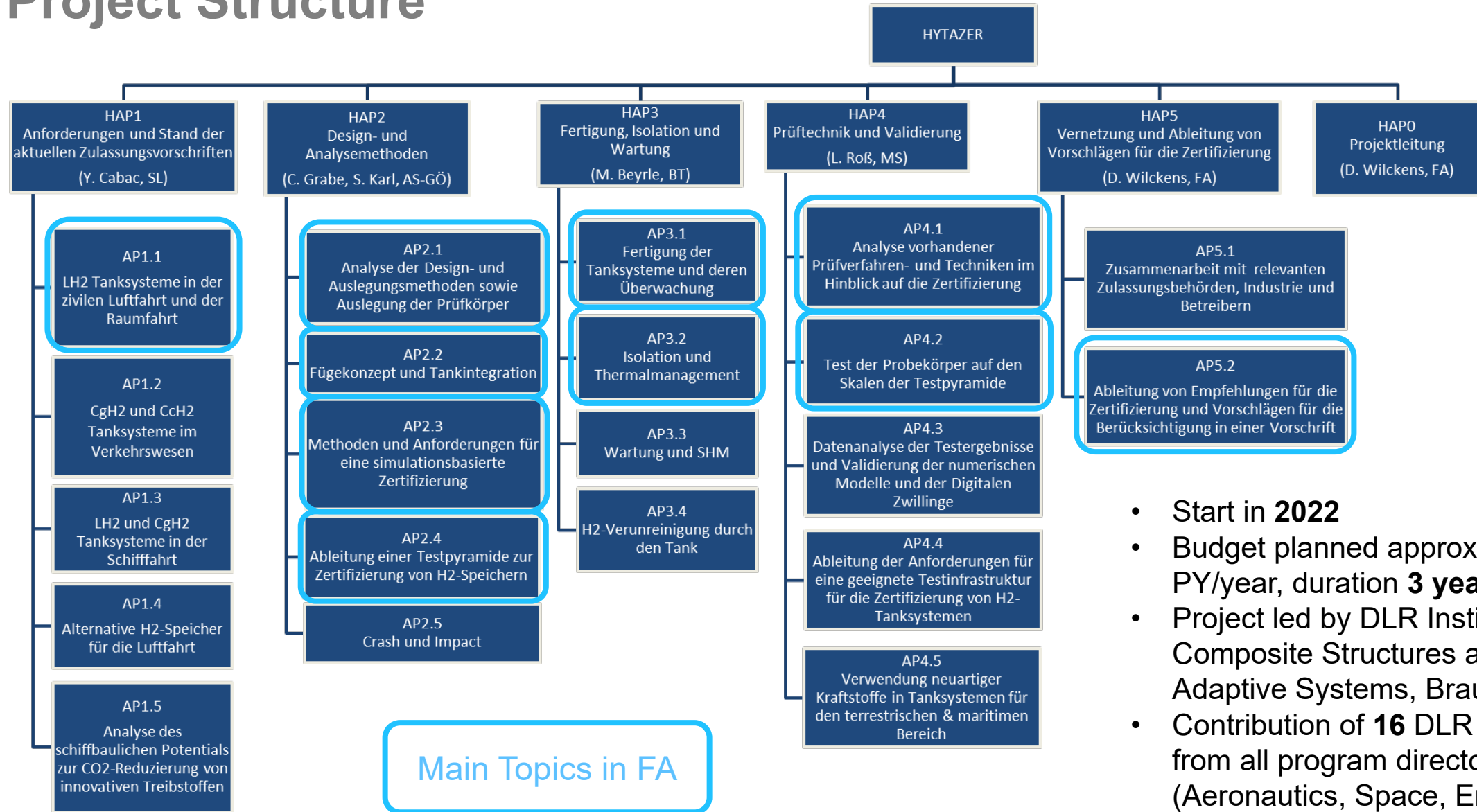
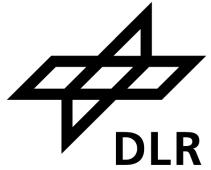
- System Installation / Sealing
- Sloshing / Refilling
- Pressure / Boil-Off Management
- Operational Safety Monitoring
- Weight / Cost / Production Rate



Integrative approach of HYTAZER



Project Structure



- Start in **2022**
- Budget planned approx. **30 PY/year**, duration **3 years**,
- Project led by DLR Institute of Composite Structures and Adaptive Systems, Braunschweig
- Contribution of **16** DLR institutes from all program directorates (Aeronautics, Space, Energy, Transport)

Summary of HYTAZER - DLR Project towards the certification of hydrogen tanks for mobility applications

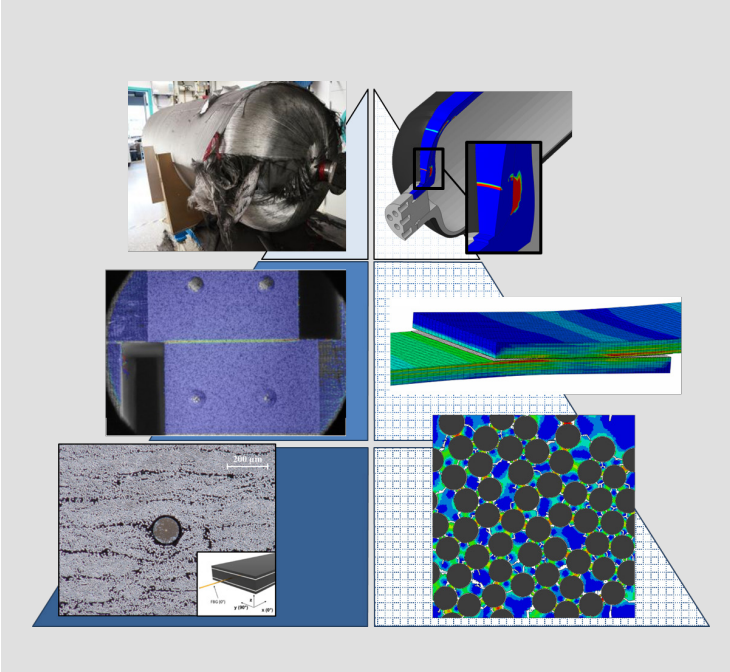


Global activities

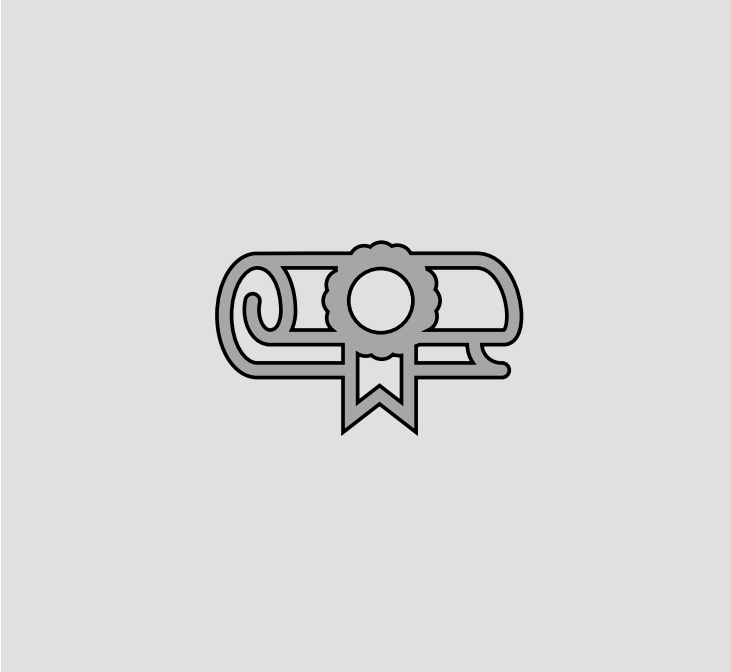
Review, tailoring and extension of qualification requirements and processes



Establishing an appropriate test pyramid (virtual & physical) for LH2 tanks



Methodologies and means to be used in the certification process

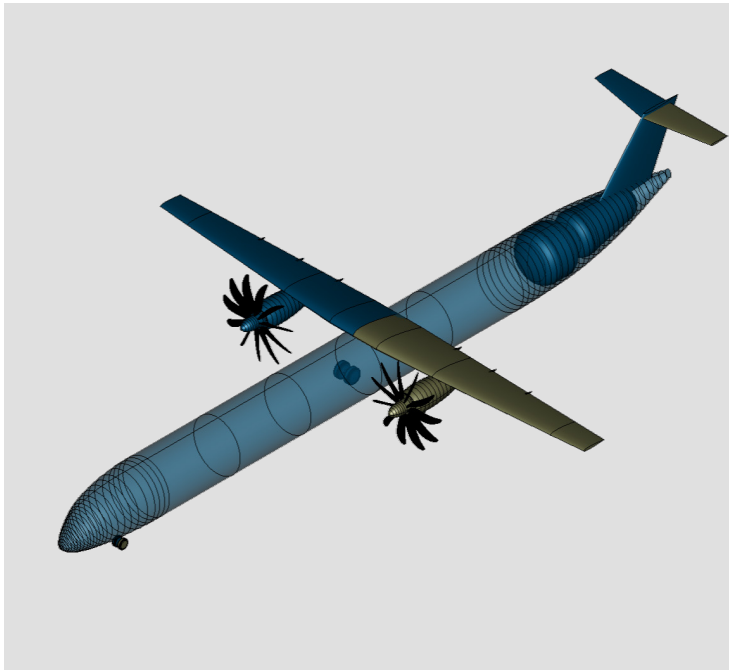


Summary of HYTAZER - DLR Project towards the certification of hydrogen tanks for mobility applications

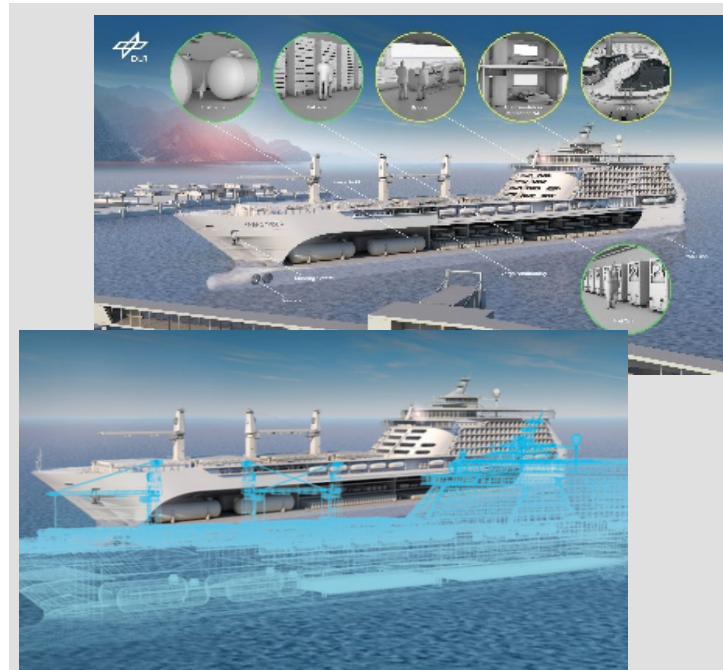


Major HYTAZER topics

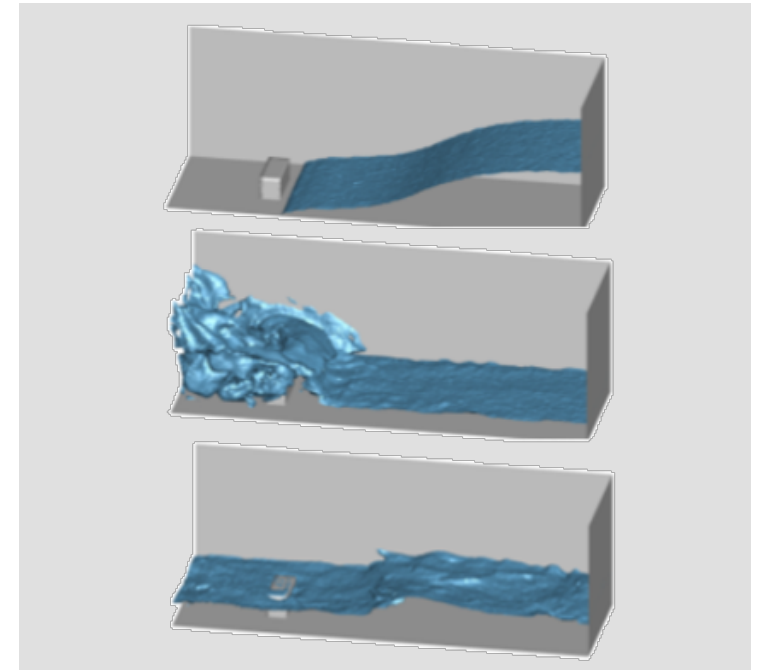
Setup requirements for LH2 tanks in aircraft design



Investigate appropriate energy carriers for ship building and establish a virtual ship



Investigation of Sloshing in LH2 Tanks in aviation and ship building wrt. effect on loads/c.g.

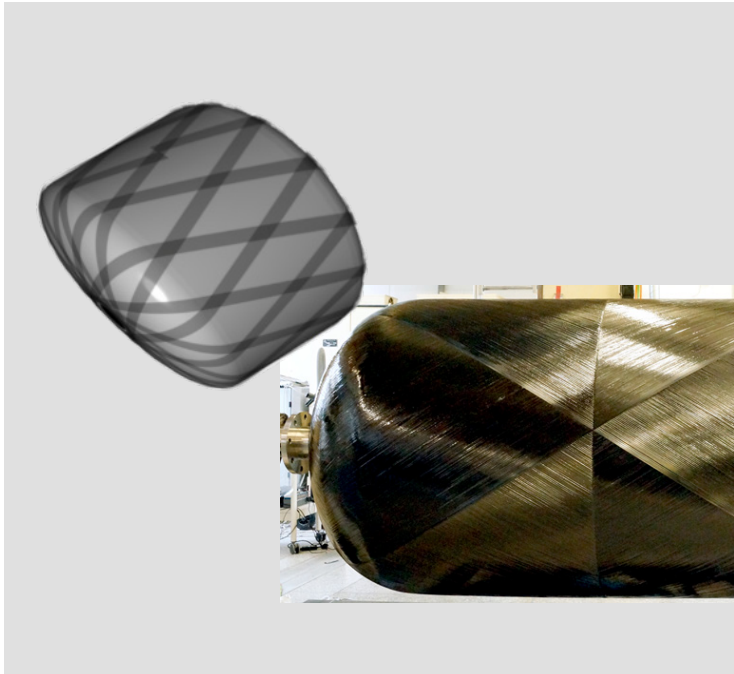


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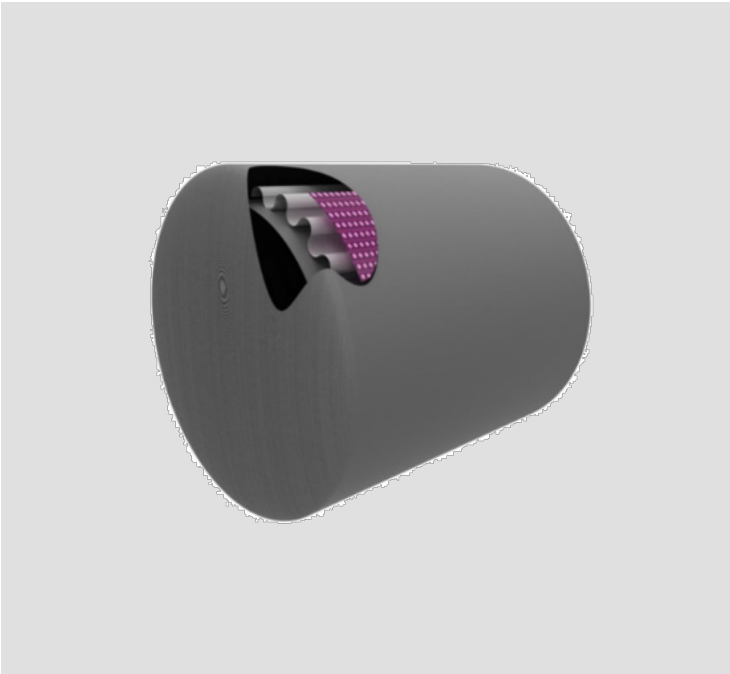


Major HYTAZER topics

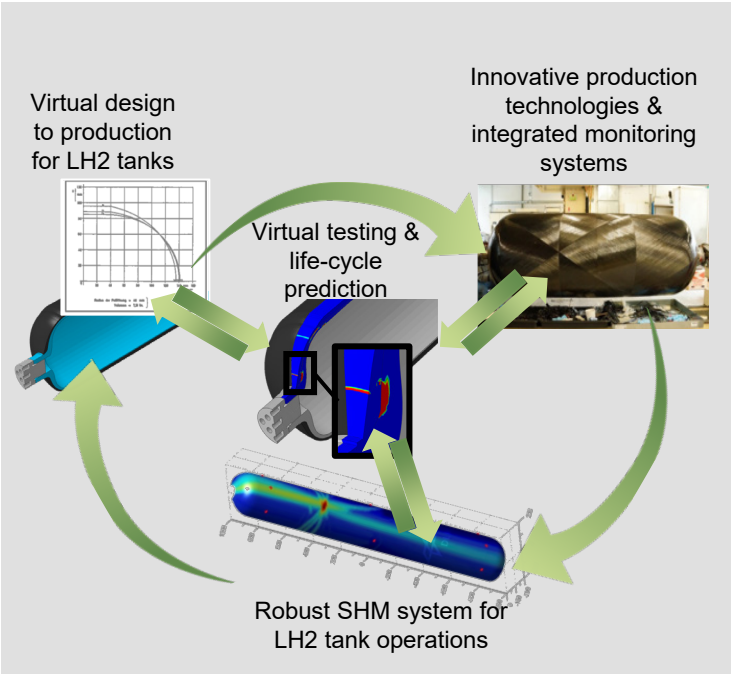
Investigation of thin-walled composite LH2 tank structures for aviation



Identification and exploitation of cost and weight improvements in design and manufacturing



Virtual LH2 Tank testing and assessment incl. manufacturing and SHM data



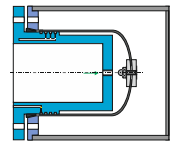
FA Test Pyramid – virtual & physical



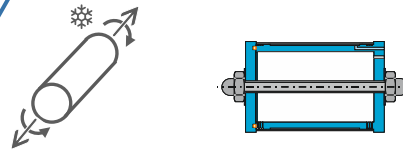
Sub/Full-scale
Durchmesser bis zu 5 m



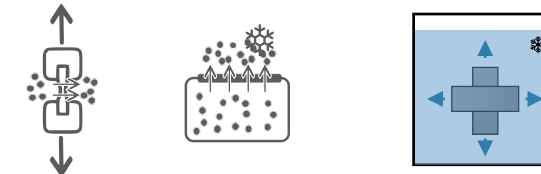
Sub-Scale II (doppelt gekrümmte Prüfkörper)
Durchmesser ~400 mm



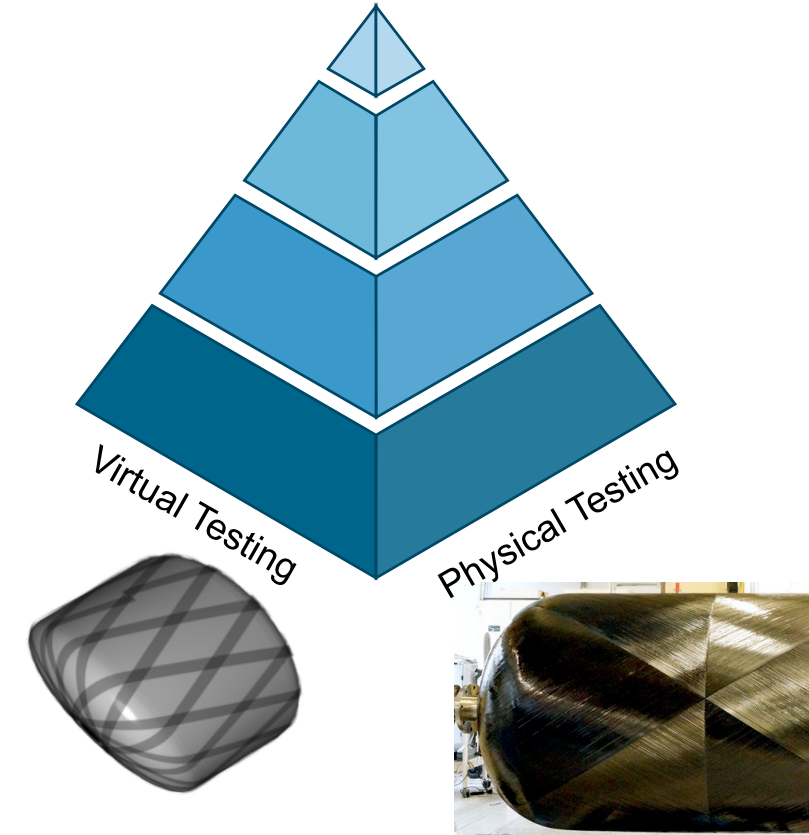
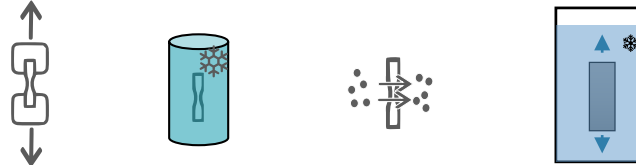
Sub-Scale I (einfach gekrümmte Prüfkörper)
Durchmesser 150 mm – 400 mm



Coupon-Ebene II (kombinierte Belastung)

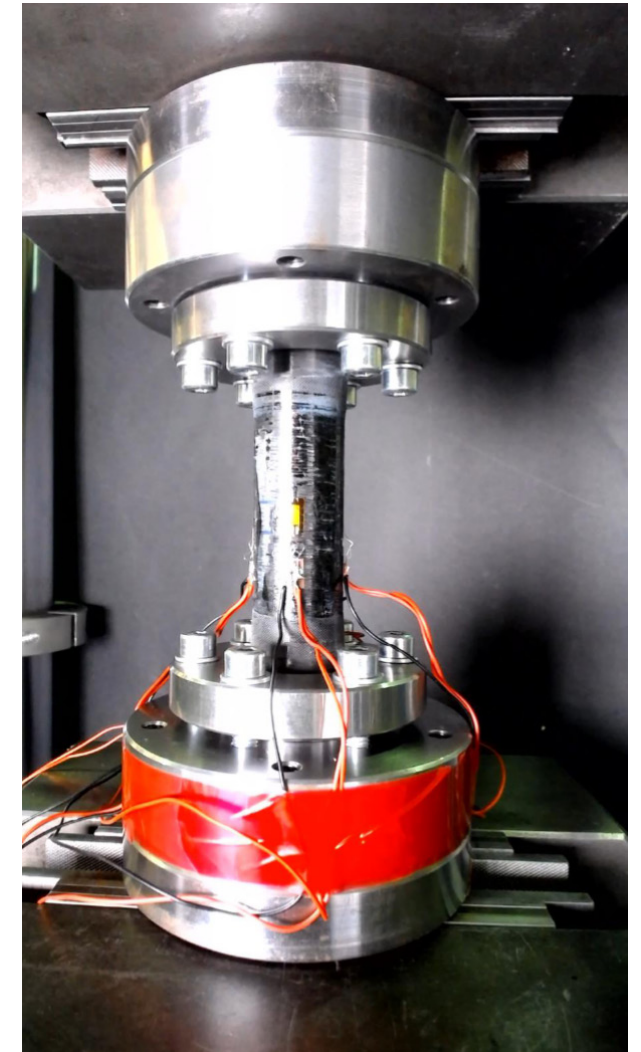
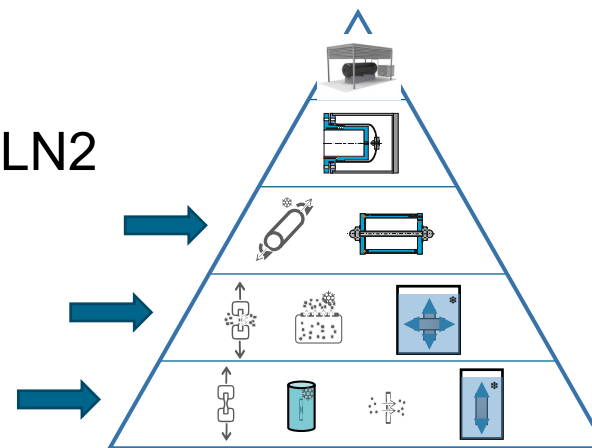


Coupon-Ebene I (isolierte Belastung)

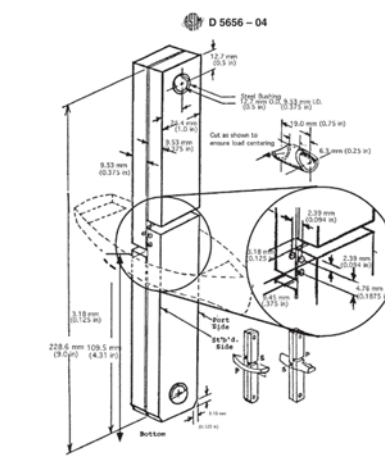
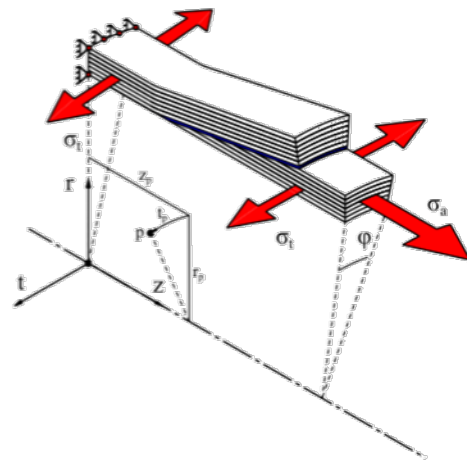
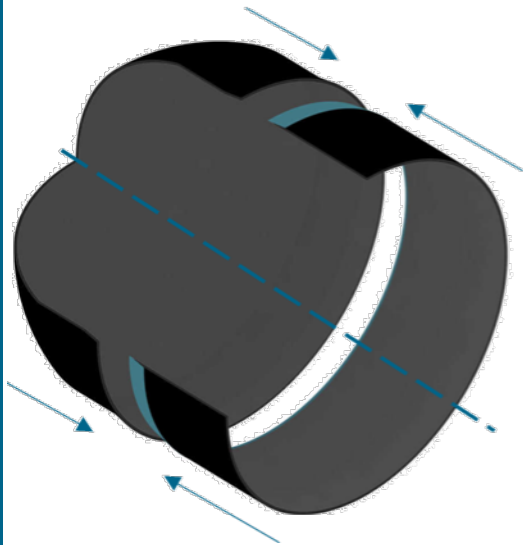


Characterization of Composite Specimen

- Usage of servo hydraulic dynamic test site
- Specimen
 - Coupons
 - Tubes ~30mm diameter
- Results
 - Mechanical material characterization
 - Investigation of fatigue strength of composites
- Extensions
 - Extension for cryogenic testing using LN2
 - Potential extension of specimen to 150mm tubes

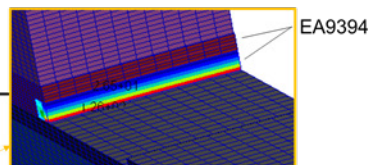
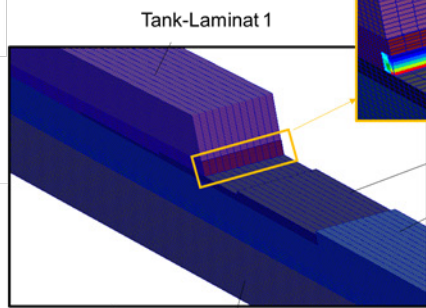
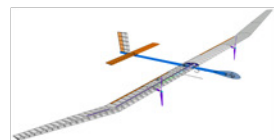


Kennwertbasiertes Design geklebter Fugstellen am LH2 Tank



ASTM D 5656-04

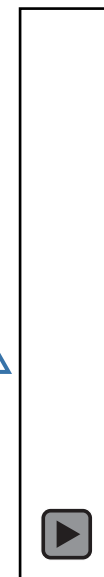
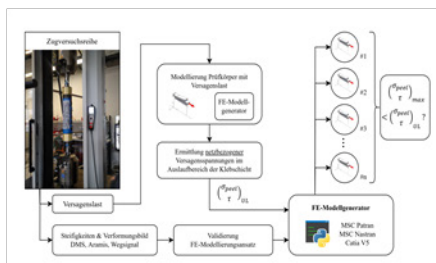
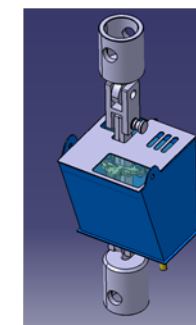
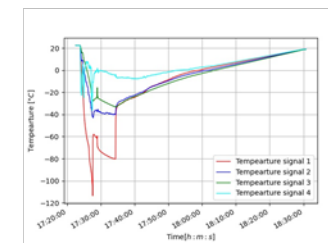
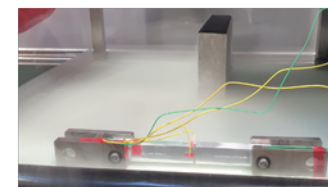
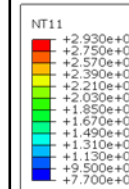
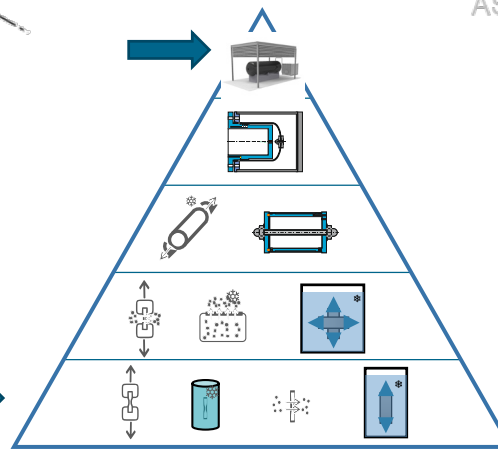
Ziel: Erweiterung der Fähigkeiten zur Bestimmung mechanischer Klebstoffkennwerte in den LN2 Bereich als Grundlage für das Kennwertbasierte Design



PVDF
Tank-Laminat 2

1° Ausschnitt der Schäftverklebung mit Zyklischer Symmetriebedingung

Doppler-Laminat



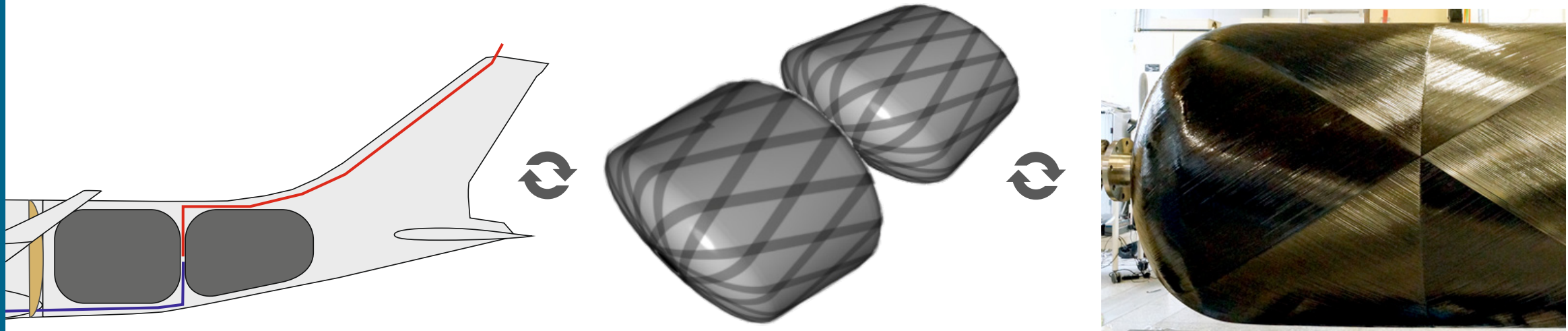
CFRP Tank Design & As-Built Assessment



Aircraft Design

Winding Simulation & Layer Optimization

Manufacturing Interface



tankoh2

Winding (μ Wind – commercial)

- CFRP winding simulation

Optimization (tankoh2 – DLR)

- Optimize layer angles automatically

CFRP Tank Design & As-Built Assessment

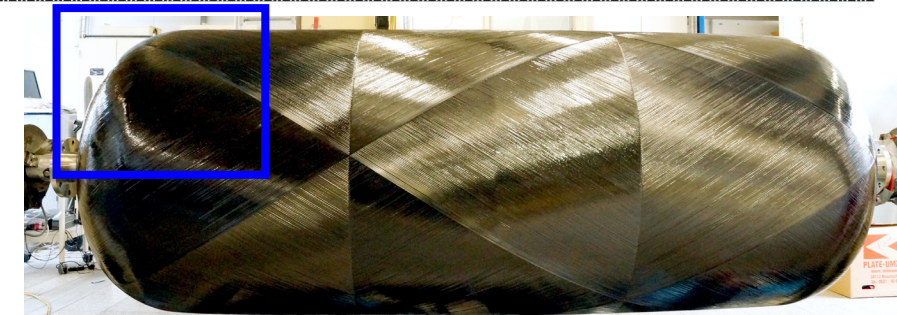
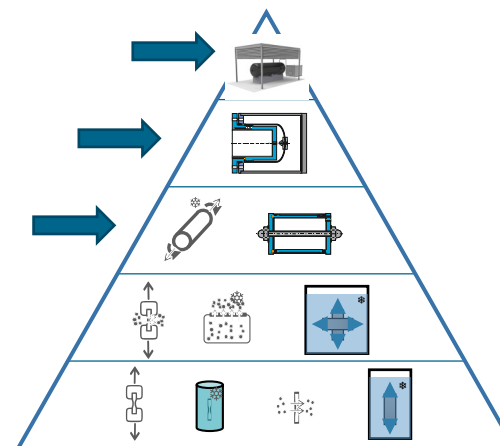
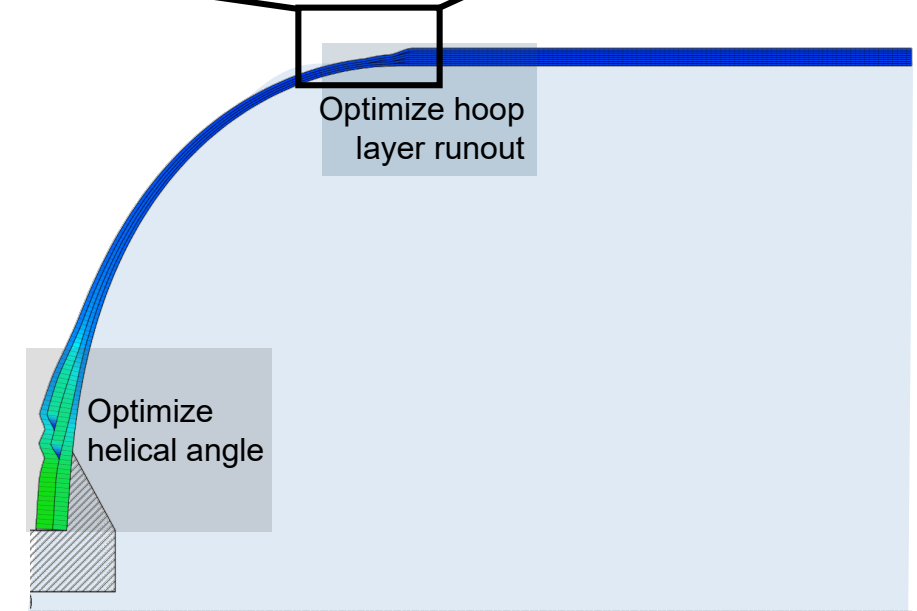
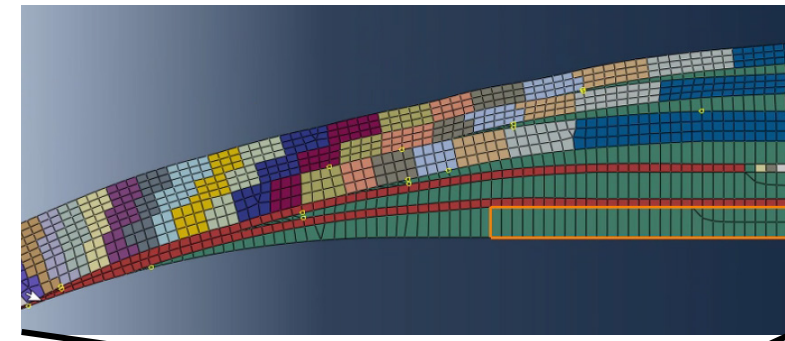


Automated Optimization

- Goal: minimize failure criterion
- Parameters: layer angles, hoop layer runout
- Reference model → downsizing for test specimen diameter

As-Built Assessment

- Model As-Built Liner
- Band path including thickness accumulation
- Structural evaluation of manufacturing tolerances



Stepwise Approach: From tubular specimen towards full scale LH₂ structure

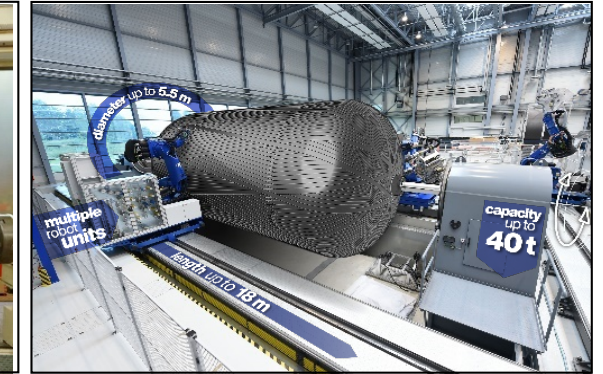
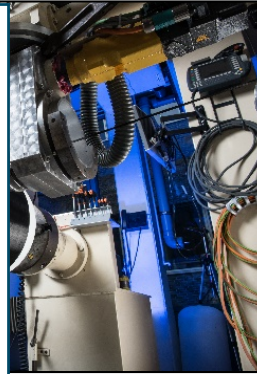
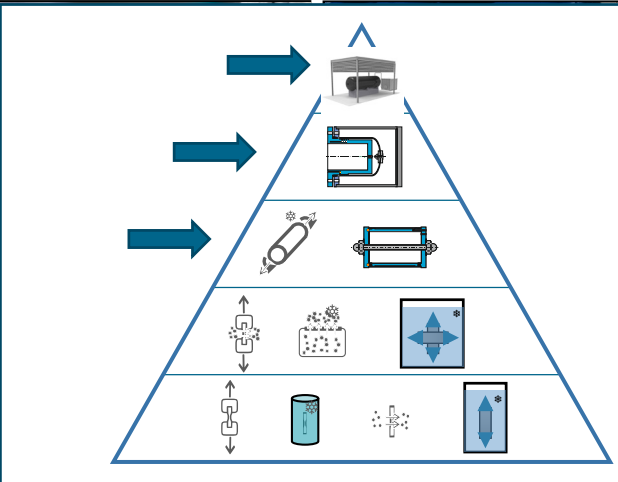
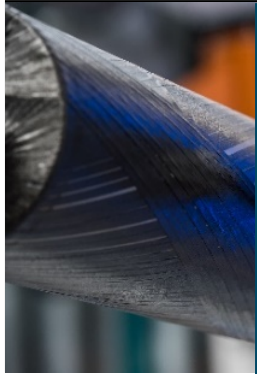


150mm diameter tubes

400mm diameter tank (L=800mm)

1000mm diameter tank (L=3m)

3m diameter tank (L=6-8m)



High Rate S

- Permeability tests
- Material characterization
- Basic manufacturing technology assessment

TRL Validation Options:

- Manufacturing technology assessment
- Tooling concept assessment
- Cryo-shock / sloshing testing
- Simplified burst & fill-and-drain test
- SHM integration

Representative Validation:

- manufacturing demonstration
- Full size tooling effects
- Cryosystem testing
- Burst & fill-and-drain test on certification level

log of process parameters for the [digital twin](#) and virtual manufacturing towards LCA and LCCA

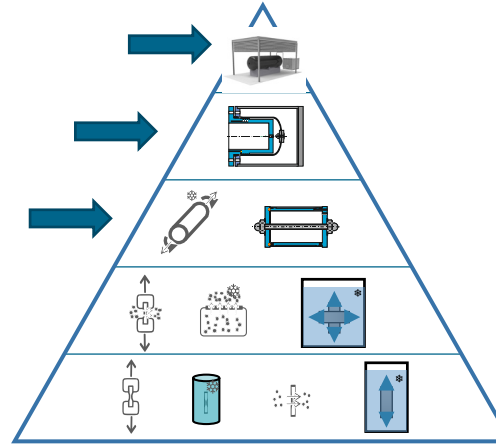
Formalisierte Fertigungsauslegung

- Formalisierte und wissensbasierte Fertigungsauslegung

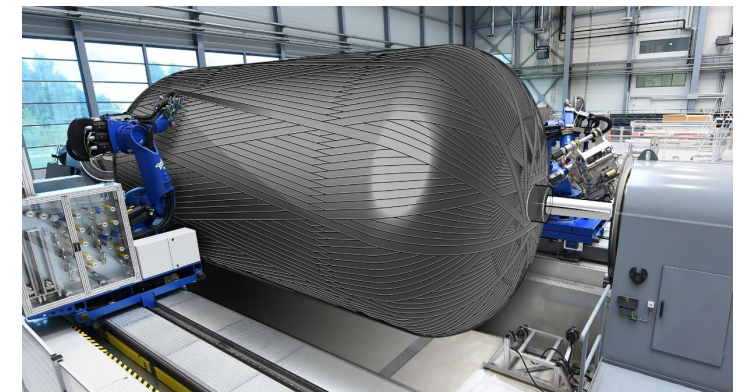
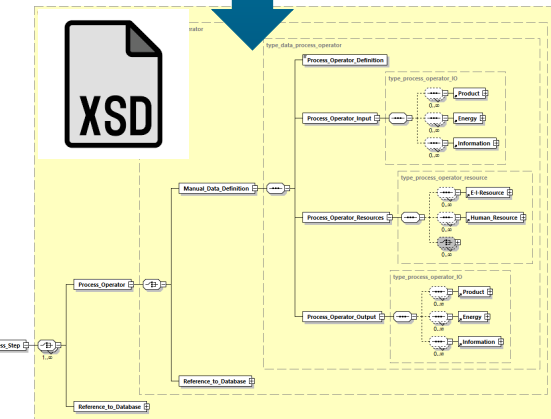
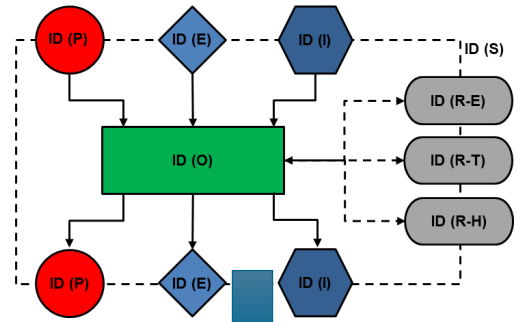
- Identifikation potentieller Materialien/Fertigungstechnologien/-prozesse mit Hilfe einer Wissensdatenbank
- Verknüpfung formalisiert beschriebener Einzelprozessschritte zu komplexen Fertigungsprozessen

- Berücksichtigung der Virtuellen Fertigung als Baustein einer as-built-Zertifizierung

- Weiterentwicklung vorhandener bzw. Entwicklung neuer Werkzeuge der virtuellen Fertigung
- Validierung der entwickelten Werkzeuge
- Implementierung der Werkzeuge in vorhandene Workflows des DLR zur Zertifizierung



Inspired by VDI 3682



HYTAZER

towards the certification of hydrogen tanks for mobility applications



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QUESTIONS?