

# *Additive Manufacturing with FDM in modern ship/yacht construction*



*Fraunhofer Additive-Alliance, Hamburg 6/7.3.2024*

**Dipl.-Inform. Michael Eichmann**

**DIRECTOR BUSINESS DEVELOPMENT / EMEA**

# • THE MARKET

- **90.000 Seagoing vessels worldwide (container, cargo, cruises, no fishing)**
  - thereof approx. **5.400 container ships**
  - thereof **385 cruise ships** (with 71 expeditions ships, 13 sailing cruises ships)
  - Seagoing vessels transport 90% of the world's good traffic**
- **927 Warships in NATO, 48 aircraft carriers worldwide**
- **German Navy**
  - with **12 frigates, 5 corvettes, 6 submarines, 12 anti-mine boats,**
  - 20 auxiliary ships**
- **5.000 Superyachts worldwide**
  - 4.000** (up to 50m), **600** (up to 50-80m), **120** (greater than 80m)
- **Sport boats/sailors worldwide**(sales in 2019: 18.2€ billion,  
in 2020: 13.6€ billion)
- **1.187 inland vessels in germany** (2.207 in 1990)



# Evaluation of the target market and research of the general conditions

## Military



Battleships

## Commercial



Cruise Liners



Submarines

## Private Use



Motorboats



Battle Submarines



River Cruise Vessels



Sailing Vessels



Racing Yachts



Transportation Vessels

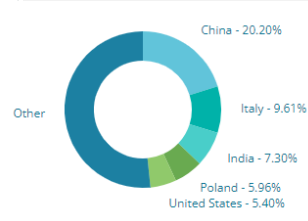


Yachts

# • INDUSTRY SUMMARY

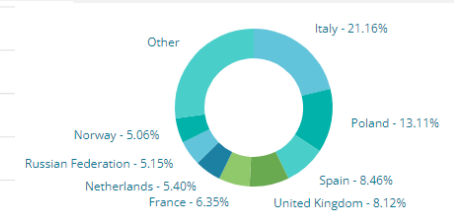
## Geographic Segment – TOP 20 Global

Country/Region	Companies	Total (%)
China	20,087	20.20%
Italy	9,559	9.61%
India	7,257	7.30%
Poland	5,923	5.96%
United States	5,372	5.40%
Spain	3,821	3.84%
United Kingdom	3,667	3.69%
Japan	3,270	3.29%
France	2,867	2.88%
Korea, Republic of	2,559	2.57%
Netherlands	2,438	2.45%
Russian Federation	2,326	2.34%
Norway	2,284	2.30%
South Africa	2,277	2.29%
Singapore	2,202	2.21%
Sweden	1,777	1.79%
Turkey	1,419	1.43%
Germany	1,155	1.16%
Australia	1,107	1.11%
Romania	1,061	1.07%



## Geographic Segment – TOP 20 EMEA

Country/Region	Companies	Total (%)
Italy	9,559	21.16%
Poland	5,923	13.11%
Spain	3,821	8.46%
United Kingdom	3,667	8.12%
France	2,867	6.35%
Netherlands	2,438	5.40%
Russian Federation	2,326	5.15%
Norway	2,284	5.06%
Sweden	1,777	3.93%
Turkey	1,419	3.14%
Germany	1,155	2.56%
Romania	1,061	2.35%
Greece	918	2.03%
Croatia	819	1.81%
Finland	770	1.70%
Denmark	599	1.33%
Ukraine	529	1.17%
Switzerland	484	1.07%
Portugal	441	0.98%
Estonia	434	0.96%



Source: D&B Hoover

# • **WHAT DO WE NEED TO BE SUCCESSFUL**

- **Customers and prospects with the know-how in ship/yacht construction**
- **A system and certified material solution**
- **A neutral laboratory which is respected in ship/yacht construction**
- **An association that is active in this market and has many members**
- **First interested parties with concrete needs and real ideas**
- **Partners who want to tackle this market together with us**
- **Other events in this market like shows, conferences ...**

# • INDUSTRY SUMMARY

## • Industry Description

- Companies engaged in operating shipyards or boat yards with drydocks and equipment for the construction of ships. Also included in this industry are companies engaged in ship and boat repair, conversion and alteration.

## • Industry Applications

- Air boat building
- Barge building
- Boat yards (i.e., boat manufacturing facilities)
- Boats (i.e., suitable or intended for personal use) manufacturing
- Boats, inflatable plastics (except toy-type), manufacturing
- Cabin cruiser
- Cargo ship building
- Container ship building
- Dories building
- Dredge building
- Drilling and production platforms, floating, oil and gas, building
- Drydock, floating, building
- Ferryboat building
- Fireboat building
- Fishing boat, commercial, building
- Hovercraft building
- Hydrofoil vessel building and repairing in shipyard
- Inflatable plastic boats, heavy-duty, manufacturing
- Inflatable rubber boats, heavy-duty, manufacturing
- Motorboat, inboard or outboard, building
- Naval ship building
- Oil and gas offshore floating platforms manufacturing
- Passenger ship building
- Patrol boat building
- Pleasure boats manufacturing
- Rigid inflatable boats (RIBs) manufacturing
- Rowboats manufacturing
- Sailboat building, not done in shipyards
- Sailing ships, commercial, manufacturing
- Ship dismantling at shipyards
- Ship repair done in a shipyard
- Ship scaling services done at a shipyard
- Ships (i.e., not suitable or intended for personal use) manufacturing
- Shipyard (i.e., facility capable of building ships)
- Submarine building
- Towboat building and repairing
- Tugboat building
- Underwater remotely operated vehicles (ROVs) manufacturing
- Yacht building, not done in shipyards
- Yachts built in shipyards

Source: D&B Hoover



# • CURRENT PROJECT PARTNERS



another 2 partners

# • CATEGORIZATION OF REQUIREMENTS



- Fire protection necessary at >12 passengers
- Different requirements depending on the ship area
- Material tests for the respective area

area of application	number of passengers	deputy	Potential areas of application	requirements	regulation	demonstrator
military	Independent	Partner-3	interior	<ul style="list-style-type: none"> <li>sea water and air</li> <li>operating temperature</li> <li>stat./ dyn . strength</li> <li>surface roughness</li> <li>post processing</li> </ul>	Internal only	-
			outdoor area			
Civil	>36	Partner-2	outdoor area	<ul style="list-style-type: none"> <li>Resistance to sea air or wind load</li> <li>salty environment</li> </ul>	<ul style="list-style-type: none"> <li>SOLAS [SOL05] (partially referenced to FTP code)</li> <li>DNVGL [DNV15, DNV17] (partially congruent with IACS)</li> </ul>	Primary mounts (see Milestone 3)
			hotel area	<ul style="list-style-type: none"> <li>Surface quality in the visible area</li> <li>reduce fire load; must not "exhale, drip or produce toxic smoke "</li> </ul>		
			kitchen area	<ul style="list-style-type: none"> <li>Additional hygiene requirements</li> </ul>		
			escape routes	<ul style="list-style-type: none"> <li>Highest fire protection requirements</li> </ul>		
			Technical part	<ul style="list-style-type: none"> <li>Resistance to high humidity</li> <li>chemical resistance</li> </ul>		
Mostly commercial, some private use	12 to 36	Partner-4	surfaces	<ul style="list-style-type: none"> <li>Very high demands on surface quality (usually wood veneer)</li> </ul>	<ul style="list-style-type: none"> <li>PYC</li> <li>IMO FTP code</li> </ul>	-
			substructures	<ul style="list-style-type: none"> <li>fire safety requirements</li> <li>Low cost</li> </ul>		
private use	<12	Partner-5	surfaces	<ul style="list-style-type: none"> <li>High demands on surface quality (usually plastic surfaces)</li> </ul>	no .	Cover in the toilet area
			substructures	<ul style="list-style-type: none"> <li>Possibly lower fire protection requirements in the case of cast-in substructures</li> </ul>		Connection of the flybridge



# • CATEGORIZATION OF REQUIREMENTS

Requirements		Salt water resistance <sup>1</sup>	UV resistance	Chemical resistance	Outgassing	Food certification	Heat deflection	Flammability <sup>2</sup>	Static strength	Material costs	Selection factor			
Evaluation	Outdoor area	20%	10%	10%	0%	0%	15%	10%	15%	20%				
	Hotel area	0%	0%	5%	20%	0%	5%	50%	5%	15%				
	Kitchen area	0%	0%	10%	15%	30%	0%	15%	0%	30%				
	Technical area	0%	0%	25%	5%	0%	15%	15%	10%	30%				
FDM-Material	ANTERO 800 NA	3	1	4	4	1	3	4	4	1	2.95	2.20	3.50	2.75
	ASA	4	4	2	- <sup>3</sup>	1	1	1	1	4	2.10	1.85	1.30	2.60
	NYLON 12 CF	4	2	2	- <sup>3</sup>	1	2	1	2	3	2.05	1.55	1.25	2.50
	ULTEM 9085	4	3	3	3	1	4	4	3	2	3.00	2.25	3.40	3.25

<sup>1</sup> IACS Electrical Installations Rev. 8:2021, E10 No. 12 Salt Mist

<sup>2</sup> IACS Electrical Installations Rev. 8:2021, E10 No. 21 Flame Retardant acc. to IEC 60695-11-5

<sup>3</sup> No declarations accessible



# • MATERIAL SPECIFIC PROPERTY PROFILES

## Outdoor area

- Saltwater resistance (20%)
- Heat deflection temperature (15%)
- Static strength (15%)
- UV resistance (10%)



## Hotel area

- Heat deflection temperature (50%)
- Outgassing (20%)
- Static strength (5%)
- Chemical resistance (5%)



## Kitchen area

- Food certification (30%)
- Outgassing (15%)
- Inflammability (15%)
- Chemical resistance (10%)



## Technical area

- Chemical resistance (25%)
- Heat deflection temperature (15%)
- Inflammability (15%)
- Static strength (10%)



# • MATERIAL SELECTION

## ULTEM 9085

- + Heat deflection temperature
- + Large number of certificates
- High material price



## Antero 800NA

- + Chemical resistance
- + Outgassing
- High material price



## ASA

- + Low material price
- + UV resistance
- Inflammability



## FDM Nylon 12CF

- + Static strength
- + Low weight
- Inflammability



# • LABORATORY REPORTS (EXCERPT)

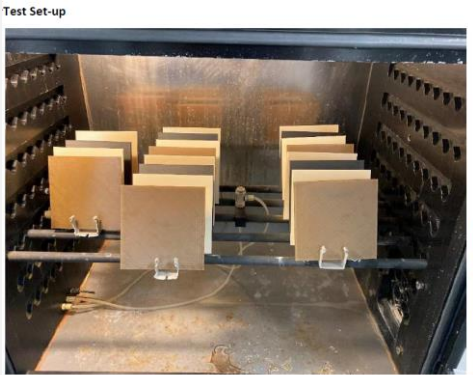


Figure 5: Test set up during Salt Mist

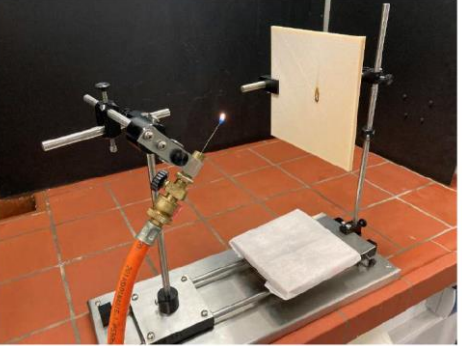


Figure 52: Exemplary Picture of the Test set-up

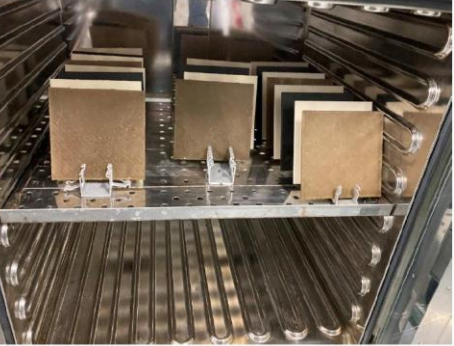


Figure 6: Test set up during Damp Heat

Not classified



Test Facility:  
 Tempowerk 10  
 D-20275 Hamburg  
 Tel: +49 30 90 700130-0  
 Fax: +49 30 90 700130-20

Erkennungs- & Zertifikatsnummer:  
 0-3000/000000000  
 Tel: +49 30 90 700130-0  
 Fax: +49 30 90 700130-20

**Laboratory Test Report**

Document No.: 389-21  
 Issue: 1  
 Assignment No.: 4014017

Equipment Under Test: Material samples  
 Client: Stratasys GmbH  
 Airport Boulevard 10, 20  
 D-22763 Hamburg-Mitte

Release Date: 2023-12-26

Issued by:   
 K. Wölschen, B.Sc.  
 Test Engineer

Reviewed by:   
 Dr.-Ing. T. Schönewasser  
 Head of Environmental  
 Simulation Laboratory

**TPEO**  
 Accredited test laboratories  
 international cooperation (accredited testing)  
 www.tpeo.de

Material samples: Not classified

### 2 Test Overview and Results

Table 1: Results

Sec.	Test	Responsible Person	Date	EUT No.	Result
4	Salt Mist ACS Electrical Installation Rev. B:2021-07, E10, Test No. 12	K. Wölschen	2021-10-12	02.01	Passed
				02.05	
				03.01	
5	Cold ACS Electrical Installation Rev. B:2021-07, E10, Test No. 11	K. Wölschen	2021-11-09	02.01	Passed
				02.05	
				03.01	
6	Flame Retardant ACS Electrical Installation Rev. B:2021-07, E10, Test No. 21	K. Wölschen	2021-10-08	01.00	Passed
				01.06	
				04.00	

Further remarks are provided to the corresponding section of this report.

This test report may contain test methods which are not part of our accredited test areas. These tests are marked with an asterisk (\*). Tests implemented in an accredited external laboratory are marked with two asterisks (\*\*). Tests implemented in a non-accredited external laboratory are marked with three asterisks (\*\*\*)

Text written in italic type is external information, not provided by TPEO. This can be for example results or additional information provided by the client. The information is not part of results reviewed by TPEO, hence TPEO is not in charge for the content.

Table 2: Logistics

EUT No.	Date	Description
01.04	2021-09-28	Delivery at TPEO Hamburg
02.04	2021-11-15	Return at TPEO Hamburg

Saltwater – ASA, Nylon 12CF, Antero 800NA & U9085 passed

Cold – ASA, Nylon 12CF, Antero 800NA & U9085 passed

Flame retardant- Antero 800NA & U9085 passed

# • LABORATORY REPORTS (EXCERPT)





Labor für Umweltsimulation GmbH

## PRÜFZERTIFIKAT | TEST CERTIFICATE

**Zertifikatsnummer | Certificate Number**  
TC-383-21, issue 1

**Prüfungsbezeichnung | Equipment Under Test**  
ANTERO 800NA, ASA, Nylon 12CF & ULTEM 9085

**Kunde | Client**  
Stratasys GmbH  
Airport Boulevard B120  
77836 Rheinmünster

**Produktnummer | Product Number**  
/

**Datum | Date**  
19-07-2022

**Prüfnorm und Schärfegrad | Test Specification and Severity Level**  
Salt Mist, IACS Electrical Installation Rev. 8:2021-07, E10, Test No. 12  
Cold, IACS Electrical Installation Rev. 8:2021-07, E10, Test No. 11  
Flame Retardant, IACS Electrical Installation Rev. 8:2021-07, E10, Test No. 21

Die Prüfungen wurden gemäß der Prüfnorm durchlaufen und bestanden.  
The tests were performed and passed according to the specification.

**TREO Prüfberichtsnummer | TREO Test Report Number**  
383-21, issue 1, dated 24-11-2021

Dieses Zertifikat ist nur gültig im Zusammenhang mit dem entsprechenden Prüfbericht und gilt nur für die geprüften Geräte.  
This certificate is only valid in combination with the related test report and exclusively effective for the tested equipment.

  
 Dr.-Ing. Till Schwermer  
 Head of Environmental Simulation Laboratory




Treo ist ein durch die Deutsche Akkreditierungsstelle GmbH (DAkkS) nach DIN EN ISO/IEC 17025 akkreditiertes Prüflaboratorium. Die Akkreditierung gilt für die in der Urkunde aufgeführten Prüfverfahren.  
 Treo is a testing laboratory accredited according to DIN EN ISO/IEC 17025 by the Deutsche Akkreditierungsstelle GmbH (DAkkS). The accreditation is valid for the test areas listed in the accreditation certificate.

Treo - Labor für Umweltsimulation GmbH  
 Tempowerkring 18, D-21079 Hamburg  
 Phone: +49 - (0)40 - 7097376 - 0  
 Fax: +49 - (0)40 - 7097376 - 23

## SOLAS 74 - ISO 18079

- ANTERO 800NA
- ASA
- NYLON 12CF
- ULTEM 9085

# • Maritime Market Strategy

maritimes cluster  
norddeutschland



The Maritime Cluster Northern Germany (MCN) is an association that promotes and consolidates collaboration within this industry. We bring partners together across federal state boundaries. We promote cooperation and innovation across various industries. We assist in the search for innovation partners, advise on incentives and grants, and arrange contacts in the maritime sector.



# • Maritime Market Strategy of MCN



The Maritime 3D Network (MN3D) aims to develop, and market improved additive manufacturing methods and products for the maritime sector. The network takes into account the special concerns and needs of the maritime economy in 3D printing.

### Partner


### Research Institution

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### Cluster Organisation

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# • Maritime Market Strategy

## Forum "Additive Manufacturing in Ship/Yacht Building"

/// Hamburg, September 19, 2023 (DNV, Brooktorkai 18, D-20457 Hamburg)

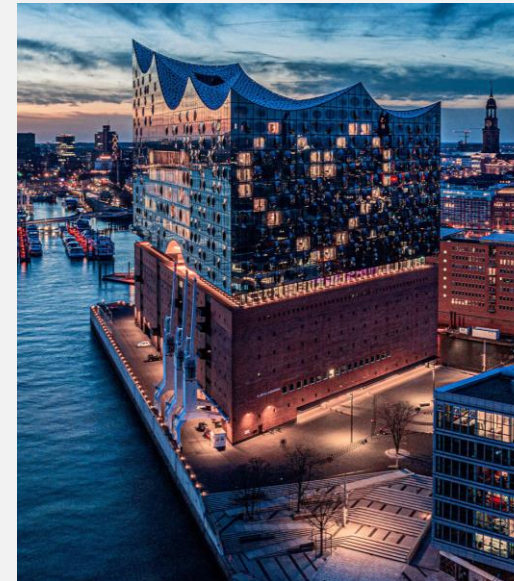
### AGENDA

Moderation: Michael Eichmann / Stratasys GmbH

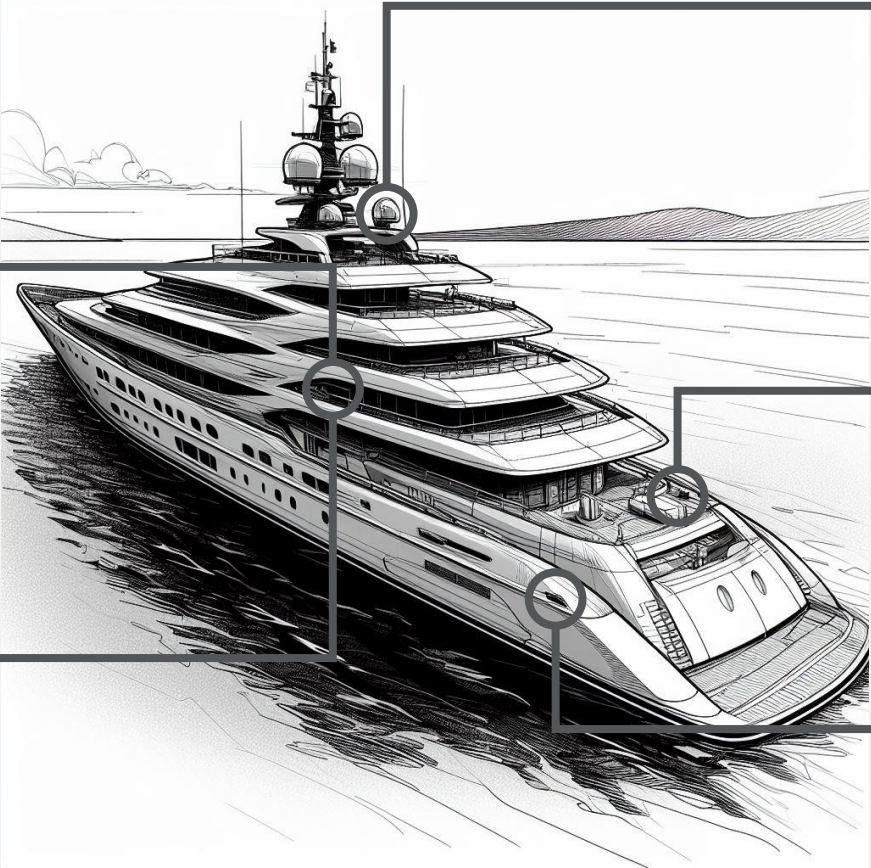
09:00 – 09:30	<b>Check-In</b>	
09:30 – 09:40	<b>Welcome</b> - Introduction to the event	<b>Maritimes Cluster Norddeutschland</b>
09:40 – 10:00	<b>Introduction DNV</b> - Additive manufacturing in the maritime sector	<b>Norbert Worm</b> DNV
10:00 – 10:30	<b>New materials &amp; technologies for customized propellers</b> - Additive manufacturing at MMG	<b>Christian Klötzer-Freese</b> MMG-Mecklenburger Metallguss
10:30 – 11:00	<b>The Icon BMW</b> - Electromobility on the water	<b>John Schönbeck</b> DesignWorks GmbH
11:00 – 11:15	<b>Coffee break</b>	
11:15 – 11:45	<b>Holistic additive manufacturing</b> - The maritime approach	<b>Santiago Ferrer</b> 3Dock
11:45 – 12:15	<b>With mobile 3D scan technology to custom-made fixtures and spare parts</b> - Efficient ways to the functional component	<b>Antonius Köster</b> A. Köster GmbH
12:15 – 12:45	<b>AM solutions in ship and yacht building</b> - Use of the FDM process with certified materials	<b>Stefan Zoller</b> Stratasys GmbH
12:45 – 13:30	<b>Lunch break</b>	
13:30 – 14:00	<b>Value creation in 3D printing using data and AI-VO</b> - The legal framework	<b>Marco Müller-ter Jung</b> Grant Thornton GmbH
14:00 – 14:30	<b>Digital warehousing</b> - and production at the point of use	<b>Matthias Schmid</b> Daimler Buses GmbH
14:30 – 15:00	<b>AM in the box</b> - Repair of components on site	<b>Olaf Steinmeier</b> Fraunhofer IAPT
15:00	<b>End</b>	

maritimes cluster  
norddeutschland

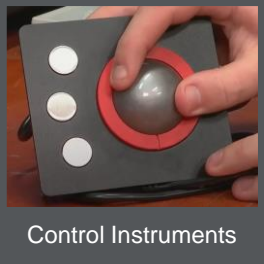
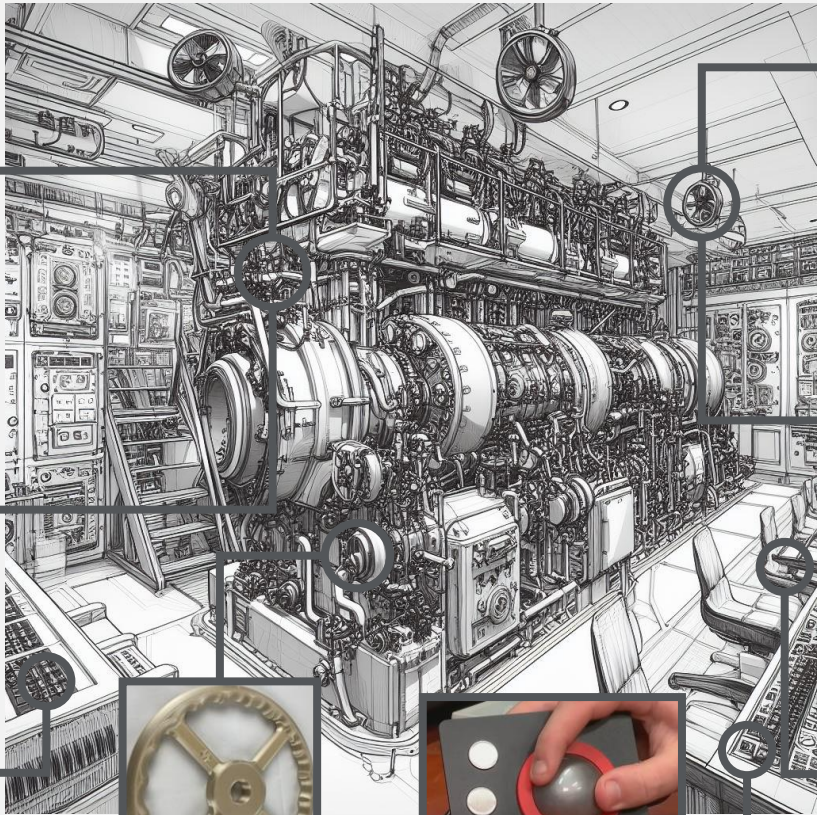
stratasys®



# Sample Parts Outside Area



# Sample Parts Technical Area





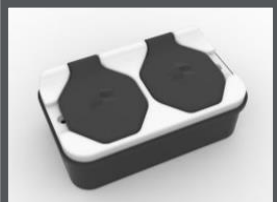
# Sample Parts Hotel Area



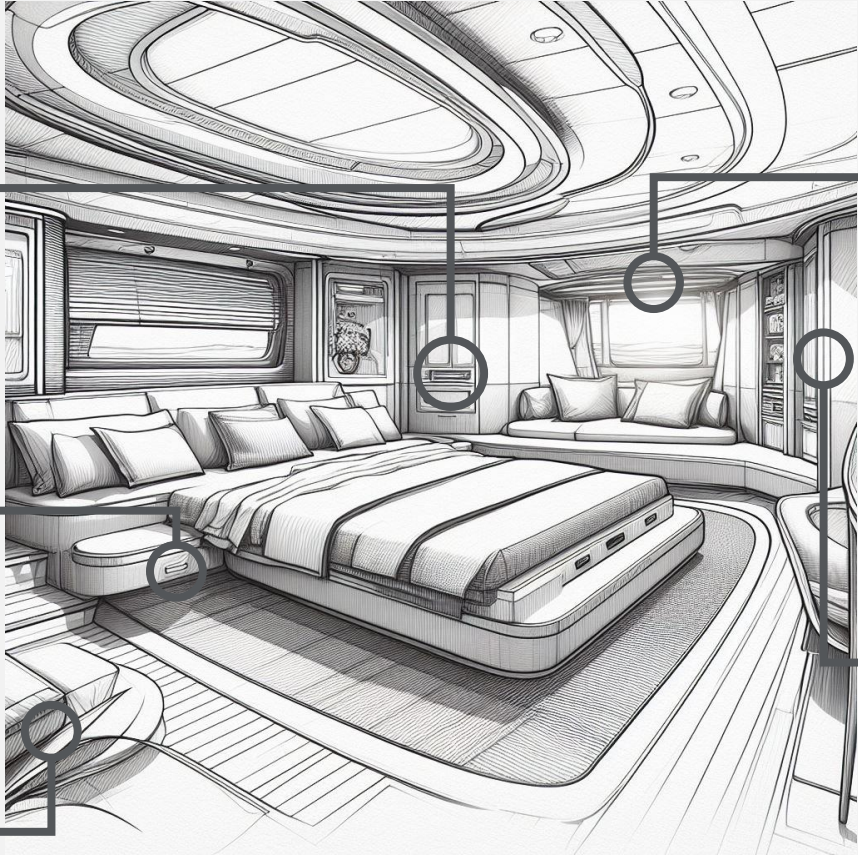
Instruments Covers



Light Housings



Plug Housings



Air Vents



Toilette Covers

# Sample Parts Kitchen Area



Brackets



Blower Fans +  
Housings



Ducts



Bottle Holders



Fire Extinguisher  
Brackets

# References Maritime market





# Outlook into next Business Development Activities

**COMING SOON**



Caravan / Motor Homes



Toolmaking  
Injection Molds with P3



Military



# Vielen Dank / Thank You

**Dipl.-Inform. Michael Eichmann**  
Director Business Development / EMEA

Mobil 0049 151 18257201  
[michael.eichmann@stratasys.com](mailto:michael.eichmann@stratasys.com)

