Mobility in Aircraft Cabins

Tailored On-Board Assistance

Development of an On-Board Wheel Chair


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Hamburg University of Applied Science (HAW)

Long Tradition
- History dates back to 1749
- 1970 Foundation of Fachhochschule Hamburg
- since 2003 HAW Hamburg (UAS)

Today
- 3rd largest UAS in Germany
- 4 faculties with ca. 15,000 students
- app. 2,000 foreign students
- 430 professors
Students

1300 in the degree programs (B.Eng. and M.Sc.)
- Automotive (800)
- Aeronautical (500)
- 200 Graduates per annum

Staff

43 professors and ca. 20 assistant lecturers
20 research assistants and other members of staff

Laboratories

Lightweight Design & Composites
CAD-Laboratory & Computer Centre
Wind Tunnel, Flight Test
Cabin & Cabin System Lab (HCAT) (newer)
Technical Acoustics (ca. 10/2016)
Aircraft Systems & Flight Deck (planned)
Prof. Dr.-Ing. Gordon Konieczny

Academic studies Technische Universität Dresden (TU Dresden)
Faculty of Transportation and Traffic Science; Institute for Aviation

PhD student Technische Universität Berlin (Technical University Berlin)
Faculty of Mechanical Engineering and Transport Systems
Topic: Determination of Service Quality in Aircraft Cabins

HAW Hamburg UAS
- Architecture of Aircraft Cabins (BA)
- Cabin Modules and Monuments (BA)
- Methods of System Design (BA)
- Human Factors (MA)
- Maintenance, Upgrade & Retrofit (MA)
- Lab for Cabin & Cabin Systems

Over 20 Years in Aviation
- Aircraft (Cabin) Design & Operation
- Airport Design & Operation
- Passenger & Aircraft Handling
- Systems (Reliability) Engineering
- Human Factors
- Commercial Pilot (CPL MEP IR(A))

www.flyprof.de
The Project

PEREC
Person-Centered Reconfigurable Aircraft Cabin

for special aircraft cabin user groups:

- Wheelchair User
- Hygiene Sensitive
- Visually Impaired
- Hearing Impaired
- Wide, Big & Tall
- Person of Short Stature, Children
- Infirm Passengers
- Mother and child, families
- Toddlers & infants
- Protection of Valuables
- Protection of Privacy
- Meditation
- Flight Attendant Work Space

Project Information
- Project Duration: 2012 - 2015
- Steps
  1. Situation and Task Analysis
  2. Concept and Implementation Analysis
  3. Demonstration and Evaluation

Methodical Approach:
- Continuous and early involvement of potential User-Groups, e.g. workshops, interviews
- Continuous Information Exchange with Stakeholders
- Development of Minimum Viable Products (MVP)
The Project - PEREC

Onboard Wheel Chair (OBW) – Concept Approach

- **Basic Assumptions:** Maintain Abilities of Home. Support Independence.

- **Main Functions:**
  1. Provide Cabin Mobility
  2. Provide Lavatory Usage Assistance

<table>
<thead>
<tr>
<th>Level of Independence</th>
<th>Main Functions</th>
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<tbody>
<tr>
<td></td>
<td>Cabin Mobility</td>
</tr>
<tr>
<td>Weight-Bearing (A)</td>
<td>✓</td>
</tr>
<tr>
<td>Non-Weight Bearing (B)</td>
<td>✓</td>
</tr>
</tbody>
</table>

- **OBW Requirements:**

<table>
<thead>
<tr>
<th>Safety &amp; Security</th>
<th>Health &amp; Comfort</th>
<th>Crew &amp; a/c Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>• FAR / CS Conformity</td>
<td>• Appropriate Dimensions</td>
<td>• High Usability</td>
</tr>
<tr>
<td>• Misuse &amp; Abuse</td>
<td>• High Usability</td>
<td>• Little additional Workload for all involved Persons</td>
</tr>
<tr>
<td>• Operational Loads</td>
<td>• Hygienic Aspects</td>
<td>• Applicable in any Lavatories</td>
</tr>
<tr>
<td>• Stability &amp; Reliability</td>
<td>• Convincing &amp; Trustworthy</td>
<td>• Little Alteration Efforts</td>
</tr>
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</table>
The Hamburg Chair 2 in 1

Onboard Cantilever Wheel Chair (OBW) - Overview

Specification:

- 95th Percentile American Male (Dimensioning)
- Width < 15” (here 380mm)
- Height acc. Lavatory Bowl Height (supporting function)
- Braked and turnable wheels
- Control Rods (adjustable)
- Foot Rest (movable)
- Necessary Cut-outs in lavatory kick-strip
- Lavatory door closure for OBW forward usage
- Collapsible for stowage – minimum dimension
- Weight limitation < 10kg

Horizontal OBW Position for (un-)dressing was a Suggestion of a PRM group from Hamburg during a PEREC Workshop.
# The Hamburg Chair 2 in 1

## Onboard Wheel Chair (OBW) – Operational Concept

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
<th>Remarks</th>
<th>Group</th>
</tr>
</thead>
</table>
| 1    | Transfer: Seat ➔ Lavatory Area | • OBW Check before Entering into Main Cabin  
• Operation as a normal (known) OBW  
• Easy and comfortable Use for PRM and Supporting Person  
• No Lavatory Assist Function recognizable | A: ✓  
B: ✓ |
| 2    | Lavatory Usage Assistance | • Position in Privacy Area in front of Lavatory  
• Preparation of PRM and OBW for Lavatory Usage  
• After Usage of Lavatory - Preparation of PRM and OBW for Transfer to Seat  
• OBW Check before entering the Main Cabin | ✓ |
| 3    | Transfer: Lavatory Area ➔ Seat | • Upon Entry into the Main Cabin – Operation as a normal (known) OBW  
• No Lavatory Assist Function recognizable | A: ✓  
B: ✓ |

**Group A: Weight Bearing Persons**  
**Group B: Non-Weight Bearing Persons**
Onboard Wheel Chair (OBW) – Process Investigation

Main Findings - Aspects:

- Area in-front of Lavatory necessary for OBW Operation (Privacy)
- Multiple Usage of Area in Front of Lavatory and Provision of Covering Material for OBW Seat Surface (Hygiene)
- Meeting social norms, standards and expectations = clear separation between the two main functions during OBW usage (Acceptance)
- Necessary Assistance – Classification of WCH Users in extent to todays IATA Classification?
Onboard Wheel Chair (OBW) – First Concept Chair

- Development of Demonstrator for Main Functions (MVP)
- Development of Tests, Test Procedures and Criteria
- Test Execution with two Test Persons (below 95th percentile)

**Test 1: Main Function On-Board Mobility**
- OBW Movement through Cabin
- Evaluation of
  - OBW Maneuverability and Wheel Movement ✓
  - Necessary OBW push / pull forces (qualitative) ✓

**Test 2: Main Function Lavatory Usage Assistance**
- OBW Movement backwards into Lavatory
- Evaluation of
  - OBW Maneuverability into Toilet Compartment !
  - Coverage of Lavatory Bowl by OBW !
  - Position of cut-outs for OBW Rear Wheels ✓
The Hamburg Chair 2 in 1

Thank you so much for the valuable comments we have received after the first Presentation of the Hamburg Chair to the Plenum – provided Aspects:

- Hygiene and Sanitation Concerns in Operation
- Lid Device – Operation of Opening
- Overall OBW Design and Operation
- Padding of Seat and Backrest
- Belts and Straps for safe PRM Movement
- Armrests
- Braked Wheels
- Applicable Loads

Result: Development of a new Concept Chair within 14 days (Functional Demonstrator)
Onboard Wheel Chair (OBW) – Second Concept Chair

- Seat Module
  - Upper Module
- Seat Belt
- Opening (covered)
  - Operation from Behind
- Translational Displacement Mechanism
- Braked & Turnable Wheels
- Rigid Backrest
- Padded Seat
- Supporting Wheels
- Safety Marking
  - FWD Position
- Safety Lever
- Frame Module
  - Lower Module
The Hamburg Chair 2 in 1

Onboard Wheel Chair (OBW) – Second Concept Chair

Position for Function:
On-Board Mobility

Position for Function:
Lavatory Usage Assistance

Two defined OBW Positions
Main Function: On-Board Mobility

Remarks:

- Second assisting Person always necessary
- For Passenger Transport Seat Module must be in most forward Position, secured and Status must be fully identifiable
- Demonstrator with Safety Lever and Safety Marking

*CG – overall CG including CG of Person and CG of OBW
Main Function: Lavatory Usage Assistance

Operation:
- Remove Cover of the Opening outside the Lavatory Compartment (Operation from behind)
- Position OBW backwards direct in front of Lavatory (lower Frame Module in contact with Shroud)
- Brake Wheels then disarm Safety Lever
- Move Upper Seat Module to the very back position (by User or Assistant)
- After Use of Lavatory move Upper Seat Module to the most forward Position (by User or Assistant)
- Arm Safety Lever then release Wheel Brakes
- Position OBW outside in front of Lavatory
- Apply Cover for the Opening (Operation from behind)
- After OBW Check transport Passenger to the Seat
Onboard Wheel Chair (OBW) – Test

Test Persons:
- 2 Female and 1 Male Test Persons
- ca. 80th Percentile, normal stature
- WCH User, all weight-bearing
- Able to hold-up for a short time with Arms and Hands
- Able to walk short distances assisted

Task:
- OBW Lavatory Usability Test for actual Lavatory Layouts
- Using and testing all Lavatory Compartment
  - with OBW
  - without OBW – Walk-In of Test Persons (Group A)

Results & Findings:
- Overall positive OBW Perception
- Lavatories in the rear a/c more suitable (Privacy)
- Area in front of Lavatory needed for OBW Operation - Assistance required
- Improvement of individual Independency
- Narrow Lavatories with Pros and Cons
- Hygienic Aspects comparable to regular Lavatory Usage (adapted Seat Covers)
- Development of Collapsible Mechanism
The Hamburg Chair 2 in 1

Comments from Tests

**Cool. Yes. I can use the Lavatory by myself – alone.**

**It is ok. The Chair is reasonably comfortable.**

**Brakes should be applicable at all wheels simultaneously by the user.**

**You sit well and safe, a handle would be helpful to move yourself.**

**This Chair is better than the other ones. You sit safer. I can do this myself. It is not difficult.**

**The sliding Mechanism works easier than expected. Chair positioning is a bit tricky.**

**The Closeness of the Side Wall of the Lavatory gave me a sense of stability, because I could lean against it.**

**This Chair appears to be wider, more stable and comfortable.**

**At first glance, the Swing made an unsafe impression, but it is no problem when you sit on the Chair.**

**This Chair is far more useful than a lot of Ideas I have been presented before.**
Closing Remarks

- Cantilever OBW as feasible solution for tailored on-board Mobility in Single Aisle Aircraft (Functions: Cabin Mobility and Lavatory Usage Assistance)
- Successful Tests with *Hamburg Concept Chair 2 in 1* and positive Perception as a very useful Item by involved Test Persons
- Discussions regarding Hygiene and Privacy ongoing – Procedures necessary
- Definition of Procedures necessary for safe OBW Operation including usage of Area in-front of Lavatory for Preparation Activities

Benefits for User
- Improvement of On-Board Mobility
- Enhanced Travel Experience

Benefits for Operator
- Better public Image and Enhanced Passenger Service
- Only Minimum additional Workload
- No Changes in Lavatory Design
On-Board Wheel Chairs

Q & A