Modular Boxes
for the Physical Internet

Ass. Prof. DI Dr.techn. Christian Landschützer
Univ.-Prof. Dr.-Ing. habil. Dirk Jodin
DI Florian Ehrentraut

Institute of Logistics Engineering,
Graz University of Technology, Austria
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MODULUSHCA
THE PHYSICAL INTERNET SMART CONTAINER
Physical internet (PI):
- open global logistics system
- physical, digital and operational interconnectivity through encapsulation, interfaces and protocols.
- evolving system driven by technological, infrastructural, business and cultural innovation

Selected needs for PI:
- Adapted physical infrastructure
- Adapted IT infrastructure
- Adapted business models
Objective

Operation in PI with iso-modular logistics units M-box:
- sizes adequate for real modal and co-modal flows of fast-moving consumer goods (FMCG),
- providing a basis for an interconnected logistics system by 2030.

Scope

- Set the landscape by developing core components
- Proof of concept of key components, functions and concepts
- Synchronization of research and implementation projects

Pilots – test runs

- Closed inter-site SC with new M-boxes
- Open network pilot with P&G SC
Role and tasks TU Graz

M-box development with/without modular detachable panels

Scientific Approach:
Functions and requirements
- Storybook
- Surveys
Virtual engineering
- Sizing
- Design
Prototyping
- Rapid prototyping for 1st models
- Production of small series
Testing
- Virtual product development CAE
- Lab testing
Iteration
Sizing the M-box

Method
- Source: product database P&G, Walmart
- 3-dimensional container-loading problem algorithm to define and assign boxes to product spectrum
- Assessment – compared to current situation
  - Fulness, number and sizes of boxes,
  - technical aspects: balanced trailer loading

Results based on 0.8 x 1.2m footprint
- Space usage - optimal set: 440 sizes
- Economically optimal set: 5 sizes
- Prototype set: 2 sizes

Comment
- Results independent from technical realization (unibody, panels)
- See paper (work of Prof. Russell D. Meller – TU Graz)
Engineering design – M-box prototype

Challenges
- Realize the first physical object of the PI
- No product development – demonstrator only
- Cover with budget limitations
- Provide engineering knowledge for further development

Method
- Methodological development VDI 2221ff.
- 3D-CAD design and mock-up for assessment through consortium
- Iteration in design towards CAE insights and lab-tests

Results see next slides
Realization of the M-box

Identification of main functional surface:
- top/bottom

- Modular
- Secured connection via lever (autom. possible) – opening/closing

Unibody design

Panels: further development till 2015

<table>
<thead>
<tr>
<th>M-Box functions</th>
<th>fulfilled now</th>
<th>fulfilled at 2nd gener.</th>
</tr>
</thead>
<tbody>
<tr>
<td>fold unit</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>encapsulate product</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>carry product</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Fold doors/sides</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>combine units</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>stack units</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Distinguish boxes</td>
<td>✗</td>
<td>✔️</td>
</tr>
<tr>
<td>Open/close box</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>include a passive track &amp; trace system</td>
<td>✗</td>
<td>✔️</td>
</tr>
<tr>
<td>Identify contents</td>
<td>✗</td>
<td>✔️</td>
</tr>
<tr>
<td>Handle units</td>
<td>✗</td>
<td>✔️</td>
</tr>
<tr>
<td>withstand normal usage</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Secure box</td>
<td>✗</td>
<td>✔️</td>
</tr>
</tbody>
</table>

KPI - M-box (new prototype design)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer dimensions [in mm]</td>
<td>300x400x300</td>
</tr>
<tr>
<td>Inner dimensions [in mm]</td>
<td>270x360x275</td>
</tr>
<tr>
<td>Volume usage</td>
<td>74.25%</td>
</tr>
<tr>
<td>Weight</td>
<td>4.5kg</td>
</tr>
</tbody>
</table>
How and where to use the M-box

Stapling – unit loads:

<table>
<thead>
<tr>
<th>Unit load building</th>
<th>Parallel</th>
<th>Criss cross</th>
</tr>
</thead>
<tbody>
<tr>
<td>With pallet</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Without pallet</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Handling – unit loads:

- Side clamping (hubs) – PI-forklifter
- Manual: handling equipment

Logistic scenarios – unit loads and single boxes

- Intra-site producer
- Between Hubs
- In shelves – retailer
- Improvements along whole SC
Overall M-box test scenario

First part: supply chain scenario works (VP, PP)

Second part: Modular Boxes work technically, proof of interlocking mechanism (VP, PP)

Third part: develop the innovative concept of the panels from the first ideas to a technical design (VP)

overall proof (virtual and practical) is a result of these 3 different parts.

VP..... virtual proof
PP..... practical proof
M-box Tests

Test procedure

- Structural integrability
  - CAE – virtual
  - Lab tests – real
- Operation of interlocking mechanism
- Handling (fall 2014)
  - Lab tests ergonomics
  - Material handling equipment interaction
  - Everyday use in DC

→ Design iteration:
  sizes, tolerances, materials, assembling
MODULUSHCA conceptual architecture

Spotlights
- Encapsulation: physically, digitally with interfaces
- Integration between existing systems
- Open architecture like TCP/IP

Layers
- I (IP):
  - Handles and delivers M-boxes = MODULUSHCA Logistic Network
  - Built on top of existing logistic systems
  - Managed by involved actors (Poste, P&G)
  - Transport of M-box handled by existing logistic systems

- II (TCP):
  - Manages transportation (grouping unit loads)
  - Interacts with Layer I and IT systems using adapters
    (translate actors own IT to MODULUSHCA)
  - Transport of unit load handled by existing logistic systems
  - Contains information systems
Tasks MODULUSHCA – deliverables

**PI and MODULUSHCA Vision:**
- Scenarios and obstacles
- Strategic roadmap towards interconnected European FMCG logistics

**M-boxes:**
- Sizing and functional specification
- Design and produce prototypes
- Operational benefits
- Standardization recommendations

**Digital interconnectivity:**
- Information needs with interconnected logistics
- Common coding and information format, architecture
- Sensing and communication approach

**Operational scenarios:**
- Demonstration scenarios with interconnected logistics
- Transport planning procedures
- Business models and benefit of interconnected logistics

**Implementation pilots:**
- Test results of M-boxes in inter-site and interconnected transportation systems
Highlights MODULUSHCA

**Improvements**

- Faster delivery – more efficient
- Better asset utilization – fuller cases and trucks
  - In-store: less re-handling, smaller backrooms
  - Truck-transport: at least 9 M-box-sizes (compared to hundreds of carton sizes) can improve truck fullness by 8%
- More agile response to market
- Environmentally, socially and economically more sustainable
- Open protocolled logistics collaboration

**Challenges**

- **Feasability:** integration into existing handling processes with interconnected logistics procedures in parallel.
- **Acceptance:** Willingness of logistics actors is linked to the success in increasing load efficiency and sustainability.
- **Commitment:** Large investments into loading units, handling and transportation assets is needed in order to achieve a critical mass of users.