Who are we?

Team River

ARCH
Ida-Katrine
Aalborg-
Denmark

E
Niklas
Bauhaus-
Germany

E
Jernej
Ljubljana-
Slovenia

MEP
Karen
DTU-
Denmark

CM
Kosuke
Stanford-
USA

CM
Mina
Wisconsin-
USA

LCFM
Julius
Bauhaus-
Germany

Owners

ARCH
Ola
Poland

E
Jacob
Denmark

MEP
Sia
USA

CM
Kristian
Denmark

LCFM
Adrian
Germany
Site: Germany - Weimar
Weimar a city full of history

Goethe: "Home is where you learn"

City investigation

Weimar Castle: Wooden Shutters
Bauhaus University: Mansard roof
Tower: Copper
Ilm park bridge: Cobblestones
Seasonal weather

Outdoor comfort: April to October

- 3 = Extreme Cold
- 2 = Cold
- 1 = Cool
0 = Comfort
1 = Warm
2 = Hot
3 = Extreme Heat
Constraints

- Flooding
- Construction site on slope
- UNESCO World Heritage
- Tree preservation
- Tight Construction Site
- Relocation of pathway
Goals

User friendly

Social sustainability

Environmental sustainability

Flexibility

Energy efficient

Economical sustainability
Goals - Challenges

Resilience

DPR
To industrialize or not to industrialize

IT Challenge
Goals - Certification

- Economic Quality
- Social and Functional Quality
- Technical Quality
- Environmental Quality
- Site Quality
- Process Quality
What are we designing for?

Users: Students and Faculty members

Study Environment
Knowledge by Sharing
User Comfort

Context: Respect
The City
(UNESCO)

UNESCO World Heritage
Utilize Familiar Materials
Utilize Familiar Typologies

Innovation:
Future of teaching

Adaptable Building
IoT
Embracing Changes
Users

Tim Fischer
Research student
- Renewable energy
Use free time with friends

Martin Becker
Professor
- Teamwork and collaboration
Spend free time with family

Tim Fischer
Student
Age: 23
Usage: 8.00 - 16.00

Way of living:

Use of collaboration spaces:

Need for socializing during usage:

Tech skills:
- Software
- Mobile Apps
- IT / Internet

Martin Becker
Professor
Age: 51
Usage: 8.00 - 16.00

Way of living:

Use of collaboration spaces:

Need for socializing during usage:

Tech skills:
- Software
- Mobile Apps
- IT / Internet
Decision Matrix Comparison

Buttercup Natural
- Design: 8.00
- Functionality: 6.00
- Sustainability: 2.00
- Construction issues: -6.00
- Economics: -4.00
- Environmental Aspects: -2.00

Buttercup Hybrid
- Design: 8.00
- Functionality: 6.00
- Sustainability: 2.00
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Linkage Honeycomb-Steel
- Design: 8.00
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Linkage Timber & Concrete
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Decision Matrix Results

Buttercup Natural

Buttercup Hybrid

Linkage Honeycomb-Steel

Linkage Timber & Concrete

<table>
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<tr>
<th>F-Environmental Aspects</th>
<th>E-Economics</th>
<th>D-Construction issues</th>
<th>C-Sustainability</th>
<th>B-Functionality</th>
<th>A-Design</th>
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<tbody>
<tr>
<td>Buttercup Natural</td>
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</tbody>
</table>
"The Buttercup is sparkling light needs the sun to be high in the sky, so May is a good time of year for the flowers.

The buttercup flowers also track the sun. On cold days, the petals make a cup shape like a satellite dish, collecting solar energy from sunshine and warming up the flowers, which makes them even more inviting to insects, perhaps because it helps them to keep up."
Concept Development

A: "Bright, open and inviting spaces"

MEP: "We need to avoid heat gains without compromising daylight"

SE: "More cantilever – More bracings"

CM: "We need to prefab the facade"

LCFM: “Economical and spectacular”

Extrusion of the footprint
More space for insects

Connection to context
Invitation for insects to keep up

Cantilevering for more space
More space for insects

Cup shaped atrium
Warm up the spaces for the insects

Facade optimized for the sun
Less heat gains
Plan 1.5F

Room Legend
- Large classroom
- Lounge

Dimensions:
- 17500 mm
- 17500 mm
- 4000 mm
- 6300 mm
- 11700 mm
- 17500 mm
- 3000 mm
- 4000 mm
A day as Tim and Martin

**Arrive at university:**
- **Time:** 7.50
- **Location:** South / West facade
- **Tim:** By bike
- **Martin:** By car

**Lecture:**
- **Time:** 8.00
- **Location:** Auditorium
- **Tim:** As student
- **Martin:** As lecture

**Research:**
- **Time:** 10.00
- **Location:** Offices / Lounge
- **Tim:** Student office
- **Martin:** Faculty office

**Lunch:**
- **Time:** 12.00
- **Location:** Café / Breakroom
- **Tim:** Café
- **Martin:** Breakroom

**Workshop:**
- **Time:** 13.00
- **Location:** Labs / Classrooms
- **Tim:** As student
- **Martin:** As mentor

**Meeting:**
- **Time:** 15.00
- **Location:** Collaboration areas
- **Tim:** Group work
- **Martin:** Meeting
# A day as Tim and Martin

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Tim: Group work
Martin: Meeting
Future of teaching - IoT

Absorbant vinyl walls
- Optimized acoustics for speaking without mic

Shading windows
- Possible to change window transmittance

Sound screens
- Warn professor of low talking

Application
- Whiteboard access from phone
- Building access from phone
Ray Tracing – Three Analysis

Wall reflection

Ceiling reflection
Ray Tracing – Optimal Solution

Absorbent walls – Louver vinyl combination

Reflective ceiling – Plywood slab
"Worst case of vision – no bad vision"
More efficient and personalized study environment

Avoid contact with germs

All information gathered at one platform

Increase privacy sensitivity
<table>
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Faculty Office
3F West

Student Office
2F North
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- **Location:** Seminar rooms

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  - Martin: Meeting
The future of teaching
Cost Comparison: Server vs. Cloud

- Cloud Computing
- Server Room
A Day as Tim and Martin

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  - Meeting
5xC For The Occupants
Communication Collaboration Cooperation Coordination Conversation
Decision-making: Floor Material

€ 350,000.00
€ 300,000.00
€ 250,000.00
€ 200,000.00
€ 150,000.00
€ 100,000.00
€ 50,000.00

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

End grain  Tiles  O/A Floor
3 Stages of Atrium
Lounge – Presentation - Stage
Rent Reduction: Additional Income

- Base Rent: €930,000.00
- Cloud service: €926,800.00
- Rent Auditorium: €870,000.00
- Rent Café: €835,000.00
- Rent Stage: €811,000.00
Systems

Primary systems

AHU
Heat pump for electric heating
Solar heating panels
SuDS grey water storage

Secondary systems

Displacement ventilation in large volume rooms
Natural night cooling in large rooms
VAV with heat recovery and temperature control
MEP SYSTEM

[Diagram of a MEP system showing various components such as rotary heat exchangers, air return and supply, small and large class rooms, labs, seminar rooms, toilets, local supplier with renewable energy, district hot water tank, solar heating PV panels, domestic heating, compressor, condenser, and expansion valve.]
Zero Energy Building

Own production of solar energy
Electric heating

DISTRICT SOLAR- OR WIND POWER SUPPLY
Electric heating

0 – 20 years

20 years – End of live span

<table>
<thead>
<tr>
<th>ENERGY USE</th>
<th>RENEWABLE ENERGY</th>
<th>REST ENERGY</th>
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<tr>
<td>52,118 kWh</td>
<td>75,446 kWh</td>
<td>+ 23,328 kWh</td>
</tr>
</tbody>
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Rent Reduction: PV Panels

- Base Rent: €930,000.00
- Cloud service: €926,800.00
- Rent Auditorium: €870,000.00
- Rent Café: €835,000.00
- Rent Stage: €811,000.00
- PV Panels: €799,700.00
Energy and Thermal Comfort

Thermal comfort in Large Class room [EN-15251]

- **Occipant hours (%):**
  - 50%
  - 60%
  - 70%
  - 80%
  - 90%
  - 100%

- **Energy Consumption (kWh/m²):**
  - 50%
  - 60%
  - 70%
  - 80%
  - 90%
  - 100%

**Base model**
- Shading
- Better windows
- Hybrid ventilation with night cooling
- Infiltration
- Set point for cooling

- (I) Best
- (II) Good
- (III) Acceptable
- (IV) Unacceptable

**Shading and lower cooling setpoints for thermal comfort**

**Hybrid ventilation for overtemperatures and user control**

**Better windows**

**Less infiltration**
User Comfort

Diffuse ceiling
Low noise level & no draught
Heat panels
Evenly distributed heat panels: 12 % draught versus 20 % draught
DGNB: 10 TLP for not exceeding 0.15 m/s
Hepa filter
Plan 1F

SUPPLY

RETURN

SHAFT

MEP ROOM

HEATING PANELS
Plan 2F & 3F

SUPPLY
RETURN
SHAFT
MEP ROOM
HEATING PANELS
Ducting

2 x AHU on roof

MEP room on 1F
Buttercup - Structure

Floors
- CLT panels
- Concrete Floors

Framing
- Steel and Timber truss
- Glulam beams
- PT beams
- CLT walls

Lateral force resisting system
- CLT Walls
- Framing

Concrete Floors
Plan 3F

**Columns – Glulam [mm]**
- 300x300
- 200x200
- 600x200
- 500x200
- 400x200
- 350x150
- 300x150

**Framing – Glulam [mm]**
- h=600

**Framing – Truss [mm]**
- h=600
Gluelam – Round duct

Implementing truss

Reshaped ducts

Mass: 100%

65%

45%
Section – Student office
Section - Auditorium

600 mm

4195 mm

550 mm
ZERO CLASHES
## Framing Solution – Truss Fire Rating

### Non-coated vs. Coated Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Non-coated</th>
<th>Coated</th>
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</thead>
<tbody>
<tr>
<td>b/h [mm]</td>
<td>150/100</td>
<td></td>
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<tr>
<td>ß [mm/min]</td>
<td>0.7</td>
<td>0.45</td>
</tr>
<tr>
<td>Residual area [mm²]</td>
<td>104</td>
<td>2012</td>
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<tr>
<td>Web steel</td>
<td>S275</td>
<td>Austentic 1.4571</td>
</tr>
<tr>
<td>Reduction factor</td>
<td>0.06</td>
<td>0.23</td>
</tr>
<tr>
<td>Possible fire rating</td>
<td>F30</td>
<td>F60</td>
</tr>
</tbody>
</table>
Auditorium – PT System

17 m
Load Path

- Compression
- Tension
Foundation

Piles
• Bearing soil in ca. 1.5m depth
• Dealing with overturning moment
• Additional uplift force
Deflections – Gravity Load

\[ w_{\text{inst}} = 39.0 \text{ mm} < 46.6 \text{ mm} = l/300 \]

\[ w_{\text{fin}} = 58.3 \text{ mm} < 70.0 \text{ mm} = l/200 \]
Deflections – Large Cantilever

\[ w_{\text{inst}} = 28.8 \text{ mm} \ < \ 35.4 \text{ mm} = l/150 \]
\[ w_{\text{fin}} = 43.1 \text{ mm} \ < \ 53.2 \text{ mm} = l/100 \]
Deflections – Lateral Load
Vibrations

CLT floor
H = 87 mm
SLS vibrations span: 3.2 m

Floor – truss - system
Lx = 4.25 m
Ly = 5.6 m
a = 2.125 m

<table>
<thead>
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<th>limit</th>
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<tbody>
<tr>
<td>Frequency f1</td>
<td>23.21</td>
<td>&gt; 8 Hz</td>
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<tr>
<td>Vertical initial deflection</td>
<td>0.128</td>
<td>&lt; 0.5 mm/kN</td>
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<tr>
<td>Unit pulse velocity</td>
<td>0.87</td>
<td>&lt; 21.95 mm/Ns²</td>
</tr>
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</table>
Flexible Floor Plans

Permanent walls

Flexible walls
## Interior Semi-Movable Wall Prefab

### Technical aspect

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Risk</th>
<th>Reward</th>
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<tbody>
<tr>
<td>Cross disciplinary integration (5%)</td>
<td>-</td>
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<td>2.0</td>
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<tr>
<td>Re-use of experience (5%)</td>
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<td>2.0</td>
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<tr>
<td>Feasibility of suppliers (10%)</td>
<td>-</td>
<td>2.0</td>
</tr>
<tr>
<td>Maintainance cost reduction (5%)</td>
<td>-</td>
<td>2.0</td>
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<tr>
<td>Construction defect reduction (5%)</td>
<td>-</td>
<td>2.0</td>
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<tr>
<td>Overall (100%)</td>
<td>0.30</td>
<td>1.25</td>
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**Risk** vs **Reward**

### Interior Semi-Movable Partition: High risk -2 ~ +2 High reward (weight)

- Cross disciplinary integration (5%)
  - Risk: 2.0
  - Reward: 1.5
- Schedule reduction (15%)
  - Risk: 2.0
  - Reward: 1.0
- Material cost reduction (10%)
  - Risk: 2.0
  - Reward: 1.0
- Installation cost reduction (20%)
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  - Reward: 1.0
- Construction defect reduction (5%)
  - Risk: 2.0
  - Reward: 1.0
- Overall (100%)
  - Risk: 0.30
  - Reward: 1.25

---

*G A E M CM LC*

*Interior Semi-Movable Wall Prefab*

*Lindner Building New Solutions*
From University

To Hospital
Pandemic – Need for beds

Assessment Flow

Hospital plan

1.5F Floor

3F Floor

Room Legend:
- Large classroom
- Lounge
- Server room

Staff office/sleep

Nursing
Isolation
Break room
Meeting room
Shower
Flexibility, clean air and surfaces

- Flex ducts - movable
- Hand disinfectant
- VAV - control
- Negative air change rate
- AHU
- Hepa filters
- Easy cleanable surfaces
Covering Cost during Pandemic

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<th>LCC</th>
<th>Hospital</th>
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</table>

The graph shows the cost distribution from January to December, categorized by Income, LCC, and Hospital.
<table>
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</tbody>
</table>

**Identify facility and clinical partner and negotiate agreements with governmental entities and stakeholders.**

**Form joint clinical, design and implementation team and identify leader.**

**Mobilize, identify objectives, organize team and assign responsibilities.**

**Remove unnecessary furniture and loose materials in the classroom and others. Desks may be used as bedside tables. Window coverings may remain.**

**Equip each classroom with necessary patient care supplies and equipment. (may have to use non-traditional equipment based on availability)**

**Set up hand cleaning stations and personal protective equipment stations outside of each classroom, and inside if enough are available.**

**Prepare support service areas with workstations, supplies, equipment, and extra prep areas etc.**

**Prepare conference or meeting rooms to function as Command Center by setting up office spaces, phones, printers, scanners, etc.**

**Evaluate electrical services and modify/implement plans. Ensure electrical load in each classroom is provided. Consider auxiliary power for HVAC systems.**

**Where needed, subdivide multi-stall toilets into female and male sections.**

**Assesses WiFi capabilities and modify/implement plans.**

**Evaluate the need to adapt any other technology systems and modify/implement plans.**

**Evaluate mechanical systems for individual rooms and large areas and modify/implement plans.**

**Set up a portion of other room for step-up care with available beds, portable medical gases, enhanced electrical availability, equipment and supplies.**

**Identity and prepare a morgue area**

---

*This part can be included in the design of the building, so no major work is required when it is converted to a hospital.*
Flood Protection

Stage 1  
*SuDs Roof*

Stage 2  
*Landscape*

Stage 3  
*Flood Walls*

Stage 4  
*Flooded Building*
Climate Effects on Germany

- 15% ↑ River discharge
- 25% ↑ Winter precipitation
- ↑ Average number of days with heavy precipitation in winter
- 15% ↓ Summer precipitation

Coastal flooding
Flash flooding
Significant population growth

<table>
<thead>
<tr>
<th>Climate impact</th>
<th>Climate signals</th>
<th>Present</th>
</tr>
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<tbody>
<tr>
<td>River flooding and flash floods</td>
<td>River flooding, flash floods (heavy rain)</td>
<td>Near Future: Weak change</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Near Future: Strong change</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distant Future: +</td>
</tr>
</tbody>
</table>

Source: Adelphi, October 2015, [http://www.umweltbundesamt.de/publikationen/vulnerabilitaet-deutschlands-gegenueber-dem](http://www.umweltbundesamt.de/publikationen/vulnerabilitaet-deutschlands-gegenueber-dem) (03.05.2020)
Drone to Topography

Restricted condition
Accurate topo
Optimized Flooding protection

Dynamo

Restricted condition
Accurate topo
Optimized Flooding protection

Drone to Topography

Restricted condition
Accurate topo
Optimized Flooding protection

Dynamo

Restricted condition
Accurate topo
Optimized Flooding protection

Dynamo

Restricted condition
Accurate topo
Optimized Flooding protection

Dynamo
Flood Protection

Stage 1  
*SuDs Roof*

Stage 2  
*Landscape*

Stage 3  
*Flood Walls*

Stage 4  
*Flooded Building*
Water circulation in building

- Domestic water
- Grey water

Storage of 180 m³ water in 24 hours

150 m³ sprinkler tank
STV – Water consumption

Stage 1
SuDs Roof
Green Roof – Wild Vegetation

White Clover
Maintain soil ecosystem

Cone Flower
Maintain bugs ecosystem

Carpet Moss
Water absorbent base

Texas Sedge
Water draining base
Smart Roof Design Cost Comparison

- Solar panel
- Blue roof
- Insulation
- Sealing
- Smartex monitoring system
- CLT slab

*PROGEO®*
we provide confidence

Stage 1
SuDs Roof
Roof unitization

Design Spec.
Panels number = 112
Panel thickness = 494mm
Size 1 = W2.4 x L3.6m
Size 2 = W2.4 x L3.9m
Weight (typ.) = 1.9 tons

Connections
Roof unitization with solar panels

<table>
<thead>
<tr>
<th>Technical aspect</th>
<th>(2.0)</th>
<th>(1.0)</th>
<th>1.0</th>
<th>2.0</th>
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<tr>
<td>Cross disciplinary integration (5%)</td>
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<td>Schedule reduction (15%)</td>
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<tr>
<td>Material cost reduction (10%)</td>
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<tr>
<td>Workflow on site (10%)</td>
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<tr>
<td>Transportation reduction (5%)</td>
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<tr>
<td>Temporary work reduction (10%)</td>
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<tr>
<td>Re-use of experience (5%)</td>
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<tr>
<td>Feasibility of suppliers (10%)</td>
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<tr>
<td>Maintainance cost reduction (5%)</td>
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<tr>
<td>Construction defect reduction (5%)</td>
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<tr>
<td>Overall (100%)</td>
<td>(0.20)</td>
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- +47 Trucks needed
- 58% Time saving
- 36% Reduction
- 1 crew needed
Roof Unitization w/o solar panels

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<td>Overall (100%)</td>
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<td>(0.15)</td>
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</tbody>
</table>

- Risk
- Reward

Stage 1
SuDs Roof

- +5 Trucks needed
- 75% Time saving
- 46% Reduction
- 2 crew needed
Flood Protection

Stage 1
SuDs Roof

Stage 2
Landscape

Stage 3
Flood Walls

Stage 4
Flooded Building
Stage 2 - Landscape

Before

During

Stage 2
Landscape
Landscape
Entrance

Plaza
Tree Relocation

- Environment
- Landscape design
- Shading
- Flooding

Stage 2
Landscape

<table>
<thead>
<tr>
<th>Protection</th>
<th>Relocation</th>
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<tbody>
<tr>
<td>12 nos</td>
<td>6 nos</td>
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</table>
Flood Protection

Stage 1: SuDs Roof
Stage 2: Landscape
Stage 3: Flood Walls
Stage 4: Flooded Building
Stage 3 – Walls response system

Before

Aluminium flood wall

200 y flood

Robustness

Performance

Rapidity, Responsiveness

Flood Protection

Stage 1
SuDs Roof

Stage 2
Landscape

Stage 3
Flood Walls

Stage 4
Flooded Building
Stage 4 – Interior Materials

Non-paper faced gypsum board
Paper faced gypsum board
Structural timber
Plywood - treated
Cement board
Concrete block
Plaster
Oriented strand board (OSB)
Wall panels - OSB
Wall panels – Plywood
Structural Steel

Acceptable
5 Highly resistant to flood water damage, including damage cause by running water
4 Resistant to flood water damage from wetting and drying, less durable when exposed to moving water

Unacceptable
3 Resistant to clean water damage, but not flood water damage
2 Not resistant to clean water damage
1 Not resistant to clean water damage or moisture damage

Protection of MEP appliances

- Redundancy/modularity
- Learning/memory, forseight
- Connectivity and safe-failure

Flooding Impact on Risk Charge

Base Risk Charge: 155,000 €
Façade elements

Grid elements
Prefabrication
Weimar typology

Evy plants
Protects facade
Student environment

Louver shading
Prevent overheating

Rain chains
Protect facade
Utilizing water for plants
Facade Design for Construction

Design Spec.
Panel thickness = 494mm
Size (typ.) = W1.5xH3.7m
Weight (typ.) = 0.9 tons
U-value = 0.129 W/m²K
Green house gas potential:
-150 kg CO₂ Eq./m²
Façade Modular Design

Total 230 pcs
- Typical: 183 (79%)
- Special: 47
Façade Prefabrication Assessment

Modular Façade High risk -2 ~ +2 High reward
(weight) (2.0) (1.5) (1.0) (0.5) - 0.5 1.0 1.5 2.0

Cross disciplinary integration (5%)
Schedule reduction (15%)
Material cost reduction (10%)
Installation cost reduction (20%)
Workflow on site (10%)
Transportation reduction (5%)
Temporary work reduction (10%)
Re-use of experience (5%)
Feasibility of suppliers (10%)
Maintainance cost reduction (5%)
Construction defect reduction (5%)
Overall (100%)

Schedule 36 days saved
Site Labor cost EUR 470,000 saved
Louver Design
Louver Optimization – Rhino

SOUTH FACADE

WEST FACADE

LOUVER PROFIL

REDUCED RADIATION (kWh)

LOUVER PROFIL

REDUCED RADIATION (kWh)
Louver Optimization

Option nr 5
- 14 X
- 100 mm
- 20 mm

Option 8
- 10 X
- 150 mm
- 20 mm

Option 11
- 6 X
- 200 mm
- 20 mm
Louver Optimization - Angle

45 degrees

25 degrees
Ivy and copper chains
Interesting façade expressions

West

East

North

South
CONSTRUCTION
Site Logistics - Accessibility

Maximum Truck Width = 2.5 m
Minimum Road Width = 3.5 m
Site Logistics Plan

Construction Area
H=3.0m fence

Semi-Construction area
H=1.2m fence
Floor Layout Optimization

- Crane position
- Panel Layout/Direction
- Crane spec
- Cost
- Duration

Dynamo

Generative Design Primer

AUTODESK REVIT

G A E M CM LC
Crane Optimization

Find the best position of tower crane

Crane capacity

Crane position

Generative Design Primer
### Bathroom Prefab

#### Spec (9 unit)
- **W1.8 x D2.9 x H2.7**
- **Wall/Ceiling**: 1.5ton
- **MEP**: 0.5ton
- **Reinforce**: 0.1ton
- **Sum**: 2.1ton

#### Cost
- **EUR/m2 saved**: 350

#### Technical Aspects

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Risk</th>
<th>Reward</th>
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<tbody>
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<td>Maintenance cost reduction</td>
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<tr>
<td>Overall (100%)</td>
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<td>1.15</td>
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</table>

**Risk vs. Reward**

- Bathroom box: High risk -2 ~ +2 High reward

---

**Cost 350 EUR/m2 saved**
### ALICE 4D simulation

#### Snowing Season

<table>
<thead>
<tr>
<th>Weeks</th>
<th>Workday (Outside)</th>
<th>Workday (Inside)</th>
<th>Milestone</th>
<th>Temporally works</th>
<th>Construction</th>
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<tr>
<td></td>
<td>4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 3 4 4 4 4 4 4 4 3 3 3 4 4 4 4 4 4 4 4 4 4 4 4 4</td>
<td>5 5 5 5 5 5 4 5 5 5 5 5 5 5 5 5 3 5 5 5 5 5 5 5 5 5 5 5 5 5 5</td>
<td>▼ Commencement • Excavation start ▼ Start Superstructure ▼ Topping up ▼ Power receive ▼ Completion ▼</td>
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<td></td>
<td>Preparation</td>
<td>Tower crane 4.5</td>
<td>▼ Complete Façade</td>
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<td>Substructure</td>
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<td>Superstructure</td>
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<td></td>
<td>Roofing</td>
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<td></td>
<td>Ext. Finishing</td>
<td></td>
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</tr>
<tr>
<td></td>
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<td></td>
<td>Int. Finishing</td>
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<td></td>
<td></td>
<td></td>
<td>Commissioning</td>
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</tbody>
</table>

#### Milestone

- ▼ Commencement
- ▼ Excavation start
- ▼ Start Superstructure
- ▼ Topping up
- ▼ Power receive
- ▼ Completion

#### Temporally works

- Tower crane 4.5
- ▼ Complete Façade

#### Construction

- Preparation
- Substructure
- Superstructure
- Roofing
- Ext. Finishing
- Int. Finishing
- Commissioning

#### Avg. Utilization (%)

- Crew Utilization
- Avg. Crew Utilization
- Avg. Days Worked
- Calendar Days
- Working Days
- 229 Days £2,193,223.76
- Project Cost Distribution
- 47%
- 33%
- 48%
- 48%
- 93%
- 36%
- 48%

#### 152 days
Identification of logistic bottlenecks

Peak workflow

- CLT Floors RF Z3
- Erection [Facade_Z3_2F_E]
- Erection [Facade_Z3_2F_S]
- SOG-Z1
- Erection [Facade_Z3_3F_N]
- Erection [Facade_Z3_3F_S]

Truck for facades modules

Concrete pump and mixer

Truck for roof panels

23rd Nov.
Simulation of construction peak flow
4D Simulation of construction plan
Target Value Design

- Budget Value is 8.69 MEUR
- Target Value is 8.21 MEUR

<table>
<thead>
<tr>
<th>Cost (EUR)</th>
<th>Area (sqm)</th>
<th>Cost/Area (EUR/sqm)</th>
<th>Cost/Area ($/SF)</th>
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<tbody>
<tr>
<td>8.210.000</td>
<td>3000</td>
<td>2831</td>
<td>288</td>
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</tbody>
</table>

European Construction Cost
Construction Cost Calculation

BIM Model

Cost database

High Level cost estimate input
- European Construction Cost
- Reference Projects
- RS Means

Detailed cost estimate input
- VAT of 19% included
- Cost database from a German Contractor Company
- Cost estimator mentor and apply a Location factor
- RS Means and apply a Location factor

Quantity takeoff

TVD Sheet
Construction Cost Tracking

Target Value is 8.21 MEUR

- Cost Guestimate: EUR 6,591,700
- Excavation work: EUR 7,582,600
- Substructure: EUR 7,243,600
- Interiors & Core walls: EUR 7,690,000

More reliable cost estimate
More developed design
Glulam Framing to trusses
Detailed facades design
Finishes + Ceiling
Flood Protection
Landscaping
Fire-rated walls
LCFM
LCC Distribution

Total LCC: €19,178,000
LLCR & DSCR development

IRR: 11.8 %
## DGNB – Conclusion

<table>
<thead>
<tr>
<th>Criteria</th>
<th>This is how we do</th>
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<tbody>
<tr>
<td>ENV1.1 Life-cycle Assessment</td>
<td></td>
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<tr>
<td>ENV2.1 LCA primary energy</td>
<td>PV panels &gt;75,000 kWh p.a.</td>
</tr>
<tr>
<td>ENV2.2 Potable water demand and wastewater volume</td>
<td>Blue roof &amp; rainwater collection</td>
</tr>
<tr>
<td>SOC1.1 Thermal Comfort</td>
<td>EN-ISO-7730</td>
</tr>
<tr>
<td>SOC1.2 Indoor Air quality</td>
<td>Co2 concentration &lt;900ppm</td>
</tr>
<tr>
<td>SOC1.4 Visual Comfort</td>
<td>Daylight factor &gt;2.5</td>
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<tr>
<td>SOC1.6 Quality of outdoor area</td>
<td></td>
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<tr>
<td>SOC2.3 Cyclist Facilities</td>
<td>120 Bicycle stands</td>
</tr>
<tr>
<td>SITE1.1 Local environment</td>
<td></td>
</tr>
<tr>
<td>PRO2.1 Construction site</td>
<td></td>
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</tbody>
</table>
Winter presentation
Excavation
From gluelam beams to trusses
Blue roof

GWP (kgCO2e)  Energy (MJ)  Water (kg)
Resilience Challenge

- From university to hospital

1. Flexible room layout
2. Flexible furniture and storage facilities
3. Sanitation given (easy to clean)
4. Controllable HVAC system w. HEPA filter
5. Disable access

- Living with the flood

1. Dependence on local ecosystem
2. Co-benefits
3. Spatial/functional diversity
4. Robustness
5. Performance
6. Rapidity, Responsiveness
7. Redundancy/modularity
8. Connectivity and safe-failure
9. Learning/memory, foresight
DPR Challenge

Metrics for Risk and Reward

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<th>Logistics</th>
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</tr>
<tr>
<td></td>
<td>Defect reduction (5%)</td>
</tr>
</tbody>
</table>

Façade Modularization
- Reduce cost, time, and wastes
- Hard to transport in a restricted site
- Additional framing required

Roof Unitization
- Reduce cost, time, and wastes
- Hard to transport in a restricted site

Panelizing Floors
- Crane Optimization

Toilet Prefabrication
- Reduce cost, time, and wastes
- High quality
- Hard to transport in a restricted site
- Additional framing required

Interior Partitioning
- Increase operability and flexibility of the building
IT Challenge

Façade design

- Visualization (Enscape)
- Modeling (Revit)
- Parametric Modeling (Grass Hopper)
- Sunlight analysis (VELUX)
- Heating analysis (IDA ICE)
- Virtualization (Iris VR)
- Cost (Excel)
- Kit of parts (KGCennect)
- Construction detail (Sketchup)
- Scheduling (Alice)
- Solar panel analysis (Be18)

Construction design

- Modeling (Revit)
- Visual Programming (Dynamo)
- Optimization (Ritney)
- Structural analysis (Diubal)
- MEP integration

Flooding protection

- Map (Google earth)
- Simulation (Infra Works)
- Topo mech (Dynamo)
- Modeling water level (Revit)

Analytical Discipline

Geometric Analytical Discipline

Analytical Discipline

 MEP integration

Analytical Discipline
Collaboration-Pile
How did VR impact Design?

Disciplinary Problem Solving

Cross disciplinary clash detection

Space Utilization

Running Simulations

ENJOY AND HAVE FUN TOGETHER !!!
Team Protocols & Practices: BEP

- Understanding Beam-Column Connections
- Model according to construction sequence
- Evolving from a BIM Manager team to a Strong BIM Team
- Floor-Wall-Bram Connection
- Model Truss as 1 piece
Project Management

Working hours vs. Meeting

<table>
<thead>
<tr>
<th></th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave. Working hours/wk</td>
<td>21 hours</td>
<td>27 hours</td>
</tr>
<tr>
<td>Ave. Meeting hours/wk</td>
<td>9 hours</td>
<td>12 hours</td>
</tr>
<tr>
<td>Depend Meeting %</td>
<td>41%</td>
<td>44%</td>
</tr>
<tr>
<td>Ave. Meeting Times/wk</td>
<td>3.7 times</td>
<td>4.4 times</td>
</tr>
<tr>
<td>Ave. Sub Meet/wk</td>
<td>6 times</td>
<td>12 times</td>
</tr>
<tr>
<td>Meeting /working hours @</td>
<td>2.1 hours</td>
<td>1.7 hours</td>
</tr>
<tr>
<td>Rework Rate</td>
<td>19%</td>
<td>11%</td>
</tr>
</tbody>
</table>

Total working hour of each discipline

- A: 21%
- E: 24%
- MEP: 17%
- CM: 27%
- LCFM: 10%
THANK YOU

Lecturer, Super Owner:
Dr. Renate Fruchter

Owners:
Adrian Koeve
Jacob Olsen
Kristian Brink
Ola Sobczyk
Sia Wang
Lessons Learned

"Golden discipline work does not equal golden teamwork."

"It's easy to throw ideas in the air, but difficult to grab them."

"I like it, but...!"

"Make sure everyone is up to date."

"You are never completely done."

“Coordination is the key to reduce the hours of rework."

"Yes, that’s what I need!"