Physical or Virtual?
Effectiveness of virtual mockups of building envelope systems

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Mock-up

A mockup of a building envelope is a replica of what will go on the building face – façade – including vertical and horizontal exterior planes.
Physical mockups

Performance Mockup & Testing

Field Mockup & Testing
Issues addressed by Mockups

- **Constructability / Assembly** – sequencing of work, transitions between planes and different materials, and corners of components.

- **Structural performance** – testing of structural connections

- **Environmental performance** – testing of thermal, air and moisture infiltration and exfiltration.

- **Planning** – effective coordination and collaborations, and scheduling.
Types of Mockups

- Visual Mockup – design focused review
- Prototype Mockup – problem solving review
- Performance Mockup – performance validation review
- Field Mockup – constructability review and precedence
- In-place Mockup – establish precedence of assembly
- Virtual Mockup – design/fabrication/constructability study review
Custom-built Curtain Wall
Prototype Mockup
Building Envelope Commissioning & Role of Mockups

- Building envelope commissioning - “all projects need some level of commissioning to perform at their best”

- Commissioning = quality control.

- Mockup and Testing highly encouraged at pre-construction phase for quality assurance.
Level of Development (LOD)

- LOD 100 – During conceptual design phase: model elements are shown as conveying information of volume, area.
- LOD 200 – Design and model elements have more definitions: models of generalized systems.
- LOD 300 – Construction information of generalized system is inserted into the model. Suitable to generate traditional construction documents.
- LOD 400 – Virtual representation of specific systems and direct translation with construction and fabrication.
- LOD 500 – Model is accurate to how the building was built (as-builts).
Designer understand constructability and parameters/limitations of fabrication and construction earlier
Virtual Mockup integrated with design tools. Physical Mockup a validation tool.
Considerations for mock-up selection

1. the building envelope systems (**ENVELOPE**)
   – Conventional / Custom ?

1. when and how to use mockup (**TIME/SCHEDULE**)
   – Project conditions / schedule

1. costs of mockups (**COST**)
   – Owner requirements and expectations under known (1) and (2).
Curtain Wall part

Detailed Drawing

Coordinated model 1

Based on detailed analysis,
> Find optimal materials or curtain wall type
> Create more similar virtual environment with the real building
> Provide fundamental sources for energy analysis
> Support creating detailed shop drawing

Inventor (skin+blgd) + MEP
- Detailed Clash detection
- Shop drawing
- Simulation

Inventor (skin) + Revit (bldg) + MEP
- Geometry use
- Clash detection

Inventor (skin+blgd)
- Energy Analysis - Revit
  - Need gbXML export directly!
- Energy Analysis
- Easy collaboration
- Shop drawing
- Still difficulty to data exchange with Inventor

Inventor (skin) + Revit (bldg)
- Create skins in Revit with Inventor file
- Energy Analysis
- Not support Shop drawing

- Energy Plus, e-quest
- Green building studio, Ecotect
- WUFI
- IDA, Design Builder
- THERM, WINDOW
- COMCHECK

HAM Stress Structural Analyses

BIM-driven

Coordinated model 2

Scheduling/Cost

Planning Coordination

Virtual Mockup
Scenario A

Performance mockup most probable with review of envelope systems before construction documents completed.

Scenario B

Field or in-place mockups more likely with Contractor driving the process.

Scenario C

Integrated Team Approach (IPD) where virtual mockups would play beneficial role in cross-collaborations over disciplines.
Virtual mockups allow for **in-depth high-level detail study** of building envelope systems and their interfaces without the high cost burden of some physical mockups. Physical mockups are undeniably beneficial, and more so with a **well-resolved or atypical system**, however excessive use of these mockups can be better controlled and intelligent choices of mockup selection can be made based on **awareness of versatility of various mockup types** within project parameters (building envelope, time/schedule and cost).

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THANK YOU.

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