Additive Manufacturing in Construction
2nd funding period: The Opportunity for Large Impact

AMC TRR 277

C06 — Integration of Additive Manufacturing into a Cyber-Physical Construction System

Prof. Dr. P. Schwerdtner, G. Placzek
Prof. Dr. M. Gerke, Dr. M. Maboudi, K. Mawas
Prof. Dr. sc. (ETH) N. Hack, C. Jantzen

Institute of Construction Engineering and Management (IBB),
Institute of Geodesy and Photogrammetry (IGP),
Institute of Structural Design (ITE),
TU Braunschweig

Project aims of 2nd funding period

- Exploration of Cyber-Physical design and manufacturing strategies for high-quality Additive Manufacturing
- Interactive data exchange in a Cyber-Physical Construction System
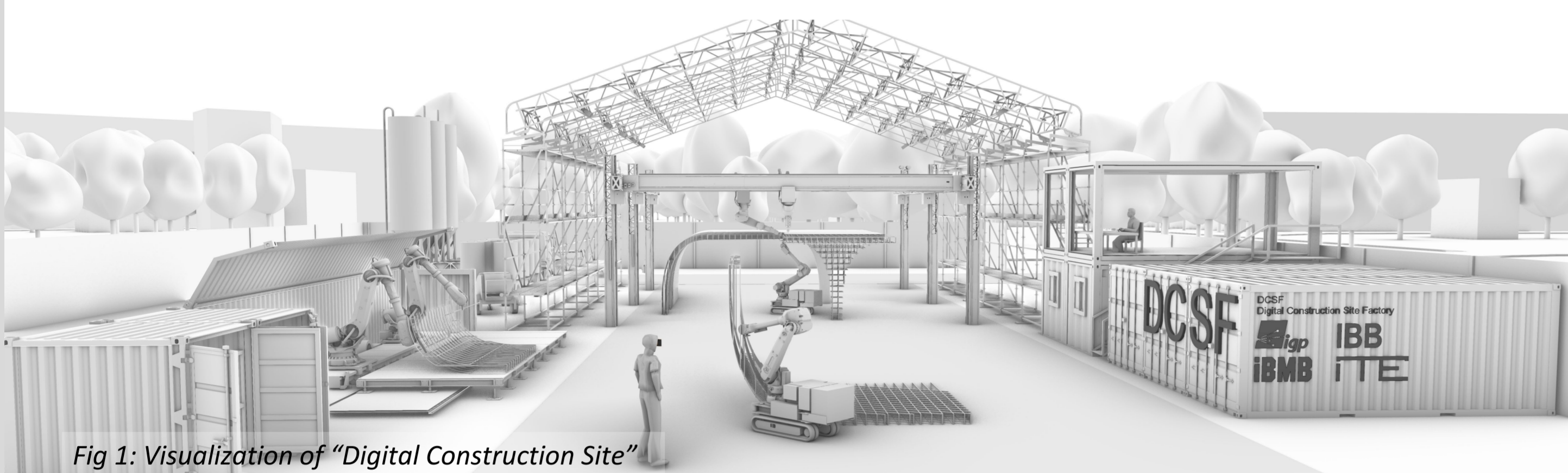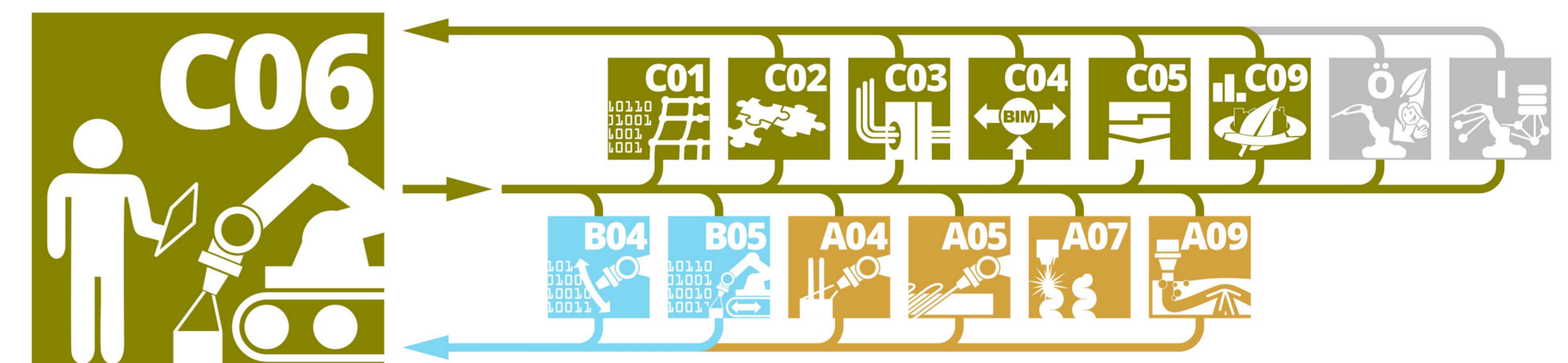- Productivity analysis via optical tracking systems

Fig 1: Visualization of "Digital Construction Site"

Key collaborations in 2nd funding period

- **A04, A05 and C04:** Multi-Level-FIM, construction site layout for in situ and on-site production
- **B04 and B05:** Robot localization, 3D-surface measurements and cooperative in situ application of mobile robots
- **C09:** Database for process parameters for Life Cycle Assessment
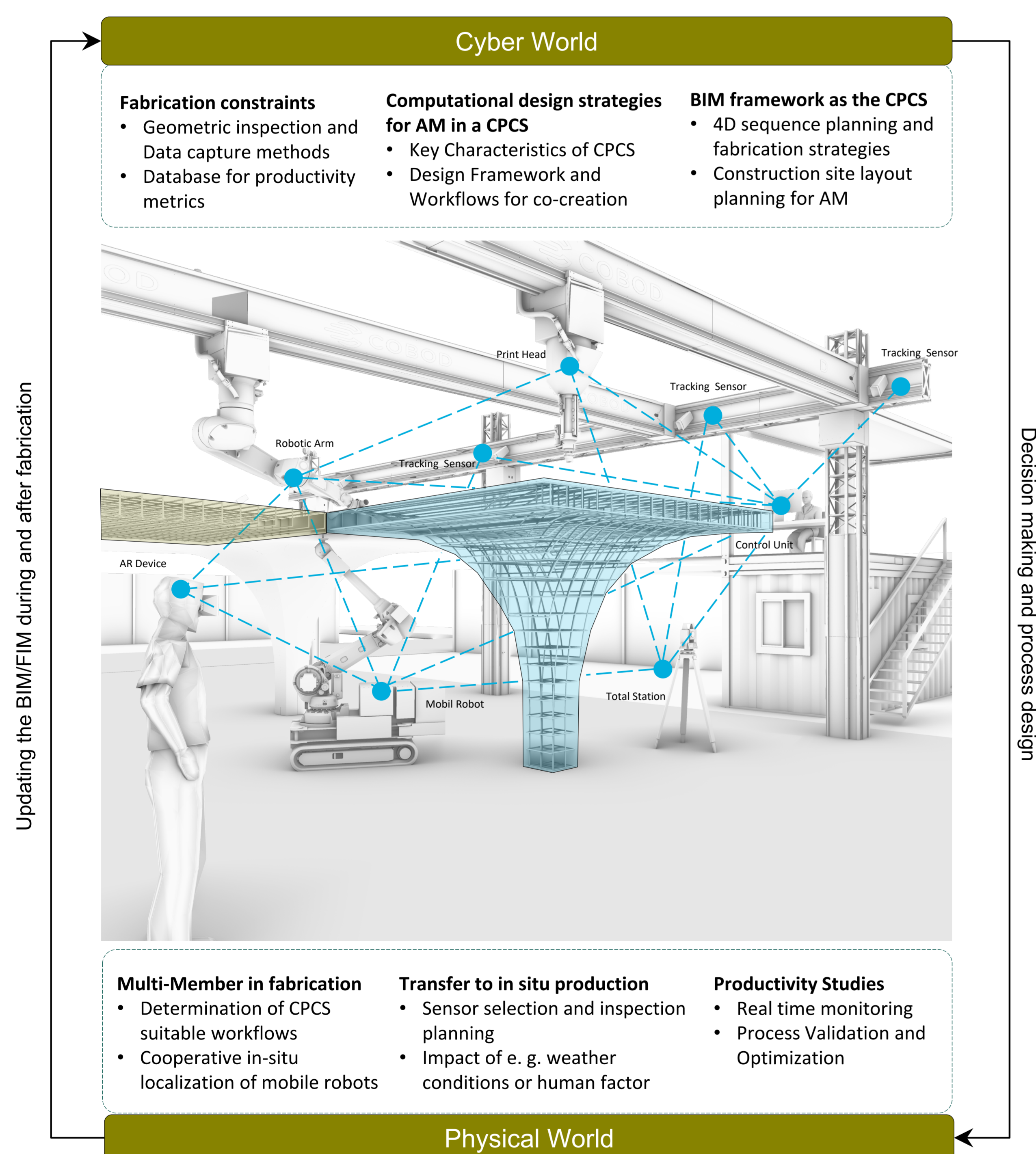
Cyber-Physical Construction System

Cyber World

Fabrication constraints
- Geometric inspection and Data capture methods
- Database for productivity metrics

Computational design strategies for AM in a CPCS
- Key Characteristics of CPCS
- Design Framework and Workflows for co-creation

BIM framework as the CPCS
- 4D sequence planning and fabrication strategies
- Construction site layout planning for AM

Print Head · Tracking Sensor · Tracking Sensor · Robotic Arm · Tracking Sensor · Control Unit · AR Device · Mobil Robot · Total Station

Updating the BIM/FIM during and after fabrication

Decision making and process design

Multi-Member in fabrication
- Determination of CPCS suitable workflows
- Cooperative in-situ localization of mobile robots

Transfer to in situ production
- Sensor selection and inspection planning
- Impact of e. g. weather conditions or human factor

Productivity Studies
- Real time monitoring
- Process Validation and Optimization

Physical World

Fig 2: Cyber-Physical Construction System (CPCS)

Work programme

WP 1 Design and assessment for AM elements in a Cyber Physical Construction System (CPCS)

WP 1.1 (ITE) Integrated Computational Design Strategies for a CPCS

WP 1.2 (IBB) AM Process Metrics for Productivity Diagnostic and Assessment

WP 1.3 (IGP) Integration of Geometric Inspection and Digital Twinning in Design and Construction

WP 1.4 (All) Modifications of the CPCS to the specific AM-construction tasks

WP 2 From Product-to-Process: Strategies and System Architecture of the CPCS for AMC

WP 2.1 (IBB) Progress Management of AM and Assembly Processes

WP 2.2 (IGP) Sensor Selection and Inspection Planning

WP 2.3 (ITE) Fabrication Strategies for distributed AM in the CPCS

WP 3 CPCS-based Additive Manufacturing of Element Systems

WP 3.1 (ITE) Implementation of a Multi-Member Fabrication Workflow in a CPCS

WP 3.2 (IGP) Multi Member Localisation

WP 3.3 (IGP) Feedback Loop and Digital Twinning

WP 3.4 (IBB, IGP) Supervision and Controlling
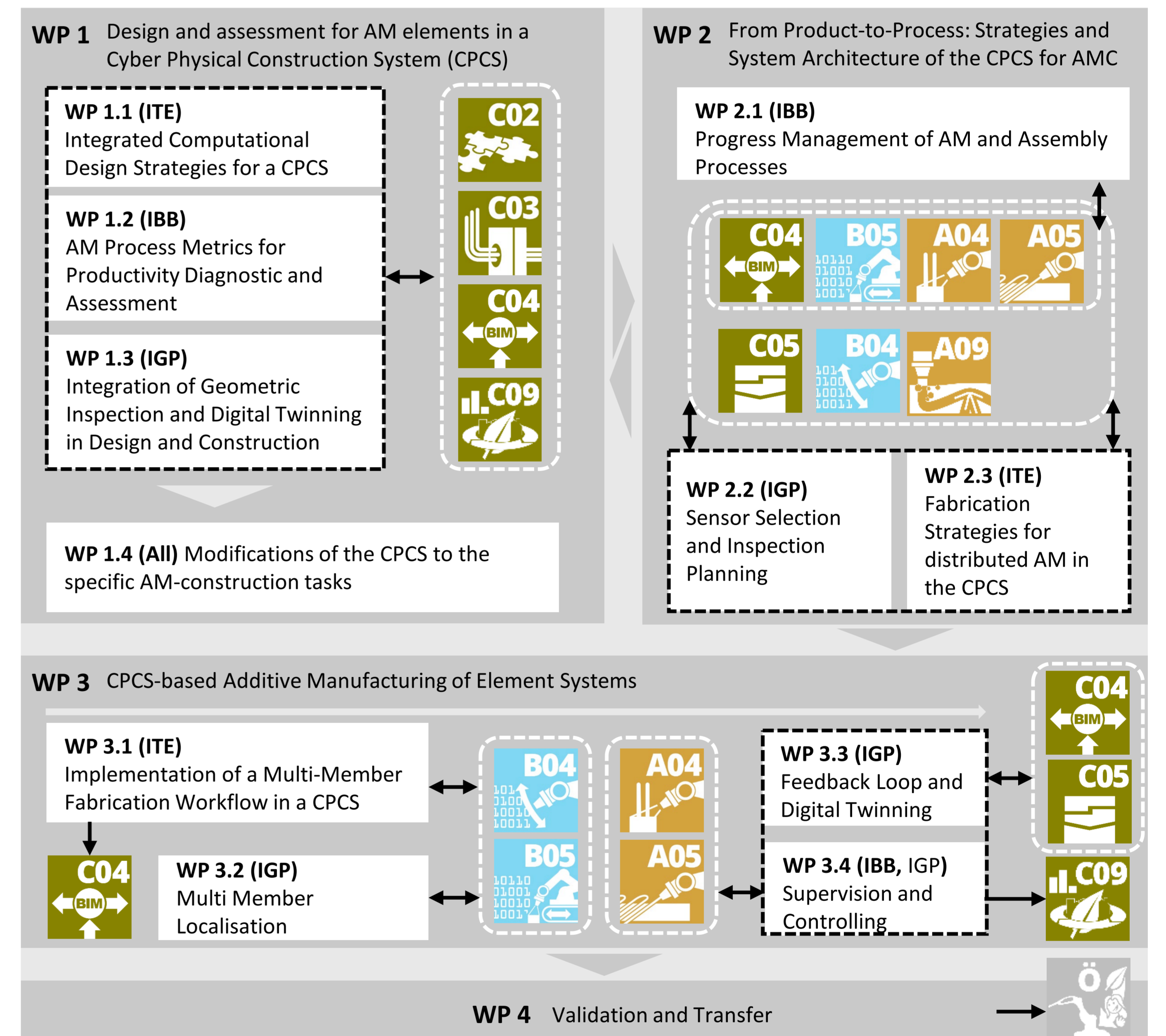
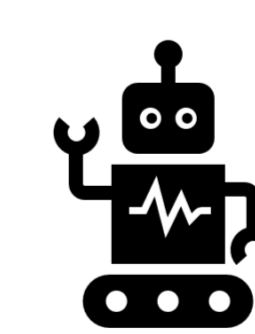**WP 4** Validation and Transfer

Fig 3: Work Package Flow Chart

Exemplary research questions

- What are the CPCS-specific workflows from design to manufacturing, where the constraints of materials, fabrication and assembly are considered from the outset?
- How can efficient and accurate quality control, as well as documentation methods be defined within a digital construction environment?
- What are the impacts of in situ/on-site conditions (e. g. weather, human factor) on AM-based production processes and how can they be measured and controlled?

Main challenges

Large scale experiments   **Level of automation**   **Interoperability**

Outlook 3rd funding period

- To extend the **variety of production processes** (AM and traditional construction methods, assembly integration)
- To create a self-learning system that considers all **three dimensions** of sustainability