Research in Construction at Fraunhofer

Stuttgart, October 15th, 2007

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Fraunhofer Institute for Industrial Engineering IAO, Stuttgart (Germany)

www.iao.fraunhofer.de

www.rdm.iao.fraunhofer.de
www.oic.fraunhofer.de
Overview

1. Fraunhofer and Fraunhofer IAO
2. Building Research at Fraunhofer
3. Integrated Planning and ICT in Construction
4. Technology Monitoring in Construction
5. Fraunhofer Vision: Some Trends in Building Research
1. Signposts to tomorrow’s markets

Definition of 12 Lead Innovations for future markets

- Internet of things
- Smart products and environments
- Micro power engineering
- Adaptronics
- Simulated reality: Materials, products, processes
- Human-machine interaction
- Grid computing
- Integrated lightweight construction systems
- White biotechnology
- Tailored light
- Polytronics
- Security
1. Profile of Fraunhofer-Gesellschaft
www.fraunhofer.de

Founded: 1949

12,500 employees

80 research institutes, of which 58 operate as independent profit centres

Annual research budget: 1.1 billion euros*

Including approx. 1 billion euros for contract research*

Fraunhofer International
  Europe: Brussels (Belgium)
  USA: Boston (Massachusetts), Pittsburgh (Pennsylvania), Plymouth (Michigan), Providence (Rhode Island), College Park (Maryland), Peoria (Illinois)
  Asia: Beijing (China), Singapore, Jakarta (Indonesia), Tokyo (Japan)
  Russia: Moscow
1. Profile of Fraunhofer-Gesellschaft

www.fraunhofer.de

Joseph von Fraunhofer
(1787 - 1826)

- Discovery of the »Fraunhofer lines« in the solar spectrum
- New methods for lens processing
- Managing partner of the Royal Glass Factory

Fraunhofer-Gesellschaft
(since 1949)

- Researcher
- Inventor
- Entrepreneur

- e.g. the President's German Future Award in 2004 for electrical biochip technology
- e.g. two new patent applications every working day
- e.g. ~ €350 million revenues from industry (approx. 4.000 contracts) per year

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1. Fraunhofer Product Highlights

- **Exhibition guide**
  personalized information and navigation system

- **Cell lab**
  cells can be carefully sorted and characterized in an electro-magnetic field

- **Transparent ceramics**

- **Intelligent functional clothes**
  with integrated electronics, e.g. for bicycle couriers

- **Tower 24**
  automatic storage and collection system for on-line purchases

- **Fuel cells**
  for mobile electronic devices

- **MP3**
  MPEG Audio Layer-3 ISO/IEC-standard for compression of digital audio signals
 Founded: IAO – 1981  
 IAT – 1991  
 Director: Prof. Dr. Dieter Spath  
 Budget: 23 million Euros, of which  
 ~1/3 from industry contracts  
 Staff: 200 employees  
 ~220 student assistants  

Figures for 2006, including IAT University of Stuttgart
1. The pillars of success – Our areas of expertise

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1. Laboratories, demonstration and consulting centres at Fraunhofer IAO

- Vehicle interaction lab
- Visual enterprise management (Visum)
- Model factory
- E-Business innovation centre
- Office Innovation Centre (OIC)
- Lab Innovation Centre (LIC)
1. Virtual Environments at Fraunhofer IAO

CAD- and Simulation Models in the Virtual Environments of Fraunhofer IAO.

- **HyPI6**: Worldwide the first 6-sided virtual environment with stereo projection.

- **Picasso**: Integration of Desktop and Immersive System.

- **Powerwall**: 3D Display system with real-time adaptation to user position.
1. Selection of Projects in Construction at FhG IAO

Consulting Projects:
- BLANCO
- ZUBLIN
- HOCHTIEF
- m+w zander
- B.
- Berker auf die eigene Art.
- vitra.
- BMW
- Schöck
- DUVOISIN GROUX

Research Projects
- i3CON
- SWOP
- ManuBuild
- intuition

Cooperative Projects:
- FuCON
- ZUKUNFT BAU
- IN HAUS
- OFFICE 21®

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Construction Research at Fraunhofer
2. Construction Research at Fraunhofer

Fraunhofer Institute
1. IAO – Industrial Engineering
2. IBP – Construction Physics
3. LBF – Structural Durability and System Reliability
4. IFF – Factory Operation and Automation
5. WKI – Wood Research
6. IRB – Information Center for Regional Planning and Building
7. EMI – High Speed Dynamics
8. IMS – Microelectronics Circuits and Systems
9. SIT – Secure Information Technology
10. ISST – Software and Systems Engineering
11. ISE – Solar Energy Systems
12. UMSICHT – Environmental, Safety and Energy Technology
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* The area is a core competency of the institute
* The institute disposes of competencies in this area

Source: FhG (2004): Innovatives Bauen

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2. Fraunhofer Innovations & Technologies

*Building acoustics*

- Room acoustics planning, design
- Sound absorbers, sound silencers
- Noise reduction for machines and plants, active silencers
- Musical acoustics
2. Fraunhofer Innovations & Technologies

New Materials

• Development and testing of new materials
• Development of components and methods
• Heating and chimney systems
• Thermal material parameters, quality tests
2. Fraunhofer Innovations & Technologies

Heat Technology

- Building and facade system
- Energy concepts
- Daylighting
- Planning tools
2. Fraunhofer Innovations & Technologies

RFID and sensoric networks

- **RFID (Radio Frequency Identification)**
  Security or access control systems for buildings or special areas become more efficient due to adjustability.

- **Intelligent carpet**
  RFID-Technologies are integrated in a carpet. Computer-chips situated at the bottom side of the carpet gather information related to a specific room or area (e.g., path finding purposes for cleaning robots).

- **Electronic dust® (E-Grains)**
  Computers shrink to grain size. The tiny electronic grains network and communicate per radio signals.

- **Intelligent football with 3D-tracking system**
  Football and shin guards with integrated radio transmitters (2000 signals/second) provide information about the flight path and the speed of the ball, running speed as well as running distances.
2. Fraunhofer Innovations & Technologies

Displays, robots

- **OLED Organic Light Emitting Displays**
  Cutting edge technology for flat and flexible screens and illumination systems.

- **VR Object Display**
  Projected virtual objects allow interaction comparable to real objects.

- **3D-Displays**
  New display technology that enables to work with extremely high stereoscopic depths for medical or architectural tasks, simulation, design and construction.

- **Facade cleaning robot**
  Automated service units for cleaning and maintenance of buildings. Quirl ® : glass cleaning robot as large as a postcard and only 600g.
2. Fraunhofer Innovations & Technologies

future environments

- „ViBaL“- Virtual Control Center for Construction Engineering, Augmented Reality
  Development of a virtual control center for buildings and for the coordination of the building process.

- Office 21®“- New Work
  Research lab for future work and office worlds in buildings and real estate.

- Virtual engineering (CAVE; HyPI-6, X- ROOMS)
  Virtual worlds extend the visualization and interaction possibilities with the help of computer-aided systems. In Virtual Environments virtual prototypes can be designed, visualized and tested.

- Pointscreen- interaction without tracking
  Intuitive computer control by touching or gesturing replaces mice and keyboards.
2. Innovation-Centre inHaus2

A platform for the prototypical realisation and demonstration

Location: Duisburg
Size: ca. 3500 m²
Construction start: March 2007
Completion: June 2008

inHaus 2 – Innovation Fields:

- Optimisation of planning and building processes
- Optimisation of operation of spaces and buildings
- New added value in applications for residential use, health and senior care, as well as for office and event buildings.

More information:
www.inhaus.de
Integrated Planning and ICT in Construction
3. Fraunhofer Building Physical Software

ADELINE - Detailed daylight and artificial light planning and visualisation software
CompAS - Sound propagation in channels lined with absorbing material
Desktop Triso - Calculation of thermal bridges
EnEVnet - Marketing tools for energy-saving rules and regulations
IBP 18599 - Energy performance of buildings, calculating the useful, final, and energy demand for heating, cooling, lighting and DHW
IBP 18599 Kernel - Compact calculations related to DIN 18599
Imedas - Internet Measurement and Data Evaluation System
Leso-DIAL - Simple daylight planning software
Noise Reduction Auralisation - Real-time auralisation system
Sound insulation according to EN 12354 - Airborne and impact sound transmission
WUFI - Calculation of the coupled heat and moisture transfer in building components

Further Information: http://www.ibp.fhg.de/software/ibp_01_e.html
3. Virtual Engineering Systems

Architecture

Immersive modelling

Component testing/approval

Production-/assembly-planning and -simulation

Visualisation of complex information structures

Ergonomic analysis (online)
3. From „disruptive“ towards Integrated Planning

**Actual Situation (Germany)**

- **Investment**
  - Basic Evaluation
  - Pre-Planning
  - Design-Engineering
  - Approval Planning
  - Sector Planning
  - Detailed Planning
  - Construction Phase
  - Use Phase
  - Optimisation

- **Owner**
  - Owner, Architect, Structural Designer
  - Owner, Architect, Structural Designer, Technician
  - Owner, Architect, Consultant

**VISION**

- **Investment**
  - Basic Evaluation
  - Owner, Architect, Structural Designer, Authority, Specialist Consultant, Facility Manager, User, ...

- **Integrated Planning**
  - Frontloading

- **Forward Displacement of user optimisation**

Building Life-Cycle

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3. Process based building design

BMW AG, Leipzig
»Zentralgebäude Neues Werk Leipzig«

Consultation for the development and implementation of an office organization and of equipment concepts for the central building. Completion in the middle of 2004

• **Networked** Technologies
• Internal and external **Communication Center**
• **Integration** of different functions and hierarchical levels
• Adaptability to an **evolutionary organisation**
• Support of **knowledge- and information exchange**
• Support of **horizontal** communication
• Support of **vertical** communication
• Individuality in a **strong corporate identity**
3. Virtual sampling for prefabricated houses

End-User integration through interactive 3D planning.
- Users can interactively choose materials in 3D models.
- Changes are directly visible, costs are calculated automatically in real time.
- Information about changes are transferred backwards to the CAD system.
3. Virtual Construction ZVE – Center for virtual engineering

- Virtual Construction and Virtual Reality
  - Realisation of complex solutions through virtualisation

- Networked Planning and Collaboration
  - Virtual project spaces
  - Innovative information management

- Life-Cycle Integration
  - Integration of requirements from all LC-phases

- Parametric Design
  - Enable the rapid-design of variants
3. Business Models in Construction

Value Proposition: What is the value for the customer?
Value Configuration: What are the key factors to create this value?
Revenue Model: How can the supplier make profit?

Which are the key factors that should have an influence on the selection of the business model?
Technology Monitoring in Construction
4. From trends to technology planning – IAO process concept

- Business/technology strategy

- Technology/market monitoring

- Technology/R&D planning

- Technology analysis
  - Internal <> external
  - Today <> future

- Future scenarios
- Delphi
- Gaps & Options

- Portfolios
- Roadmaps

- Technology/R&D programme, resources and cooperation management

- R&D management

- Systematic development of new products, services and technologies

Continuous process, integrated into the enterprise planning
4. Modules of technology monitoring – Identifying trends

Definition of the search field according to products, markets and technologies
What are we looking for?

Identification of impact factors and creation of scenarios
What may the future be like?

Making use of experts/customers etc for the evaluation of future scenarios
How likely are the scenarios?

Permanent technology watch
Who will how often update and evaluate the findings?

Technology / R&D Planning
4. Challenges of Technology Monitoring in the Construction Industry
4. First Results (Draft)

- **Definition of the Search Field for Technology Monitoring:**
  The search field is often defined according to the direct needs of the divisions and projects.
  → *There seems to be a need to define clear technological fields beyond today’s business needs.*

- **Distribution of Responsibilities for Technology Monitoring:**
  The responsibilities for Technology Monitoring are in most cases not clearly defined or communicated but an implicit part of the daily work.
  → *Distribution of clear responsibilities and space for information exchange between different divisions.* „Information Collection as a real work“ seems to be beneficial.
4. First Results (Draft)

- **Information Management in Technology Monitoring:**
  Internet and the cooperation with universities or other construction companies seem to be the most important source of information. In most cases, there seems to be a lack of structured information storage.
  \[\textit{The structured use of a balanced portfolio of information sources seems to be beneficial. Also the structured storage and communication of this information is a key factor.}\]

- **IT-Support:** generally, further IT-support is judged as being very interesting for most construction companies.
  \[\textit{A prioritisation of IT-solutions is necessary to answer the needs of the construction industry.}\]
Fraunhofer Vision:
Some Trends in Building Research
5. Vision – Paradigm Shift through Innovations

Transfer of the digital production towards integrated workflow planning

Integrated bottom-up planning:
- integrates all stakeholders in an efficient network
- is based on active and cooperative participation
- is managing the continuous planning process
- optimises not only parts but integrates the entire building life-cycle
- is based on readiness (in any situation) and capability for planning
- is using integrated services, tools and methods of the digital production
- is using visualisation and simulation to speed up planning and decision making processes
5.1. Challenges for the Construction Industry

Optimisation of construction processes and project organisation

- Integration of planning and execution
- Early involvement of manufacturers and suppliers (frontloading)
- Cooperation of stakeholders of the building lifecycle in partnership
- Development of new cooperation and business models
- General restructuring of building processes e.g. based on the principles of lean construction

A key factor for the improvement of productivity in production in the construction sector today is the **industrial organisation of planning and building processes in construction companies**

*Prof. Dr.-Ing. G. Girmscheid, IBB ETH Zürich*
5.2. Challenges for the Construction Industry

Use of innovative tools and technologies for planning and execution

- Established tools and technologies, e.g. of the digital production have to be made available for building processes
  - Industrial manufacturing, parameterisation, modularisation
  - Virtual reality, augmented reality, simulation
  - Support of building logistics through sensor technology (e.g. RFID)

- Overcome innovation barriers
  - Reduced acceptance for new technologies by various stakeholders
  - Rigid legal conditions

Construction is one of the most underdeveloped production forms. You can observe the technological progress in all other areas. **Now this knowledge about new technologies has to be used also for construction.**

*Helmut Jahn, Murphy Jahn Architects*
5.3. Challenges for the Construction Industry

Integration of new product and system solutions

- Society is changing and user requirements are shifting
  - Increased knowledge work
  - Aging society
  - Increased ecological awareness
  - Increased safety needs

- The requirements towards real estate are changing between others towards
  - Functionality (e.g. through automation and networking)
  - Profitability and efficiency
  - Flexible space concepts / multi-functionality
  - Easy refurbishment and renovation
  - Energy efficiency

Due to increasing user-, ecological, and other requirements our buildings become more and more complex and are developing towards high-tech products.

Univ. Prof. Dipl.-Ing. Architekt D. Wiegand, TU Wien
Close the gap – Research vs. Practice
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