Industry Advisory Board Meeting
CIFE Industry Advisory Board Meeting

8:00 Welcome coffee
8:30 Update on CIFE business and research and education activities
9:15 Discussion of CIFE update and decisions
10:00 -- Break --
10:30 CIFE member updates on successes, initiatives, and challenges and discussion
12:30 -- Lunch --
13:30 Potential initiatives for the CIFE community for the next 24 months
14:00 Breakout groups to develop the most promising initiative
15:15 Reports from breakout groups and discussion
16:15 Vote to determine the highest value initiatives for the CIFE community
16:30 Summary of the decisions taken including reflection on voting and next steps
17:00 – Open House/Meet with Students --
18:30 -- Informal Dinner --
Topics

• Advice
• People
• Stanford Context
• Money
• Members
• Events
• Teaching
• Research
Advice

• VDC Certificate Program
  • Leave as is (1-2 open sessions, dedicated sessions as demand and capacity allow
  • Offer only dedicated sessions on demand
  • Executive Program

• Seed Project Process
  • Leave as is
  • Flagship projects

• Sustainable Urban Systems
  • Role of CIFE?

• BuiltX
  • Accelerating startups that improve the built environment

• Partnerships
• Research focus
People: John Kunz retired
People

Visiting Fellows & Interns
Austin Becker (WDI)
Ramon Iglesias (Mortenson)
Hal Rolnick (RIB)
Devini Senaratna (Glodon)
Min Song (CCC)
George Venetsanopoulos (CCC)
Tongda Zhang (DPR)
Plus many summer interns

Research Associate
Forest Flager

Consulting Professors
Vladimir Bazjanac (LBNL)
Calvin Kam (bimSCORE)
Bill McDonough
Ben Schwegler (WDI)

Visiting Scholars
Patrick Shiel, Apr 2013 – Mar 2015
Lea Urup, Jan. 2014 – June 2014
Stanford Context

• Graduate Construction Program is strong
• 5 tenure line faculty
• 31 lecturers and consulting professors
• 111 graduate students
  – 73 MS
  – 38 post MS

• New School of Engineering Leadership
  Persis Drell    Jennifer Widom

• Sustainable Urban Systems Initiative
Stanford Construction Curriculum Overview

**Overview of Program Curricula**
- SDC – Management (Formerly CEM)
- SDC – Energy (Formerly SDC)
- SDC – Structures (Formerly DCI)
- SDC – Water (New)

**Related Undergraduate Program**
- Architectural Design

**Related Centers and Labs**
- Center for Integrated Facility Engineering (CIFE)
- Project Based Learning Lab (PBL)
- Global Projects Center (GPC)
- Sensing, Data Analytics, and Optimization
VISION

Students will learn to create integrated urban infrastructure systems in a re-conceptualized educational setting.

**Traditional:** Separate power plants & Wastewater treatment

**Integrated:** Clean the water while producing fuel, fertilizer and plastics
SUS Program Elements: Team Project

Company

Executives

Industry and Faculty Mentors

SUS Students

Company Support:

- Student RA-ships
- Student internships
- Field trip(s)
- Mentors (in kind)
Sources of Membership and Program Income

- Contributor $15,000
- Small Business $12,000
- Member $35,000
  - $15k discount for tech companies
- Visiting Fellow $20,000
  - $18,750 with partner discount
  - 1-3 VF Quarters: Associate Member
  - 4+ VF Quarters: Partner

- VDC Certificate Program
  - $75,000 per program (with partner SPS/PPI)
  - ~25 participants

- Other Events
Currently 33 CIFE Members
Changes since last IAB

NEW MEMBERS
Bentley Software
Implenia Schweiz
MT Højgaard
Nemetschek Allplan
Royal HaskoningDHV
Synchro Software

CHANGE IN MEMBERSHIP LEVEL
CCC Associate → Partner
DPR Construction Member → Associate
Parsons Brinckerhoff Associate → Member
Skanska Member → Contributor
SMART Technologies Associate → Member

FORMER MEMBERS
Cadwork Informatik
Oracle Primavera
Slavenburg BV
Teaching: Major Stanford Courses with Significant CIFE Content and Industry Participation

- CEE220 BIM series
  - Autodesk

- CEE212 Industry Applications of VDC
  - Bechtel
  - bimSCORE
  - CCC
  - GSA
  - Mortenson
  - Obayashi
  - Walt Disney Imagineering
  - AIA
  - NASA
  - Smithsonian
  - Swiss VDC program participants

- CEE222 Computer Integrated AEC Global Teamwork
  - Too many to list here

- CEE241 Managing Fabrication and Construction
  - RIB
  - Trimble
  - CCC
  - Clark Pacific
  - DPR
  - Webcor
Teaching: Educational Events for the CIFE Community

- 62 VDC Certificate Program Graduates last year
- 7 VDC Certificate Courses
  - WDI Dec. 13
  - WDI Feb. 14
  - Veidekke Mar. 14
  - Implenia May 14
  - CIFE Jun. 14
  - Singapore Jun. 14
  - PB online Apr.-Sep. 14
  - RHDHV Dec. 14
  - China Mar. 15
  - Peru Mar. 15
  - NCC Aug. 15
- Other Events
  - Strategy Meeting Oct. 13
  - Parts List Workshop Mar. 13
  - Key Performance Indicators Mar. 13
  - Summer Program Jun 14
  - VDC Workshop Hong Kong CIC Sep. 14
  - Facility Energy Management Workshop Sep. 14
  - Tongji VDC Conference Shanghai Oct. 14
  - iTWO World Hong Kong Nov. 14
  - BIM Seminar Zurich Jan. 15
  - 3rd BIM Conf. Dubai Feb. 15
# Proposed CIFE Calendar 2014-15

<table>
<thead>
<tr>
<th>EVENTS</th>
<th>DATES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Call for Seed Proposals</td>
<td>March 4</td>
</tr>
<tr>
<td>Proposals Due</td>
<td>April 22</td>
</tr>
<tr>
<td>Technical Advisory Committee</td>
<td>April 30</td>
</tr>
<tr>
<td>Summer Program</td>
<td>September 9-10</td>
</tr>
<tr>
<td>Industry Advisory Board</td>
<td>October 15</td>
</tr>
<tr>
<td>VDC Certificate Program</td>
<td>???</td>
</tr>
</tbody>
</table>
2013-14 CIFE Seed Projects

- Space Constraint Method – M. Fischer, M. Lepech, R. Morkos ($30,000)
- Using MDO to Support Sequential Conceptual Design Decisions – M. Lepech, M. Fischer, F. Flager, J. Basbagill ($40,000)
- A Framework for Bringing 3D Printing into the Construction Industry – M. Fischer, V. Bazjanac, N. Mrazovic ($30,000)
- Integrated Virtual Parts Library - Parts List Definition – M. Fischer, C. Kam, B. Schwegler, C. Chi, D. Hall, H. Chen, J. Wei, N. Zhao, P. Padachuri, S. Tao ($45,000)
- Statistical Analysis of KPIs: the Missing Links in the VDC Decision Making Process – M. Fischer, C. Kam, D. Senaratna ($30,000)
- Enhancing Pre-Construction Decision-Making on Sustainable Commercial Building Projects – M. Lepech, G. Griggs, K. Abraham ($30,000)
- Achieving Large-scale Energy Reduction in Commercial Buildings Using Closed Loop Energy Analysis (CLEAN) – M. Fischer, C. Kam, P. Shiel ($35,000)
2013-14 Visiting Fellow Projects

- Austin Becker (WDI)
  - Engineering and Policy Implications of Sea Level Rise for Sea Ports
- Forest Flager, Ramon Iglesias (Mortenson)
  - Windfarm Optimization
- Hal Rolnick (RIB)
  - Global Implementation of 5D Modeling
- Devini Senaratna (Glodon)
  - VDC Scorecard
- Min Song (CCC) and George Venetsanopoulos (CCC)
  - BIM-based Construction Management
- Skyler Holloway (DPR)
  - Review of IPD Practices
- Tongda Zhang (DPR)
  - Worker Movement Analysis
- Forest Flager, Calvin Kam, Several Students (WDI)
  - Integrated Infrastructure; Optimization of Supply and Demand for Energy for Neighborhoods
  - Parts List

- Robert Gräbert, Alissa Cooperman (CBRE – RGRC)
  - Facility Energy Management Practices by Leading Owner-Operators
2014-15 CIFE Seed Projects

- Managing Construction Parts - From Manufacturing to Construction – M. Fischer, C. Kam, B. Schwegler, C. Chi, D. Hall, H. Chen, N. Zhao, S. Tao ($50,000)
- A Simulation-Based Approach to Accounting for Uncertainty and Variability in Look-Ahead Planning – M. Fischer, J. Choo, N. Garcia-Lopez (35,000)
Productivity in construction is lagging productivity in other industries!

Labor Productivity for Construction Industry and all Non-Farm Ind. 1964-2008

Const $/mhr index, 1964 = 1
Non-Farm Productivity Index, 1964 = 1
Virtual Design and Construction (VDC)

Client/Business Objectives

Project Objectives

Integrated Concurrent Engineering (ICE)

Product Modeling (BIM+)

Process Modeling & Management

NOTE: Drawings are batched into sections- then subdivided into building components. Each component is an assembly package, e.g. rail box floor, wall, etc. The number of drawing sheets per building component vary depending on the work. On ART for example, each component may consist of 8-15 GA drawings and 8-15 RC detail drawings. All of the GA drawings are complete - pending changes from other design disciplines. Design changes during detailing (from: architecture, baggage, systems, etc.) are upsetting RC drawing development.

NOTE: Design changes during detailing (from: architecture, baggage, systems, etc.) are upsetting RC drawing development.

Other / None/ Unknown

Preliminary RC detailing

Iterative process

Consists of:

- engineering calculations,
- sketches, etc.

Most of the checking process is done concurrently with RC detail development.

BAA building control accepts the opinion of the independent design check - and does not perform a check of its own.

Assembly

Existing Process - 6 weeks
The ability to predict performance will be a key competitive advantage

Increase the number of **virtual** buildings or design options considered

Increase the number of **real** buildings considered

Improve the **quality** of analysis and simulation **models**
Sustainable Integrated Materials, Structures & Systems (SIMSS) Research and Design Approach

- Materials
  - Material Properties
  - Material Production

- Structure
  - Structural Properties
  - Shape
  - Construction
  - Constituents

- System
  - Performance
  - Maintenance
  - Loads

- Evaluation
  - Environmental Indicators
  - Social Indicators
  - Economic Indicators
  - Infrastructure Sustainability

Life Cycle Analysis

Feedback
Materials – Biological Composites

5% Engineered Protein + 95% Inorganic Minerals =

3000 PSI Compressive Strength

Structures - ADAPT

ADAPT software allows environmental evaluation of early stage decisions (orientation, materials, etc.) through visualized probability mass functions.

\[ \Delta \mu = -57\% \]
System – Energy System Modeling

Optimized Building + Optimized Power Plant ≠ Optimized System


OPTIMIZE THE ENERGY MIX
- Fuel used: 43%
- Heating oil: 30%
- Wood: 15%
- Balance on heating oil: 30%
- In 2006: only 40% in 2006

REDUCE ENVIRONMENTAL IMPACTS
- In 2006, installation of continuous emission measurement and analysis equipment
- Emission energy as a percentage of the total energy consumed: 15%
- Emissions avoided:
  - 9,800 metric tons of CO2 in 2006; 15,700 metric tons of CO2 in 2000
  - 38% less dust particles compared with 2002
- 44% less sulfur dioxide compared with 2002

AREAWAY OF REDUCED CONSUMPTION
- Brochure with information to improve awareness of sustainable development and energy management

Heating network
- Heating and domestic hot water
- 49 kilometers
- Fuel: 115,749 MWh
- Hot water: 366,177 MWh

Electricity network
- 100 MWh

www.stanford.com
System – Energy System Modeling

Modeling and optimizing energy demand and energy generation simultaneously allows for improved efficiency across the overall system.
Evaluation – Ecosystem Services

Developing science-based, rigorous methods to consider the value of natural ecosystems on the financial balance sheet of private companies according to Generally Accepted Accounting Principles (GAAP).

- **Lifecycle Inventory Analysis**
  *Measure* the effect of business decisions on natural ecosystems (reduced emissions, reduced land use)

- **Ecosystem Functions**
  *Model* changes in ecosystem functions due to decisions (denitrification in natural solar field soils)

- **Functional Substitutability**
  *Value* ecosystem changes via market pricing of engineered substitutes (cost of waste water treatment)

- **Financial Accounting**
  *Recognize* the ecosystem asset value on the firm’s balance sheet (value of denitrification per acre)

**Decision Analysis**

*Decide* how protection of ecosystem service assets can minimize solar generator cost or maximize profit (increase competitiveness)
Data Analytics – Ram Rajagopal

Sensing Networks   Data Analytics   Optimization and Control

❖ Civil Engineering and Management Context
❖ Hands-on and Real World Problems
MDO
Multidisciplinary Design Optimization

“Multidisciplinary Design Optimization involves the formalization of design iteration and coordination to leverage computer processing power to systematically search the design space”

Why?

\[ \text{(1955 MEMBERS)}^{20} \times 4 = 1.47 \times 10^{2487} \]

Possible design configurations

Conventional design practice

39 alternatives evaluated \times 4 average cycle duration (man hrs) = 156 design time (man hrs)
Why?

<table>
<thead>
<tr>
<th>PROCESS METRICS</th>
<th>CONVENTIONAL PRACTICE (ARUP)</th>
<th>MDO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design cycle time</td>
<td>4 hrs</td>
<td>3 sec</td>
</tr>
<tr>
<td>Alternatives evaluated</td>
<td>39</td>
<td>12,800</td>
</tr>
<tr>
<td>Set-up time</td>
<td>60 hrs</td>
<td>140 hrs</td>
</tr>
<tr>
<td>Total design time</td>
<td>216 hrs</td>
<td>151 hrs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PRODUCT METRICS</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Steel Weight (met t)</td>
<td>2,728</td>
<td>2,292</td>
</tr>
<tr>
<td>Est. Cost Savings (USD, Millions)</td>
<td>-</td>
<td>4 (-19%)</td>
</tr>
</tbody>
</table>
Why?

SCOPE
Building shell and services

OBJECTIVES
(1) Minimize life-cycle cost
(2) Minimize carbon footprint

VARIABLES
(1) Building orientation: +/-10°
(2) Glazing percentage: 30-70%
(3) Glazing type: 26 candidate products
Why?

<table>
<thead>
<tr>
<th>Life-Cycle Cost (USD, Millions)</th>
<th>Carbon Footprint (met tns CO₂e)</th>
</tr>
</thead>
</table>

**KEY**

- + Baseline
- ○ Lowest Cost
- □ Lowest Carbon

Preference Shading

- Worst
- Best
Applications
CAMPUS MASTERPLANNING
Scope:
• Building position and massing
Partner:
• The Beck Group
Results:
➔ 12% life-cycle cost
➔ 8% carbon footprint

WIND ENERGY
Scope:
• Turbine layout and crane path
Partners:
• Mortenson + MAP Royalty
Results:
➔ 7% construction cost
➔ 3% cost of energy

URBAN ENERGY SYSTEMS
Scope:
• Development size and density
• Building use composition
Partner:
• WDI
Results:
➔ 11% primary energy efficiency

OIL AND GAS
Scope:
• Work sequencing for well completion
Partner:
• Strategic Project Solutions
Results:
To be determined

Applications
Why now?

- Challenging project performance requirements
- Demand for data-driven design
- Integrated project delivery (IPD)
- Advancements in BIM and simulation
- Low cost and high availability of ‘cloud’ computing
Challenges / Opportunities

OWNERS
• Greater involvement in process
• Expect data to support decisions

ARCHITECTS AND ENGINEERS
• Technology as a differentiator
• Change in designer skill set

CONTRACTORS AND SUPPLIERS
• Early Involvement
• Product data transparency
• Premium on supply chain management
Advice

• VDC Certificate Program
  • Leave as is (1-2 open sessions, dedicated sessions as demand and capacity allow)
  • Offer only dedicated sessions on demand
  • Executive Program

• Seed Project Process
  • Leave as is
  • Flagship projects

• Sustainable Urban Systems
  • Role of CIFE?

• BuiltX
  • Accelerating startups that improve the built environment

• Partnerships

• Research focus
  • Outcome and Production Performance
  • MDO
  • Data Analytics
  • Integration