Modular Components, Integrated Practices: Managing Complexity and Interdependence in Temporary Organizations

Richard Tee  LUISS - Libera Università Internazionale degli Studi Sociali, Italy
Andrew Davies  University College London, UK
Jennifer Whyte  University of Reading, UK
Sam MacAulay  UQ School of Business, Australia
Overview

- **Research Question**: How do organizations coordinate to manage interdependence in complex projects?

- **Setting**: Complex Project: Heathrow Terminal 5

- **Our argument**:
  - There are *emerging interdependencies* in complex projects
  - These are managed by combining modular product designs with integrated software and practices
  - Why? Importance of visibility as well as information hiding to aid coordination
Background literature (1)

- **Organizational interdependence**
  - Degree to which two or more activities interact to jointly determine an outcome (Sorensen 2003)

- **Interdependence in complex systems**
  - Manage complexity in nearly decomposable systems by containing interdependencies within individual subsystems (Simon, 1962)

(Source: Danilovic & Sandkull 2005)
Background literature (2)

• Modularity literature
  – Importance of systems integrator firms (Brusoni et al., 2001; Prencipe et al, 2003)

• Different views on modular designs and coordination
  – Modular designs reduce complexity - facilitating or substituting for organizational coordination (Sanchez & Mahoney 1996, Langlois 2002, Sturgeon 2002)
  – Modular designs as imperfect substitute for organizational coordination, requiring organizations to manage ongoing interdependencies (Staudenmayer et al. 2005, Zirpoli & Becker 2011, Tiwana 2008)

• How do you coordinate to deal with emergent interdependencies?
Setting: Heathrow T5

- Complex projects deliver complex product systems (Shenhar & Dvir 1996; Hobday 2000; Davies & Hobday 2005)

- Construction of Heathrow airport Terminal 5. Opened in March 2008, within budget and ahead of time

- Overall project consisted of 16 main projects, 147 sub-projects, and over 11,000 pre-assembled modules

- Key stakeholders
  - BAA (British Airports Authority, project sponsor/client)
  - Laing O’ Rourke (LOR, main contractor)
  - BA (British Airways, main operator of T5 upon delivery)
Data sources

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<tr>
<td>Objectives</td>
<td>Explore general dynamics in T5 project focused on 1) usage of digital technologies to manage risk and complexity, 2) capabilities and learning</td>
<td>Focus on the interaction between digital technologies (e.g. SME) and behavioral mechanisms (e.g. T5 Agreement)</td>
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<td>Interview Data</td>
<td>Interviews (total 30)</td>
<td>Interviews (total 9)</td>
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<tr>
<td></td>
<td>LOR (19), BAA (10), BA (1)</td>
<td>LOR (3), BA (1), BBM (1), GO Ltd (1), Severn Trust (1), Rogers Stirk Harbour &amp; Partners (1), Volkswagen (1)</td>
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<td>Archival sources</td>
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<td>Research papers and books on T5</td>
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Key elements managing interdependence

• **T5 Agreement**
  Legal document codifying a set of behaviors for T5 project participants. Stimulated collaboration through “integrated teams” emphasizing shared identities, incentive alignment and co-location

• **Single Model Environment (SME)**
  Repository to share design information and updates. Facilitated use of modular designs, focus on standard components, interface compliance, and pre-fabricated / off-site construction
### Project organizing:

- T5 agreement
- Single model environment

#### Integrated software and practices:

- Co-location
- Shared risks and rewards
- Team identity

#### Increased visibility

- Used to manage

### Complex product systems:

- Modular designs

#### Emergent interdependencies

- Standardized components
- Prefab – offsite construction
- Interface compliance

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**time**
T5 agreement: integrated team working

- Risk and incentive alignment
  “They’re incentivized (i.e. T5 project participants) on the performance of the integrated team; i.e. the completion of all the work.”

- Project roles and identity
  “But if you look at all of our people you can, you can’t tell, distinguish between, you know, who are the, which company you work for generally.”
  “if you went into any part of the offices, either on site or off site, there were completely integrated teams. So you had people from any of the disciplines, professional disciplines, including the constructors.”
Single Model Environment (SME): Integrated software

• Intended to facilitate information transparency
  BAA’s vision: “to make it possible for all of the companies involved in the project to have access to a single design model, to be able to interrogate it, to be able to take a section from it, do their work and plug it back in.”

• Visibility for coordination
  “to coordinate the designs of all parties and a design integration and a design review process so that there was one view of the truth, one absolute design statement”
Modular Designs

- **Standardized components to manage costs and complexity**
  - "there’s modularization of building fabric and there’s modularization and standardization of […] stuff that passengers always interface with […] they’re all standard components."

- **Off-site, prefab construction & just-in-time development**
  - "managing the whole construction methodology around offsite fabrication, modularization, building sub-assemblies, creating a facility which was about a mile away from the site where these sub-assemblies could be brought together and assembled into a larger sub-assemblies, and then transport it to the site on a just-in-time basis."
Integrated software and practices

Emergent interdependencies

Project organizing:
- T5 agreement
- Single model environment
- Co-location
- Shared risks and rewards
- Team identity

Increased visibility

Used to manage (by monitoring and mitigating)

Complex product systems:
- Modular components
  - Standardized components
  - Prefab – offsite construction
  - Interface compliance

Emergent interdependencies
(both endogenous and exogenous)

time
Emergent interdependence

Endogenously emergent interdependencies
- Roof sub-project (project within a project)
- Control tower

Exogenously emergent interdependencies
- 9/11
Emergent interdependence

Endogenously emergent interdependencies

• Roof sub-project (project within a project)
  – Seen as highly successful (and as an exemplar)
    1. Changing interdependence with other sub-projects – *at a late stage, there is a decision to build the roof as a shed, to disentangle it from decisions about baggage handling and the 6 storey station below (emergent use of a modularity strategy, information hiding (or at least less dependence), etc)*
    2. Interdependencies with the supply chain that were not anticipated – *the software created visibility across first tier of professionals consultants, not the materials suppliers, temporary works designers, manufacturers etc.*

      These interdependencies are *monitored* through creating new visibility practices (not the single model environment software)

• Control tower
  – Successful in mitigating an issue that arose when dependencies emerged that had not been anticipated
Visibility

• Monitoring capabilities
  – Single model environment
  – Integrating practices

• Mitigation capabilities
  – Reduce dependencies (evolving modularity)
  – Integrating practices
Discussion and conclusions

• Complementing modular designs with integrated practices
  – Modular designs not a technological fix; instead, organizational practices needed to implement modules. Emphasis on integration (e.g. co-location, strong team identities, incentive alignment), not modularity (e.g. arms-length contracts, virtual collaboration)

• Information transparency aids coordination
  – Actionable transparency (see e.g. Open Source software, cf. Colfer & Baldwin, 2010)
  – Challenges in achieving transparency (maintenance and controls); SME as empirical manifestation to improve “analyzability” (Adler, 1995)