Management of Innovation and Knowledge Integration in Product Development Projects

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Presentation outline

- Knowledge Integration and Innovation: The problem
- Integrating Knowledge in Complex Product Development Projects
- (Knowledge Integration Challenges in Project-based Firms)

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Why knowledge integration and innovation?

- Knowledge specialization increasingly important, as firms are increasingly multi-technological (Granstrand et al 1997; Brusoni et al, 2001)
- Knowledge integration is difficult (Dougherty, 1992; Hoopes and Postrel, 1999; Lindkvist, 2005)
- Knowledge integration important for performance (Piscitello, 2004; Brusoni et al, 2005; Nesta and Saviotti, 2006)
- Innovations as “new combinations” (Schumpeter, 1942) require integrative capabilities (Henderson and Clark, 1990)

What firms do

- Firms produce products and services
- To produce things firms need capabilities
- To be capable of producing, firms need to integrate knowledge
- Knowledge integration takes place under conditions of bounded rationality

Conceptions of Firms

	Production	*Exchange*
Unbounded rationality	**Textbook Orthodoxy**	**Working paper Orthodoxy**
Bounded rationality	**Evolutionary Economics**	**Transaction Cost Economics**

(Winter, 1988)

Governance/Organizational problem

- Problem of co-operation
  - Incentive alignment
- Problem of co-ordination
  - Knowledge integration

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How to achieve cooperation?

- Firm as a nexus of contracts that unify property and decision rights
- Incomplete contracts (firms as failed markets)
  - Hierarchy – authority relationships
  - Reward sharing schemes (incentives)

"The key idea is to provide as focused, intense incentives as possible within the constraints implied by the corporate form and the interdependencies that it both creates and is meant to control. The key architectural elements involve redrawing the vertical and horizontal boundaries of the firm to increase strategic focus; creating relatively small subunits within the organization in which significant decision rights are lodged […].

(John Roberts, *The Modern Firm*, 2004: 180)

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Co-ordination problem

- How to integrate different knowledge bases for efficient production?

"Coordination means, at a minimum, that all the needed tasks are completed without pointless duplication. Better yet, it seeks to ensure that the tasks are done efficiently, by the right people, in the right way, and at the right time and place. Ultimately, full coordination also requires that the tasks undertaken are the right ones."

(John Roberts, *The Modern Firm*, 2004: 75)

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How do firms produce new things?

- Through new combinations, Schumpeter told us…
- New combinations require integration of existing knowledge as well as generation of new knowledge

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The problem of knowledge integration

- Knowledge specialization requires integration
- Knowledge complementarities
- Knowledge transfer is not always efficient

(Grant, 1996)

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Achieving knowledge integration

- Some contingencies:
  - Knowledge differentiation and complexity (Grandori, 2001)
  - Interdependencies: pooled, sequential, reciprocal (Thompson, 1967; Grant, 1996)
  - Task features: frequency, homogeneity, causal ambiguity (Zollo and Winter, 2002)
- Integration mechanisms:
  - Hierarchy, rules, prices, property rights sharing, communication networks, knowledge integrators, teams, communities (Grandori, 2001)
  - Rules and directives, sequencing, routines, group problem solving (Grant, 1996)
  - Tacit experience accumulation, articulation, codification (Zollo and Winter, 2002)

Organizing for innovation

- New product development projects example of knowledge integration in innovative (although not always radical) settings
- How is knowledge integrated?
  - Knowledge integration in the development of complex products under time constraints (Lindkvist, Söderlund and Tell 1998)
  - Knowledge integration and near decomposability in product platform projects (Yakob and Tell, 2007; 2009)
  - Integration of distributed knowledge in new product development projects (Enberg, Lindkvist and Tell, 2006; 2009)

Projects and knowledge integration

- Projects as a separation strategy
- Projects as a device for dealing with non-repetitive tasks
- Projects are made up of temporary constellations of people

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NPD in telecoms

- How is knowledge integrated in large and complex development projects?
- Concurrent engineering in NPD projects: Now (in operation 2006) and then (in operation 1994) in the telecom industry.
- Large development projects (>100 engineers)
- Follow up-projects on major breakthrough technologies
- Researched by retrospective, interview-based, qualitative case-studies

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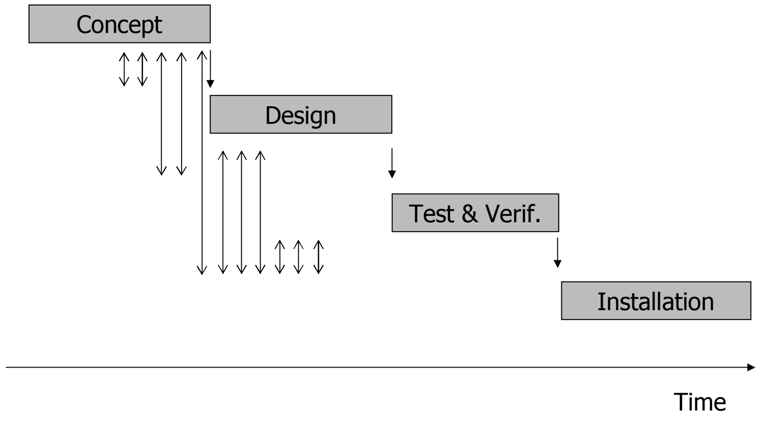
1990s NPD: Post GSM

- Digital cellular telephony system for a new important customer
- New standard partly based on GSM
- Software and hardware
- Half development time of GSM
- 1 country, >100 engineers, 2 years

Lindkvist, L., J. Söderlund and F. Tell (1998), Managing Product Development Projects – On the Significance of Fountains and Deadlines, *Organization Studies*, 19(6): 931-951

Concurrent engineering



Analysis

Type of complexity (Perrow, 1970)

Type of error problematic (Levinthal & March, 1993)

	analyzable	*systemic*
error detection	Scheduling logic	Coupling logic
error diagnostics	Separating logic	Semi-coupling logic

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Implications for knowledge integration

- High complexity but error detection rather than error diagnosis – Tightly coupled projects
- Tight knowledge integration
  - Practicing the processes
  - Solving problems due to interaction effects among units
  - Continuous feedback – little buffers
  - Less 'work breakdown structure' oriented
  - Arenas
    - Systems emergency ward
    - Daily meetings
    - Video/telephone conferencing
  - Combination of hierarchical and network structures

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Knowledge integration in complex product product platforms

- On-going work with Ramsin Yakob
- How do organizations solve complex problems in product development?
- Example of platforms

Yakob, R and F. Tell (2007), Managing Near Decomposability in Complex Platform Development Projects, *International Journal of Technology Intelligence and Planning*, 3(4): 387-407

Yakob, R. and F. Tell (2009), Detecting Errors Early: Management of problem-solving in product platform projects, in: Gawer, A. (ed.), *Platforms, Markets and Innovation*, Cheltenham, UK and Northampton, MA, US: Edward Elgar

Telecoms in the 2000s: Post 3G platform

- Leading global telecommunications firm - develops, produces, supplies, and installs telecommunications systems
- n th version of third generation cellular telephone system
- Run partly in parallel with version n-1 and n+1 version
- Software platform (hardware negligible)
- 5 countries, > 200 engineers, 24 months

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Research problem

- Previous research particularly concerned with *outcomes* of platform development approaches rather than the *process* itself

  (e.g. Krishnan and Gupta, 2001; Muffato and Roveda, 2000; Meyer and Lehnerd, 1997)

- Previous research primarily dealt with complexity in platform development by *modular* approaches, assuming perfect decomposability

  (e.g., Ethiraj and Levinthal, 2004; Baldwin and Clark, 2000; Ericsson and Erixon, 1999)

Types of problems

- Low interaction problems
  - Fully decomposable systems
- Moderate interaction problems
  - Nearly decomposable systems
- High interaction problems
  - Non-decomposable systems

(Nickerson & Zenger, 2004)

Understanding Complex platform projects as nearly decomposable systems

"(1) In a nearly decomposable system the short-run behaviour of each component sub-system is approximately independent of the short run behaviour of the other components; (2) in the long run the behaviour of components depends in only an aggregate way on the behaviour of the other components" (Simon, 1996: 198)

"While decomposing a problem is necessary in order to reduce the dimension of the search space, it also shapes and constrains a search process to a specific sub-space of possible solutions thus making it possible for optimal solutions not to be ever generated and for systems to be locked into sub-optimal solutions" (Marengo, Pasquali and Valente, 2005: 3)

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Perceived problems with previous ways of working

- Quality not up to standard
- Difficulties in adapting to emerging objectives and new specifications
- Time delays

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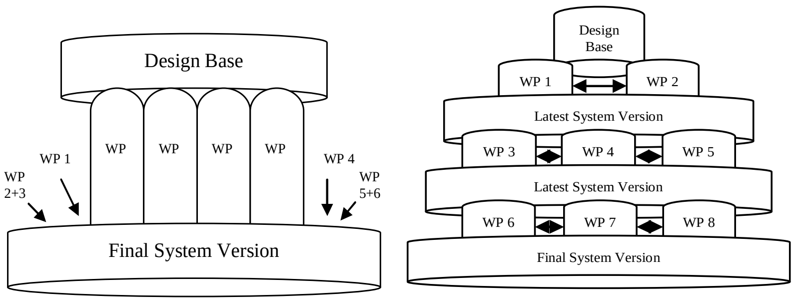
Developing telecom platforms in work packages

- Starting early by defining small work packages (WP)
- Work out a genealogy of the project
- Set up interdisciplinary teams working with each package (teams of 10-15)
- Each WP is an entity in the anatomy (60-70 WP)
- Fairly brief “slots” for delivery from WP to systems integration (second weekly build)
- Continuous integration enabled by “build” environment tool

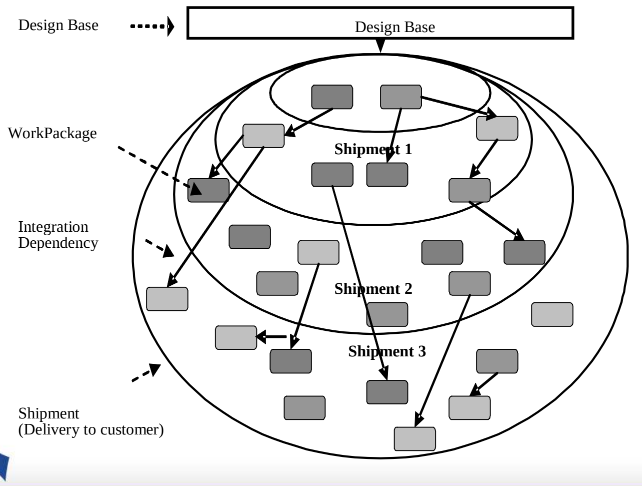
Ways of Working



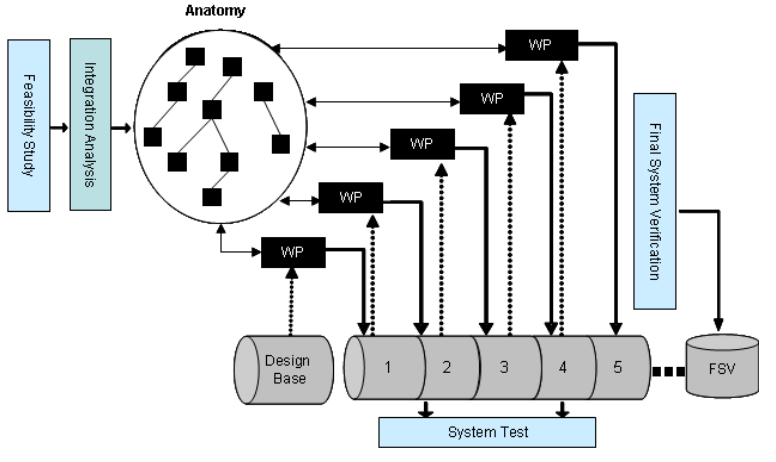
Previously

This project

The Anatomy of a project



Development Pattern



Understanding product development as problem-solving

- Directional search
- Analytical search

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Directional search processes

(experiential, on-line, local)

- Actual experience of how action and outcome interlink, problems that cause a gap between actual and potential performance can be discovered (Pisano,1994).
- Attempt to bridge the lack of prior knowledge of how action and outcome interlink by independently observing how performance reacts to changes. Incremental approach towards problem-solving where experience of the resulting performance of the changes made is an important input into the subsequent choice made.
- Assumes that whenever a problem is encountered and taken on, the problem can be divided into several constituent parts; each part worked on independently; and the contributing results of this action in finding a solution to the problem observed independently from other parts.
- Feed-back (from errors) the central process (Gavetti & Levinthal, 2000)

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Analytical search processes

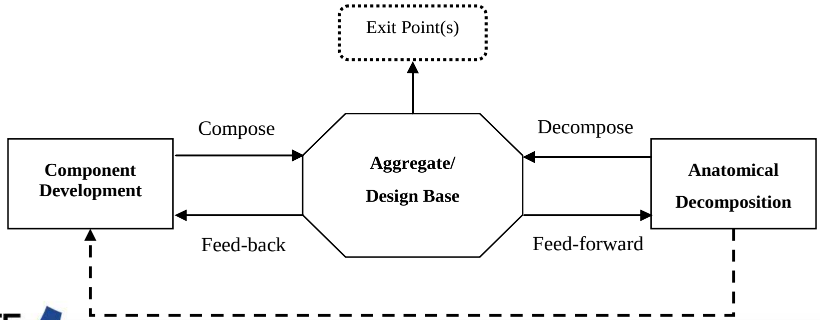
(cognitive, heuriustic, scientific)

- Understanding a complex problem and analytically determine action – outcome linkages, problem-solvers need to revert to finding good enough rather than optimized solutions to problems
- Drawing upon rough representation of complexity and problems faced efforts towards establishing what type of solutions are sought for can be made.
- Analyticalproblem-solving search processes are concerned with attempts to cognitively evaluateprobable consequences of choices taken and identify useless directions of search beforehand and providing a glimpse of the possible (Fleming and Sorensen, 2004)
- Feed-forward (to problems) the central process (Gavetti & Levinthal, 2000)

Managing near decomposability

Search process

- System aggregation and knowledge integration
- Decomposition and (re)composition (cf. modularity)
- Learning dynamics of feed-back and feed-forward



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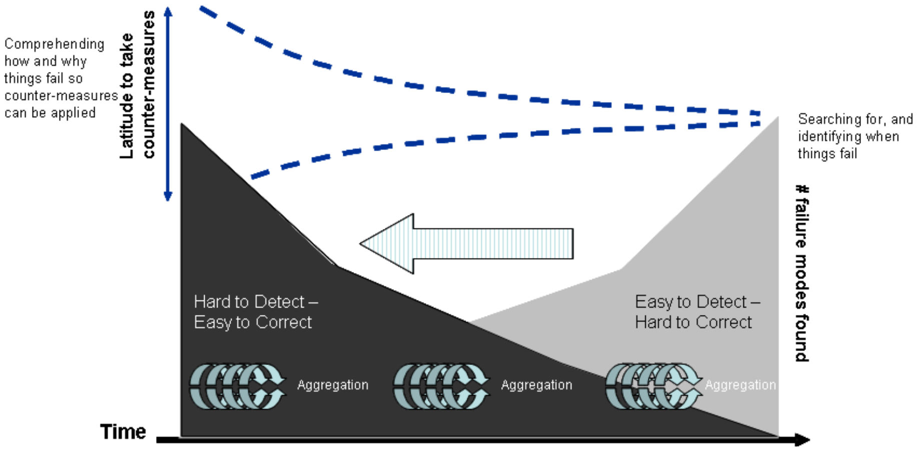
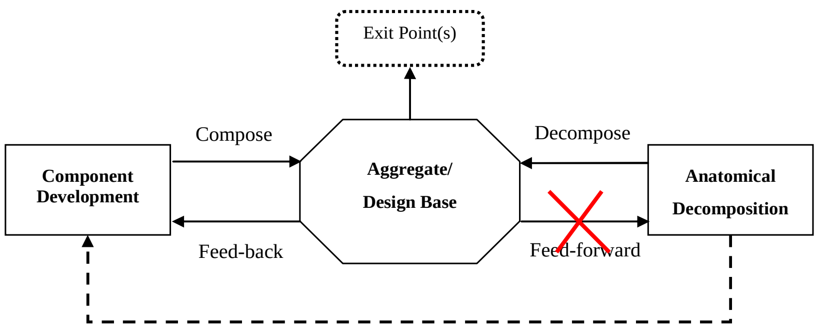
Detecting errors early



Automotives: solving errors but not problems



Integration of distributed knowledge: The stacker NPD project

- Incremental, 1 country, 13 engineers, 2 years
- Not much of a shared goal
- Project members were not working tightly together
  - Located in different departments
  - Little communication
  - Met primarily at project meetings – but not in conducting their work
- Knowledge did not seem to be shared
- How did knowledge integration take place?

Enberg, C., L. Lindkvist and F. Tell (2006), Exploring the Dynamics of Knowledge Integration: Acting and Interacting in Project Teams, *Management Learning*, 37(2): 143-165

Integrating Knowledge

Traditional KM view

- ***Codified*** **knowledge for simple tasks and standardized products**
- ***Tacit*** **knowledge for advanced tasks and customized solutions**

(e.g., Grant 1996; Hansen *et al* 1999;)

Alternative view

- **Task features and knowledge integration**
- **Learning investment function**
- **Frequency**

↓ → *Articulation/Codification*

- **Homogeneity**

↓ → *Articulation/Codification*

- **Causal ambiguity (complexity)**

↑ → *Articulation/Codification*

(Zollo and Winter, 2002)

A process typology

Learning typologies, outcomes and economic benefits

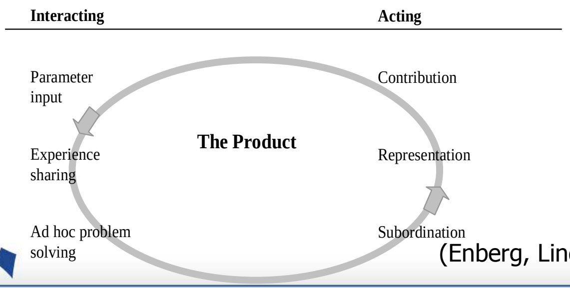
	Learning Processes *Experience accumulation*	*Knowledge articulation*	*Knowledge codification*
Learning typology	• Learning by doing • Learning by using	• Learning by reflecting • Learning by thinking • Learning by discussing • Learning by confronting	• Learning by writing and re-writing • Learning by implementing • Learning by replicating • Learning by adapting
Outcome	• Local experts and experiential knowledge in individuals (e.g. subject matter expert)	• Symbolic representations and communication • Improved understanding of action-performance relation (predictive knowledge)	• Codified manuals, procedures (e.g. project management process)
Economic benefit	• Economics of specialisation	• Economics of co-ordination	• Economics of information (diffusion, reuse of information)

Prencipe, A. and F. Tell (2001), Inter-project learning: processes and outcomes of knowledge codification in project-based firms, *Research Policy*, 30/9: 1373-1394

The Stacker case

An iterative model of knowledge integration

Frequency	High	Low	**High**
Homogeneity	High	Low	**High**
Complexity	Low	High	**High**
Knowledge integration mechanism	Experience accumulation	Articulation/ Codification	**Iterative model**



(Enberg, Lindkvist & Tell, 2006)

A more complicated case

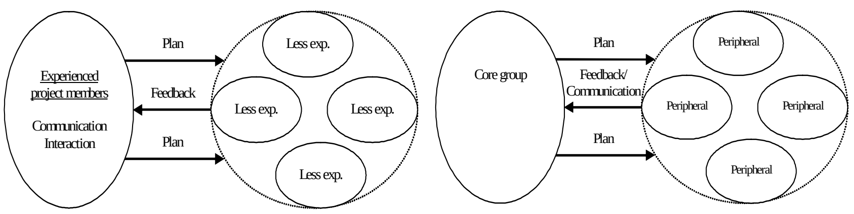
Steam Turbines
Enberg, C. (2007), *Knowledge Integration in Product Development Projects*, PhD Diss., Linköping University

A ”segregated” team

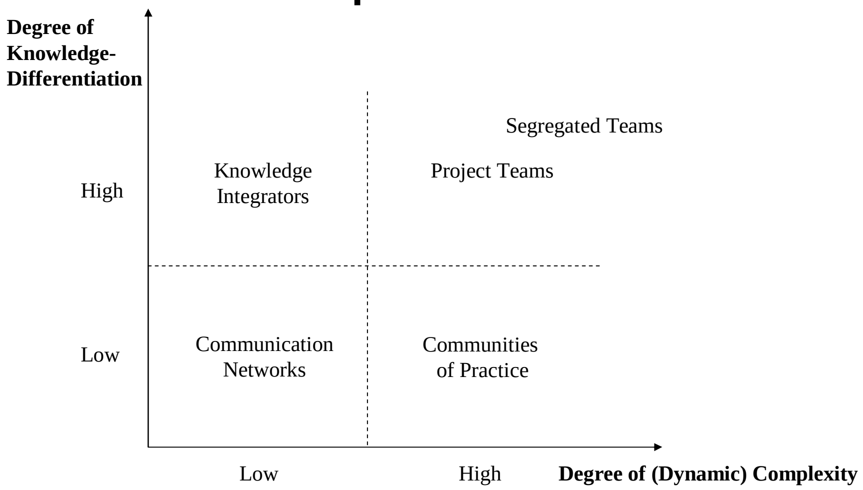
Core group		Peripheral group	
Experienced	Less experienced	Experienced	Less experienced
Arno (aero) Leonard (aero) Lukas (MI) Nikolaus (MI) Urs (aero, project manager) Valentin (MI)	**Alain (aero) Dieter (MI) Dominik (project manager) Franz (MI) Marcel (MI) Simon (MI)**	**Victor (cycle/FS) Jürgen (MI) Matthieu (MI) Gerhard (MI) David (MI)**	**Beat (aero)**

When complexity increases…

…so does division of labor and the need for communication



A tentative interpretation



(Adapted from Grandori, 2001)

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Conclusions and discussion

- The integration of knowledge in NPD
  - Both sequencing and group problem solving
  - Both tacit experience and articulation/codification
  - Both collectively and individually
- Technology as one contingency
  - Complexity and degree of decomposability (interaction/interdependencies)
  - Degree of novelty in relation to technological trajectories

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