Towards a Production Complexity Model that Supports Operation, Re-balancing and Man-hour Planning

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Research project: COMPLEX: Support for Operation and Man-hour Planning in Complex Production

Volvo Technology AB, Volvo Trucks Corp
Stoneridge Electronics, Örebro
Electrolux, Mariestad Plant
Volvo Cars Corp

Total budget 12.6 M SEK
Funding from Vinnova 6 M SEK
3.5 years: 2010 - July 2013
Parallel COMPLEX project in Belgium

- BE and SE projects: almost same scope, targets, organisation.
- BE project focus more on Re-balancing, less on indirect work.
- Flanders’ DRIVE as the coordinator
- Univ Gent as the research partner

- Funded by IWT
- 2 years, 2.2 M € (Also Ind. partners funded)
- Coordinated & linked with Swedish project
Complexity – an industrial challenge

Continuous strive for more **efficient** processes!

High degree of **customization**
Must have **flexible** processes
- Variants
- Components
- Changes
- Volume

Introduction of **sustainable** products further increase complexity.

Achieving both efficiency and flexibility requires **methods to better handle complexity**
Paper presents two studies

- **Initial case studies** – study of industrial needs
- Literature study of available models and methods
Initial case studies – study of industrial needs

AIM:
- gaining a better understanding of industrial needs and potential users of complexity models and methods
- certify that results applicable to industry
- delimit the literature study

METHOD:
- company visits,
- observation
- dialogue
Case studies on production complexity – method & status
Case studies conducted at Electrolux, Volvo Cars, Stoneridge (AB Volvo case study being planned)

Preperations
- Production system; delimitations – boundaries
- Theoretical Platform
- Common interview-guide
- Planning, information, practical issues
- Identification of participants

Planning step 1 & 2

Step 1: Systems´perspective: Objective focus
Product Flow, Level of Automation, Indirect work, etc.

Step 2: Function perspective: Subjective focus
Individual view: Actions taken to minimize complexity, effects/consequences, ways of working, challenges, etc.

Summary step 1 and 2
Crossfunctional complexity workshop
- Feedback
- Identification of improvement opportunities
- Priority of in-depth studies

Step 3: In-depth studies

Volvo Cars

Volvo Tech AB, Volvo Trucks Corp

Electrolux

Case study progress
Industrial case study results: needs & problems

- Models and methods must be easy to use / practical
- Function governs complexity perspective, problems & needs for support
- Four problem areas:
Literature study of available models and methods

PURPOSE
- purpose to identify models and methods to build upon for the continued research.

FOCUS
- definitions and perspectives of complexity,
- models of complexity considering different aspects of production,
- methods and models for measuring complexity,
- and means of visualization.
Difficult balance: theory vs. practice

\[ H_{\text{dynamic}}(S) = -P \log_2 P - (1 - P)P \log_2(1 - P) \]
\[ - (1 - P) \left( \sum_{m=1}^{M} \sum_{j=1}^{N} p_{ij} \log_2 p_{ij} \right) \]
\[ + \sum_{i=1}^{M} \sum_{j=1}^{N} p_{ij} \log_2 p_{ij} \]
\[ + \sum_{i=1}^{M} \sum_{j=1}^{N} p_{ij} \log_2 p_{ij} \cdot Q \]

\[ H(X) = - \sum_{i=1}^{n} p(x_i) \log_2 p(x_i) \]

Theoretical models
Generic results
Practical methods
Specific and directly applicable results
"Complex" means...

- difficulty of understanding, analyzing or solving something.
- that interdependency and behaviour emerging on system-level are central
- the opposite of independent, in contrast to “complicated” which is the opposite of simple.
- having a synthesis process of putting parts together and understanding the emerging behaviour of the whole system.
- complexity of a system is the degree of difficulty in predicting the system properties, given the properties of the system’s parts.
Complexity models: Entropy

- Complexity measurement
- Complexity entropy model
- Information needed to describe the states of a system.
- Based on probability of states
And what is complexity?
Characterization? Models?

What are the causes, drivers?

Support methods & tools for handling increased complexity...

What is the effect of increased complexity?

Needs and problems depend on who we ask......
Conclusions

- We present a suggested framework for dealing with complexity, which provides structure to models and ideas found in the literature and industrial study.

- **unknown events** increase with complexity
- Management of **uncertainty** increasingly important;
- role of **humans** in work systems crucial for coping with uncertainties
- need for support for **coping with complexity**
- A model and method must be **easy** to understand and use.
- Many of published models have a **theoretical** view of production
- Complexity model must
  - take a **holistic** view including all causing factors and both direct and indirect work;
  - and include **different user’s** perspective of the system.
- A complexity model and method should separate
  - **subjective complexity** from objective complexity,
  - **static complexity from dynamic** complexity, which includes uncertainties, variation, and changes.
Current & future work

CASE STUDIES
- The framework guided the design of case studies
- Case studies conducted
- In-depth studies

DEVELOPMENT
- Development of models and methods that support the users/tasks
  - Station complexity measurement
  - Complexity effects model:
    - man-hour planning,
    - information/competence req
  - Re-balancing support
Ur "Så bygger man en bil" av Norbert Andersson.
Bild: Eva Montén

Tack!

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**Literaturstudie**
- Beskrivit industriella utmaningar, behov
- Modell/definitioner: subjektiva och objektiva definitioner
- Plattform för design av fallstudier
- Paper SPS 11

**Forskning**
- Paper in progress ICPR 2011
- Mappar komplexitetsmodell mot resultat från fallstudier
- Definiera orsak-verkan
- Beskriva objektiva och subjektiva parametrar
- Plattform för djupstudier

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**Industrins engagemang och omhändertagande/nyttjande av resultaten**

![Diagram showing stages of research and development](Diagram)

- **Step 1:** Systems perspective
- **Step 2:** Function perspective
- **Step 3:** Indepth studies

- Prep: Preparations
- Planning: Planning
- Step: Step
- Step 1, 2, 3

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**Utveckling av modeller/metoder**

**Early Research**

**Research Challenges**

**Industrial Needs**
Work packages, structure, relations and work done

WP 1: Definition and analysis of Production Complexity (Johan Stahre, Chalmers)
WP 2: Determination & Planning of indirect tasks in complex production (Kerstin Dencker, Swerea IVF)
WP 3: Information and competence requirement for complex operations (Ulrika Harlin, Swerea IVF)
WP 4: IT tool and methods supporting line re-balancing work in complex process (Per Gullander, Swerea IVF)
WP 5: Integrated methodology for managing complex production and collaboration (Anna Davidsson, Volvo Cars)
WP 6: Project dissemination: Academic and Public (Asa Fasth, Chalmers)
WP 7: Management and administration (Per Gullander, Swerea IVF)

Generic Results
I Models and Methods generically applicable to manufacturing industry
II Models and Methods and tools specific to certain company’s work procedures, methods, tools, and needs
III WP 5: Integrated methodology for managing complex production and collaboration (Anna Davidsson, Volvo Cars)
IV WP 7: Management and administration (Per Gullander, Swerea IVF)
Deliverables/Plan
(From application)

D1.1, D2.1, D3.2: Case study plan for WP1,2,3

D1.2: A definition of complexity feasible for production on factory, line and station levels

D2.2: Model of the effects of increased complexity on organization and operations

D2.3: A method for planning the total plant man-hours with complex production processes, providing the relation between indirect and direct manning needs

D3.2: Description of requirements of information and competence in relation to added complexity and more indirect work tasks

D3.3: Methods to determine and support fulfillment of these requirements

D4.1: Definition of complex line rebalancing method needs and potentials for sustainability

D4.2: Model of a complex line rebalancing method indicating activities, methods, tools, and roles

D5.1: Integrated methodology to manage complexity in systems and operations


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