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ANALYSIS OF DECISION-MAKING PROCESSES IN THE DEVELOPMENT OF COMPLEX SOLUTIONS

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1 INTRODUCTION

Today's companies are focused on two topics – optimising their existing processes and generating growth – to increase their own wealth and assure a prosperous future.

Companies therefore concentrate on the work of their product development department because this department transforms ideas to products for their customers. Furthermore the methodology of concurrent engineering is often applied to optimise the product development process regarding the classical success factors cost-time-quality.

Concurrent engineering takes a holistic approach and accelerates projects by parallelising processes. Its biggest danger is the risk of iteration, especially loops of processes. Design Structure Matrix developed by Steward (1981), Eppinger (1997) and Browning (2001) is a tool to reduce this risk by illustrating, on the one hand possibilities for process parallelisation and on the other hand the process interdependencies. Design Structure Matrices as well as Multiple-Domain Matrices (Maurer, 2007) have been used to map dependencies between tasks, processes, actors, projects, risks and decisions. This paper focuses on Decision-Decision Matrices which are "few developed".

2 INTEREST OF DECISION-DECISION MATRICES

Decisions are an important part of development projects as they influence the tasks that will be done, the actors that will be assigned and the product that will be designed. They are often conducted by several actors with different and even sometimes conflicting interests. Whereas matrices of tasks, processes, projects and actors are helpful to show dependencies between different entities, they risk being superficial or not accurate during the time of the project. Decision-Decision Matrices can give more accurate information about dependencies at a given time, as it includes decisions which have influence during the project and decisions which have influence after the project, in the rest of the product lifecycle. In figure 1, decisions can have influence on other decisions which have to be made during the project, whether they are related to the project or the product. Other decisions may have influence on the product parameters, which can be its performance (use phase), its maintainability (maintenance phase) or its scrapping environmental impact (recycling and destruction phase).

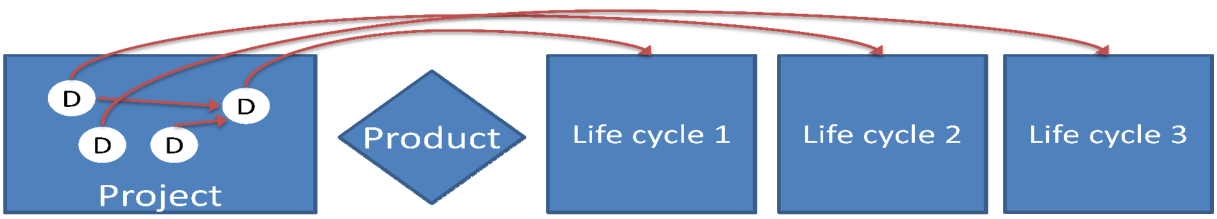

Figure 1. Influences of decisions during the life cycle

These decisions are interrelated in Decision-Decision Matrix. This information is essential to take a decision in order to not only reduce iterations but also to accelerate the whole process by synchronizing decisions. These matrices are especially helpful in the process of decision making to visualize the consequences of the decision which is about to be taken. Thus, these matrices illustrate which people should interact and coordinate themselves because they are directly or indirectly concerned in the decision-making process.

3 CHARACTERISTICS OF DECISIONS

As we map decisions and their dependencies in matrices, we have to understand the nature of decisions and their different types of dependencies.

First of all, decisions can be characterised by their affiliation. Decisions can either concern the final product of the product development process or they can relate to the process itself. The decision of the colour of a product concerns primarily the product for example and the decision of which actors take part in the weekly meeting is a project decision. The main risk is to forget that a Decision about the Product may also have an impact on the project parameters, and reciprocally. For instance, a decision about the geometry of a component may influence the duration of the development task, and then influence the final delivery date. On the contrary, a reduction of the project budget may put more constraint on the choice of a material.

For that reason, we model interrelations between Decisions and Parameters related to Product and Project into a MDM composed of 4 DSM and 12 DMM. Some of these DMM are of great interest, since they are not managed explicitly. This is the case of heterogeneous matrices, linking project and product components.

Examples of Product Parameters are: geometry, thermodynamics, mechanical performance, colour, functional property. Examples of Project Parameters are: project duration, project cost, project budget, potential return on investment. Whatever we choose, there will always be interdependencies between these parameters. A project delay may cause fines or need a higher budget to finish on time. The question of the nature and number of parameters will be discussed, as it influences the size and density of matrices. For the same reason, the number of considered decisions, respectively about product and project, has also to be carefully fixed. Too many decisions will result in a big and empty matrix. Too few decisions will cause a very dense matrix where everything is connected to each other. In both cases, it does not help decision-makers.

	$D_{prod,1}$	$D_{prod,2}$	$D_{prod,3}$	D_{proj1}	D_{proj2}	D_{proj3}	$P_{prod,1}$	$P_{prod,2}$	$P_{prod,3}$	P_{proj1}	P_{proj2}	P_{proj3}
$D_{product,1}$		1							1		1	
$D_{prod,2}$	1	1					1			1	1	1
$D_{prod,3}$				1	1			1		1	1	
$D_{project,1}$				1	1			1				1
D_{proj2}		1							1	1		
D_{proj3}	1						1			1		
$P_{product,1}$		1		1	1							
$P_{prod,2}$	1											
$P_{prod,3}$			1									
$P_{project,1}$				1								
P_{proj2}	1				1	1						
P_{proj3}				1								

Figure 2. Example of decision-decision matrix

4 BENEFITS OF THE USE OF DECISION-DECISION-MATRICES

We have already mentioned that a higher visibility of the dependencies of decisions is the basic goal of the Decision-Decision Matrices, because it helps to anticipate the potential global consequences of each decision. Moreover, other indicators may help to know whether the current project structure is too complex or to know how to reassign people to decisions in order to reduce this complexity. Decision-Decision Matrices may be used at a fixed point of time as well as in real time during the project.

Interpretation of the Decision-Decision Matrix at a fixed point of time, generally the beginning or the end of a project, permits a higher degree of details and helps to sum up the iteration risks in this project or to capture lessons learnt for future projects.

The strength of analysis of Decision-Decision Matrices in real time is the capability to react to the dynamics of the decision network. Iteration loops can be interrupted and anticipation can be made for instant reaction. This can therefore help to save projects from some problems, including sometimes global failure, whereas the analysis at a fixed point of time could explain the cause of these failures. The main difference is that it may help to react during the project instead of learning for the next one.

5 ONGOING STEPS OF RESEARCH: CASE STUDY

During a project of construction and launch of a public tramway project in the Middle East, a French industry giant encountered difficulties because the dependencies of decisions were not transparent [VIDAL 2009]. The need for tools to master the complexity of decisions was clearly identified. This example is especially useful as the decisions taken by the government, the contractor, the suppliers and the French company influenced each other.

The case study based on this industrial project will check and prove the validity of the characteristics of decisions. It will also permit to study the usefulness of modelling interdependencies between decisions for post-mortem project analysis and for real time project management. Ultimately, the case study might indicate further needs for research of the theory of Decision-Decision Matrices.

6 CONCLUSIONS AND PERSPECTIVES

In this paper, we have shown the significance of Decision-Decision Matrices as a tool which enables to map interdependencies at a given time or even for the global project. Afterwards we have discussed the different types of decisions and their ways to interact.

When the case study on the tramway project has successfully established the system of determining Decision-Decision Matrices, it will be necessary to analyse the structure patterns of Decision-Decision Matrices. The analysis of DSM-structure has already been well developed for entities as tasks and actors. The findings from these fields need to be applied to Decision-Decision matrices in order to verify their meaning for these matrices. For example, is the number of loops in a Decision-Decision Matrix an indicator for the complexity of the project?

Another perspective is to use numerical matrices to analyse decision dependencies. An evident difficulty is the pondering of the different types of dependencies to create a fusion factor.

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Introduction

Why focusing on decision interdependencies?

- Through trends as collaborative design, decisions tend to be taken by multiple actors who have to agree and to coordinate
- Decisions are highly interdependent
- Decisions are important and formal milestones in a project

Introduction

Motivation for DSM:

- Managing complexity
  - Reducing it
  - Adapting the organisation to cope it
- Method of Systems Engineering
- Way to obtain a higher transparence
- Master interpretation of data

Introduction

Entities dominantly used in the DSM-community:

- Tasks
- Actors
- Risks

But only few research on the entity type **"decision"**.

Decision-Decision Matrix

- Type DSM/MDM: Decision-Decision Matrix (DD), Actor-Actor Matrix (AA)
- Type DMM: Decision-Actor Matrix (DA), Actor-Decision-Matrix (AD)

- Calculations with Decision-Decision Matrix:
  - DA*AD=DD (number of common actors)
  - AD*DA=AA (number of common decisions)
  - DD*DD=DD (propagation of dependencies)
  - AD*DD*DA=AA (actors connected because they are assigned to interdependent decisions)

- Clustering of Decision-Decision or Actor-Actor matrices
  - To group strongly interdependent decisions (actors)
  - Allows for better coordination on decisions which are strongly related

Case study

Data of New Product Development Process of French automotive manufacturer permitted detailed analysis of interdependencies and validation of Decision-Decision Matrix

Mapping of:

- Official Order of Decisions
- Level of decision
- Affiliation of Decisions to Decision Groups (Processes)
- Clear roles of actors in Decisions
  - Manager
  - Decider
  - Impacted

Quality of Data → Multiple matrices → Analysis

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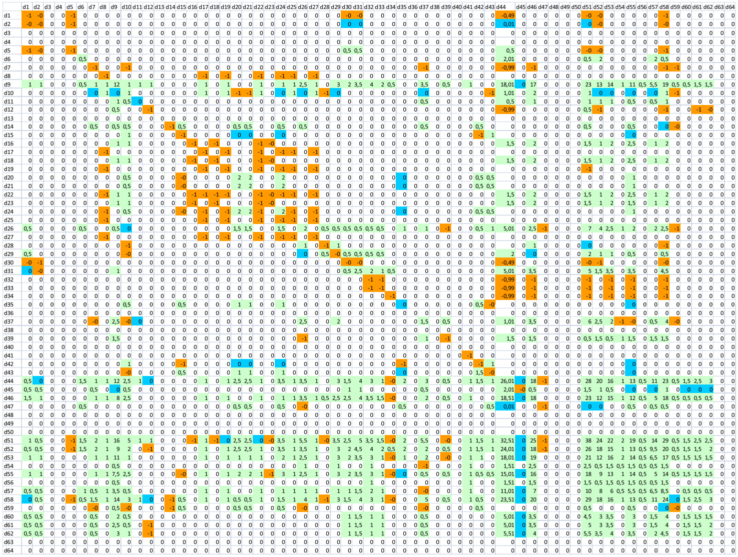
Case Study

- Comparison Decision-Decision Matrix calculated by DA*AD=DD with formal decision order of the company
  - To what extent is the number of actors in common an indicator for the impact of one decision on the other?
- Taking in consideration the level of a decision in the formal decision order
  - Does an impact between two important decisions share more actors than the impact between two low-level decisions?
- Comparison Actor-Actor Matrix calculated by AD*DA=AA with formal organizational diagram of the company
  - In what way does the number of decision two actors share in indicate an exchange between these two actors?

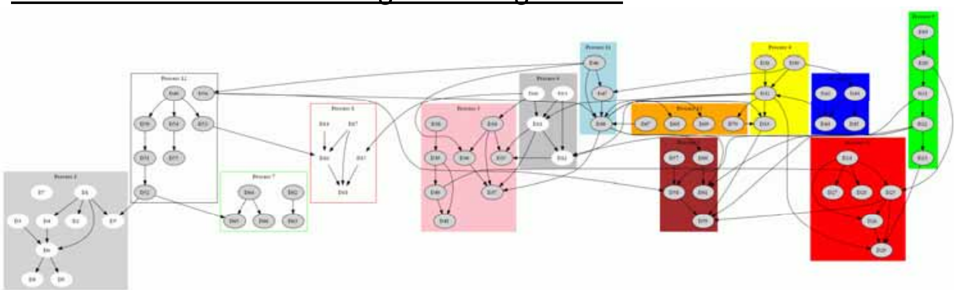
Case Study

Formal versus informal: AD*DD$_{formal}$*DA-AD*DA

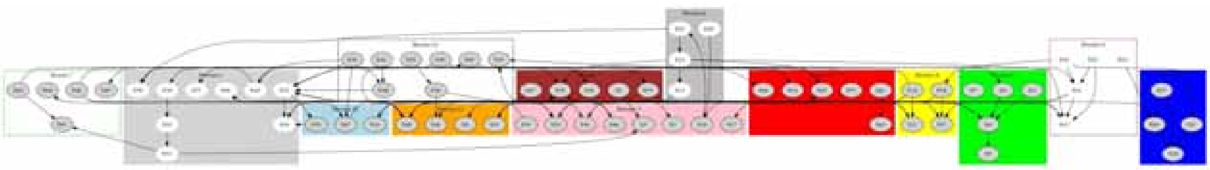


Case Study

Clustering:
Formal decision order in original configuration

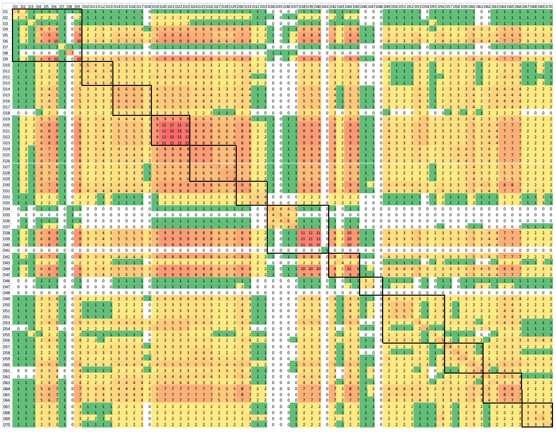


Decision order in clustering rearrangement



Case Study

Clustering: Impact on dependencies
Actual configuration compared to clustered configuration



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Outlook

Results:

- Promising work on Decision-Decision Matrix

Further Steps:

- Continue case study and identify further fields of research.
- Validate results of case study with other applications.