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DMM PARTIONING ANALYSIS FOR DESIGN STUDY PROCEDURE OPTIMIZATION

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Keywords: DSM, DMM, QFD, Partitioning, Design, Evaluation, Process Optimization

1 INTRODUCTION

DSM is one of the most suitable ways to analyze product development processes. On the other hand, describing and maintaining DSM matrix which has complex dependencies is painful. This is one of the major issues when we expect to use DSM in practice.

DMM partitioning method we developed is to overcome this issue in design study procedure optimization. This method adopts user inputs as Domain Mapping Matrix format (DMM, QFD like format, matrix of requirements vs. components or parameters). The DMM contains inter-domain dependency and design risk and design freedom of each item. Then it converts user inputs of DMM format to DSM format automatically which describes detail process of design and evaluation. This generated DSM matrix can be analyzed to optimize design and evaluate process with existing DSM sequencing technique.

By using this DMM partitioning method, we can describe and analyze design study procedure or detail process of design and evaluation with approx. 1/4 to 1/20 load and time compared to when user describes DSM in the conventional way. In addition, we can maintain and update DSM much more easily when situation is changed because DMM as user input maintains eigen information dependencies between items and status information of each item (risk and design freedom) separately.

2 MOTIVATION

In past, focal point of product development process improvement for almost manufacturers was to establish and optimize gate management process. But recently, leading manufacturers' focus is shifting to inter-gate process optimization. This is to achieve higher productivity with less variance.

When we look at product development process, we can outline the process schematic as three layered process. Figure 1 shows the three layers of product development process. The top layer is gate management process as described above for minimal process leveling through the organization and this gate management process is defined as static or ruled process. In this layer, we don't find any loops. The middle layer is inter-gate work-process mainly for inter-module or inter-division process synchronization at rough level and this level has intermediate characteristic between rule and situation depend. In this layer, we can see a few loops but not strong loops. The bottom layer is inter-gate design study process to define detail procedures what requirement should be evaluated before than others? Or what design parameters should be fixed before than others? In this layer, we can see a lot of loops. When we look at the third layer, design study process, this layer is typically very complicated and also situation depending process. This process layer should be optimized repeatedly according to the situation changes. But, describing and maintaining the design study process is painful when we use DSM in the conventional way.

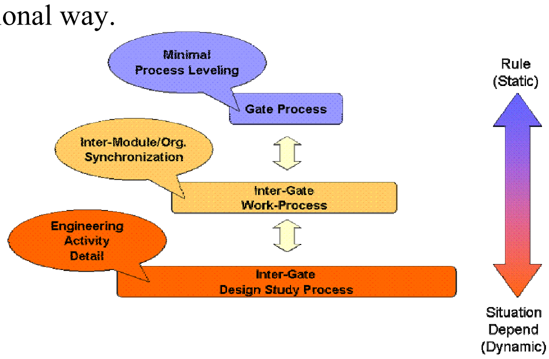

Figure 1. Three Layers of Product Development Process

3 BASIC THEORY OF DMM PARTITONING

3.1 Analysis overview

In this approach, User Input and Output is DMM format. When user invokes DMM partitioning analysis, the first step is DSM generation from DMM input. Then generated DSM is partitioned and then DMM is reordered according to DSM partitioning result. These steps are automatically executed by analysis tool we developed. Figure 2 shows the analysis overview.

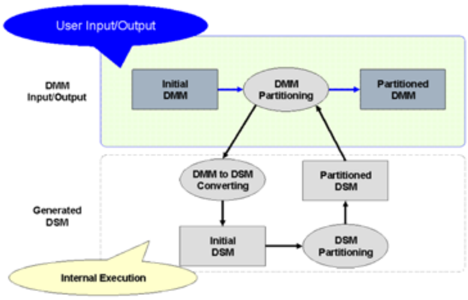

Figure 2. Analysis Overview

3.2 Extended DMM format

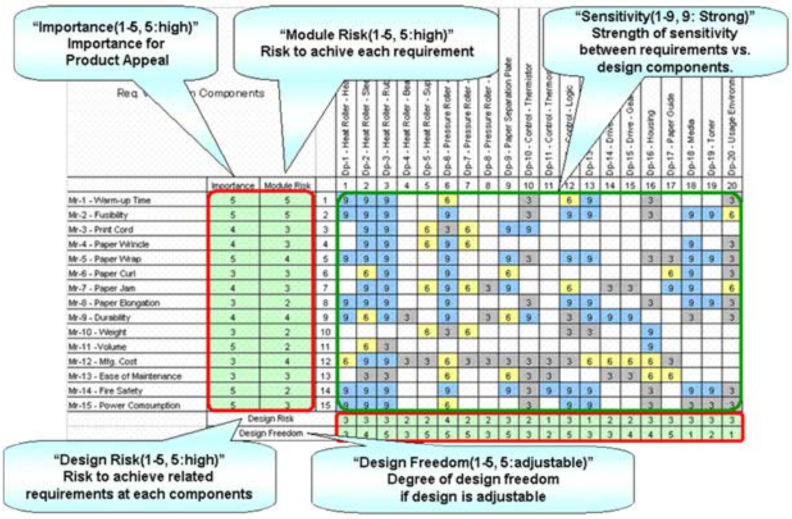

Figure 3. Extended DMM Format

Figure 3 shows extended DMM format for user input and output. This format consists of sensitivities between requirements and parameters as non-directed dependencies and status information of each item (importance, requirement risk, design risk and design freedom)

3.3 DSM generation

DSM generation is to generate directed dependencies between all items from non-directed dependencies and each item status in DMM input. Generated DSM example is shown in Figure 4.

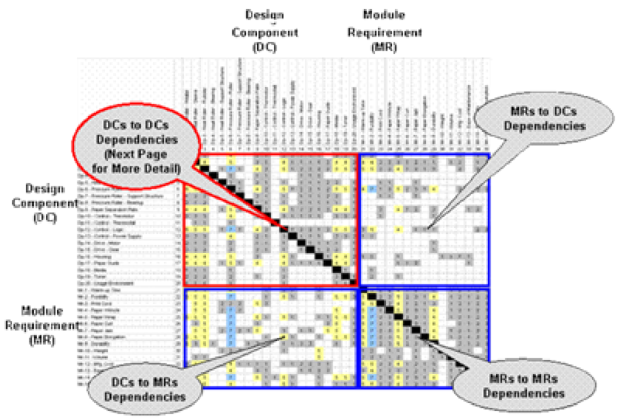

Figure 4. Generated DSM

To automatically generate DSM from DMM input, firstly, it puts all of design components and module requirements in row and column. Secondary, it calculates directed dependencies by using 4 different conversion algorisms for 4 categories as shown in Figure 4. These directed dependencies means strength of unexpected information flow between items. These prediction schematics are basically analogous to water flow strength prediction in the water flow system. Figure 5 is the schematic of directed dependency strength calculation for DCs to DCs.

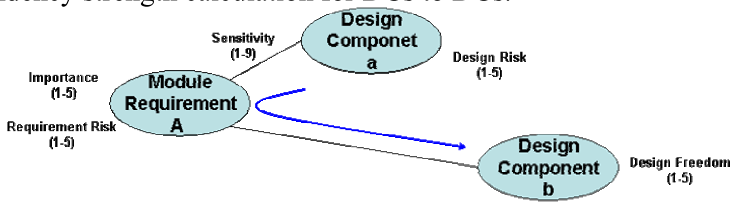

Figure 5. Schematic of DSM Generation for DCs to DCs

- A design component which has higher risk tends to generate more unexpected Information.
- Stronger Information flow tends to occur between sensitivity paths which has stronger sensitivity and higher requirement importance and requirement risk.
- A design component which has more design freedom tends to adapt more unexpected information flow.

Generated DSM is analyzed by conventional DSM partitioning technique. Then, user output as DMM is re-ordered according to generated DSM partitioning result and loop contour is also described.
This DMM partitioning result as shown in Figure 6 suggests where iterations are predicted between components design and requirements evaluation and it also summarize DSM partitioning result as optimized design and evaluation process.

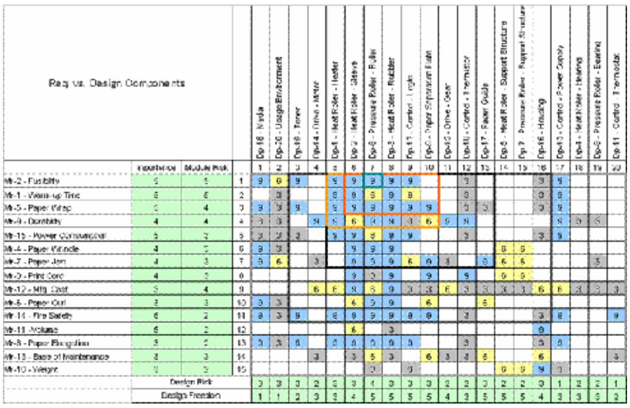

Figure 6. DMM Partitioning Result

SUMMARY

By using DMM Partitioning method, we can analyze design and evaluation process more easily because DMM partitioning method can reduce user input load and time at around 1/4(2 domains case) to 1/20(3 domains case or more) compared to when describing DSM in the conventional way. Reducing user input load is key enabler to analyze design study procedure in practice because these processes are typically very complex. In addition, we can maintain and update DSM of directed dependencies much more easily when situation is changed because DMM as user input maintains non-directed eigen information dependencies between items and status information of each item (risk and design freedom) separately.
We have applied this methodology for recent 3 years to our consulting clients including copier and automotive cases and these clients accept the DMM partitioning result as reasonable suggestion. We will continue to increase cases and improve this methodology based on clients' feedback.

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DMM Partitioning Analysis
For Design Study Procedure Optimization

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Japan

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- Motivation
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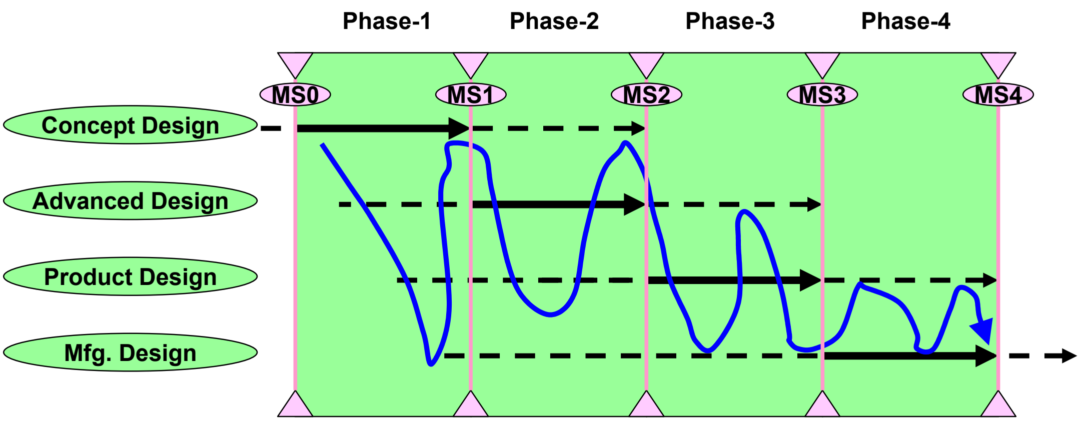
- Usage Scene
- Summary

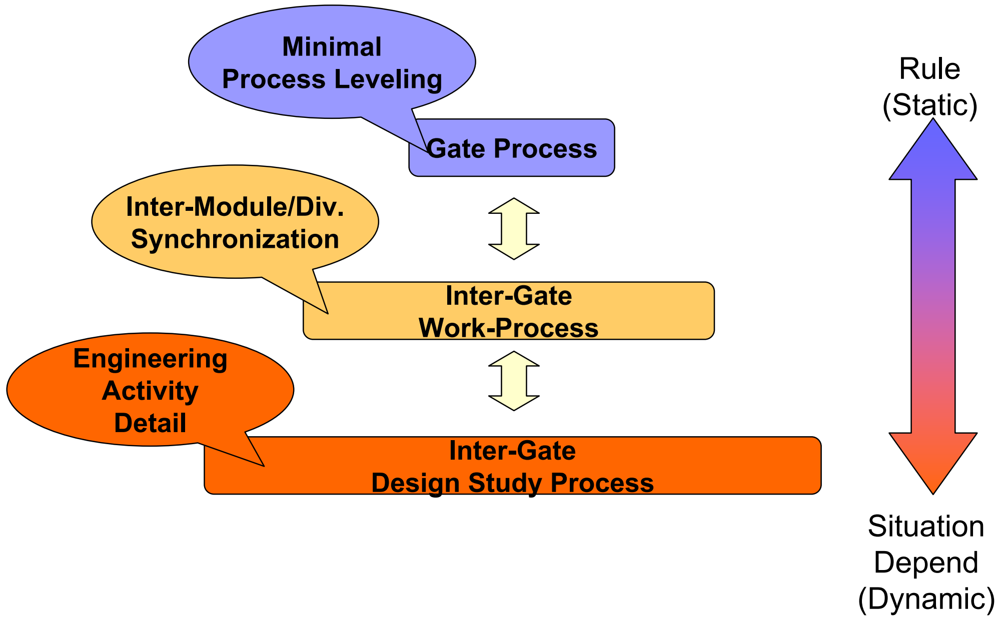
Motivation

Product Development Process Overview

- Past
  - Gate Management Focus
- Current
  - "Inter-Gate Process" have to be optimized for higher productivity with less variance.



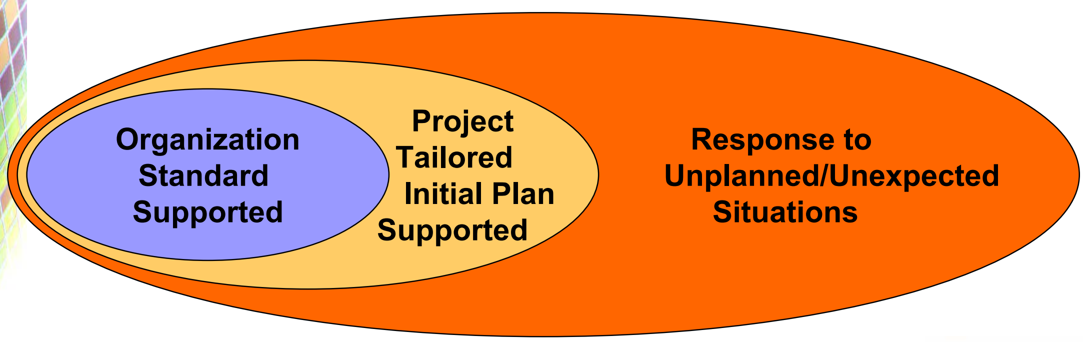
3 Layerd Product Development Process



Requirement for Process Optimization (Cont’d)

- Limited support by organization standard and initial plan
  - Standard is definitely necessity…… but….
- Majority of process management is to response unplanned/unexpected situation especially for high risk project.
  - Management ability gap between managers become obvious once unplanned/unexpected situations happen.

Typical Design Study Process Management



Challenge for Design Study Procedure Optimization

- How to handle complex process includes loops?
  - ✓ **DSM!!**
- How to manage large system within reasonable time and effort?
  - **Describing and maintaining DSM is painful especially for large systems.**
- How to manage uncertainty and quickly response unexpected?
  - **DSM dependencies are frequently changed according to situation…**

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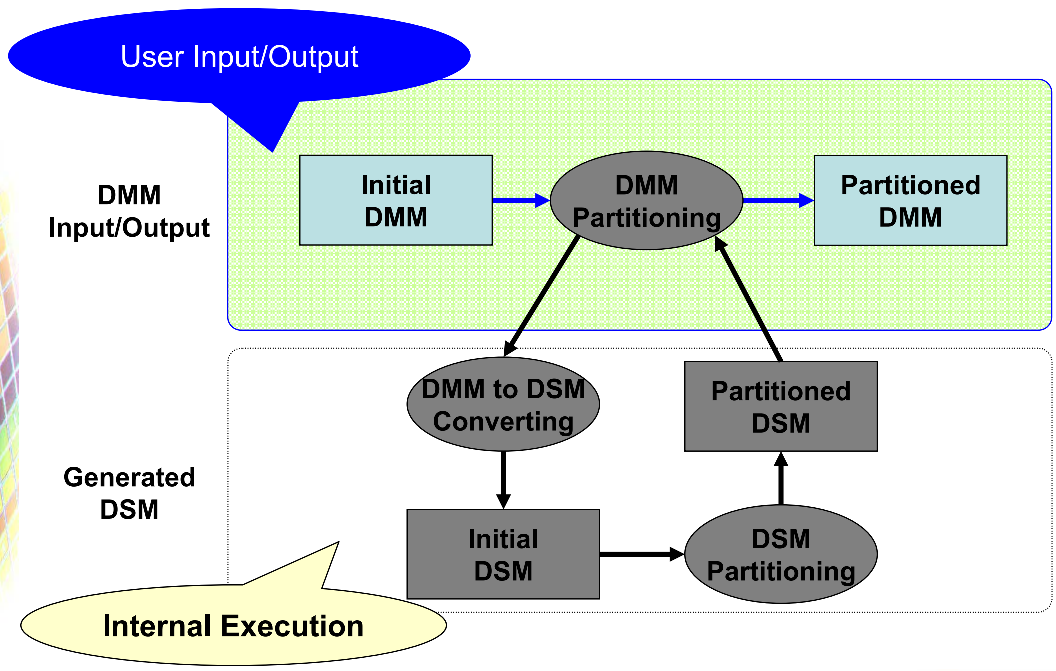
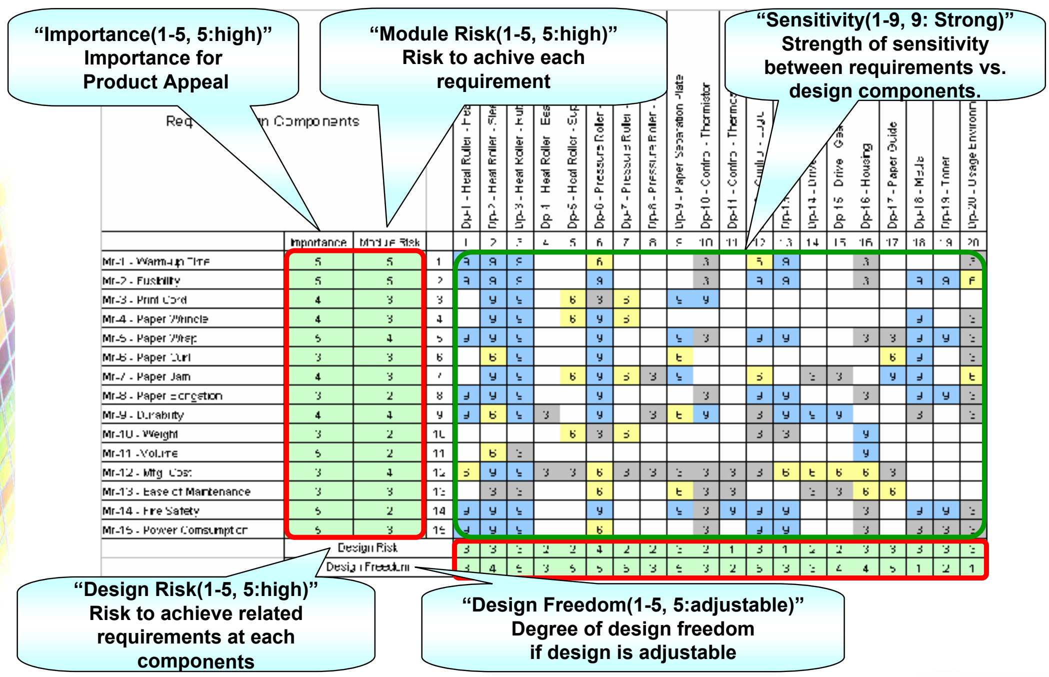
Basic Theory of DMM Partitioning

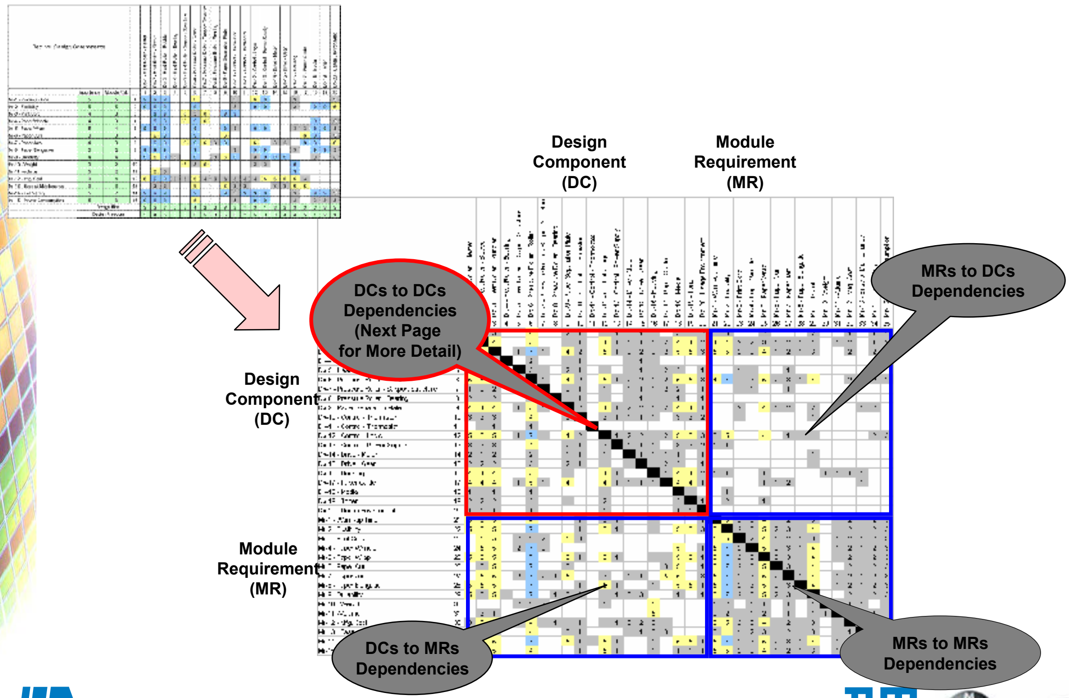
Analysis Overview



User Input as DMM format

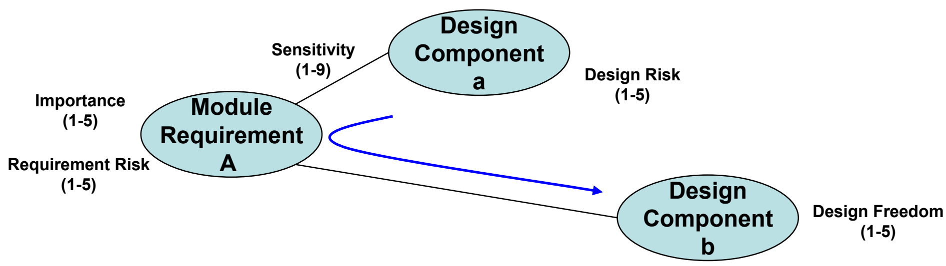


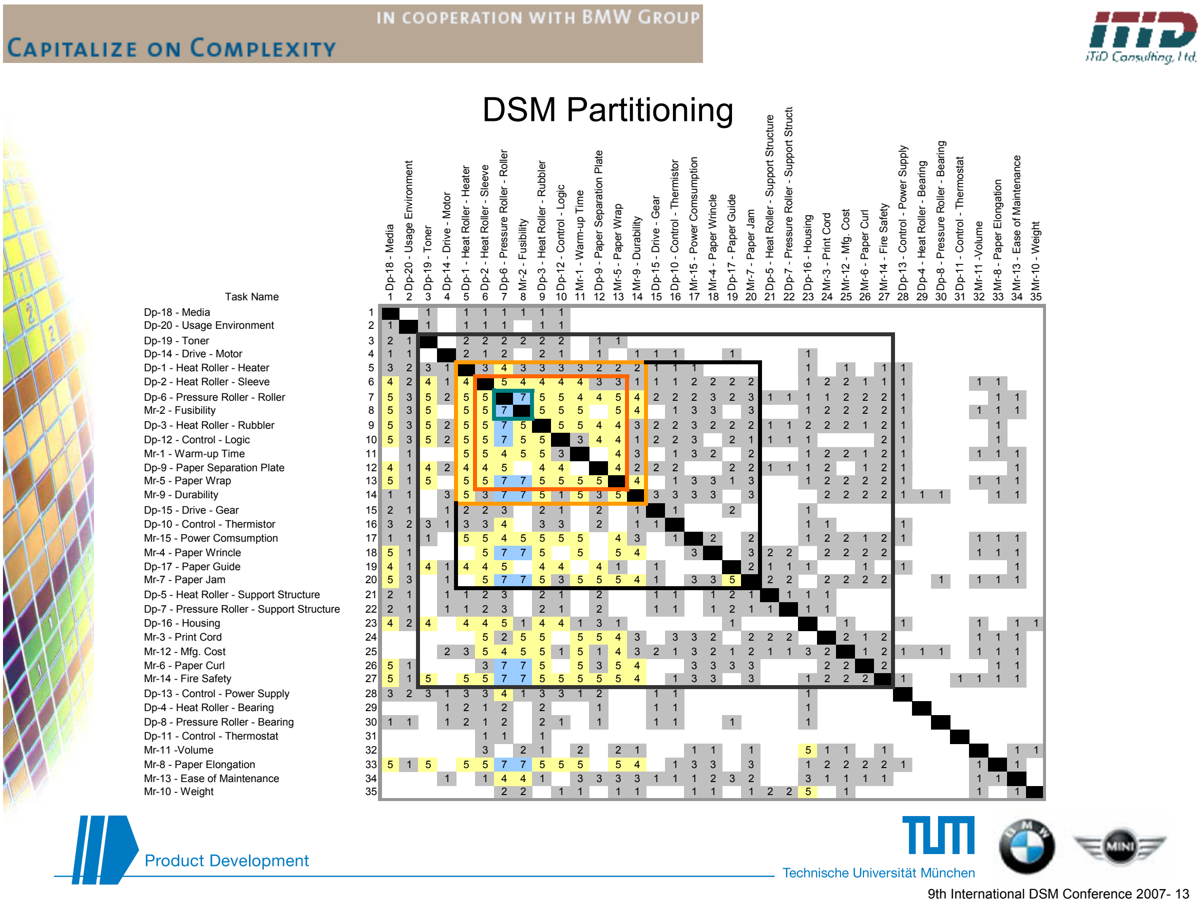
About DMM to DSM Conversion



About DMM to DSM Conversion (Cont'd)

- How to predict "Unexpected Information Flow" between DPs?
  - A design component which has higher risk tends to generate more unexpected Information.
  - Stronger Information flow tends to be occurred between sensitivity paths which has stronger sensitivity and higher requirement priority.
  - A design component which has more design freedom tends to adapt more unexpected information flow.





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DSM Partitioning
Task Name
Dp-18 - Media
Dp-20 - Usage Environment
Dp-19 - Toner
Dp-14 - Drive - Motor
Dp-1 - Heat Roller - Heater
Dp-2 - Heat Roller - Sleeve
Dp-6 - Pressure Roller - Roller
Mr-2 - Fusibility
Dp-3 - Heat Roller - Rubbler
Dp-12 - Control - Logic
Mr-1 - Warm-up Time
Dp-9 - Paper Separation Plate
Mr-5 - Paper Wrap
Mr-9 - Durability
Dp-15 - Drive - Gear
Dp-10 - Control - Thermistor
Mr-15 - Power Comsumption
Mr-4 - Paper Wrincle
Dp-17 - Paper Guide
Mr-7 - Paper Jam
Dp-5 - Heat Roller - Support Structure
Dp-7 - Pressure Roller - Support Structure
Dp-16 - Housing
Mr-3 - Print Cord
Mr-12 - Mfg. Cost
Mr-6 - Paper Curl
Mr-14 - Fire Safety
Dp-13 - Control - Power Supply
Dp-4 - Heat Roller - Bearing
Dp-8 - Pressure Roller - Bearing
Dp-11 - Control - Thermostat
Mr-11 -Volume
Mr-8 - Paper Elongation
Mr-13 - Ease of Maintenance
Mr-10 - Weight
Product Development
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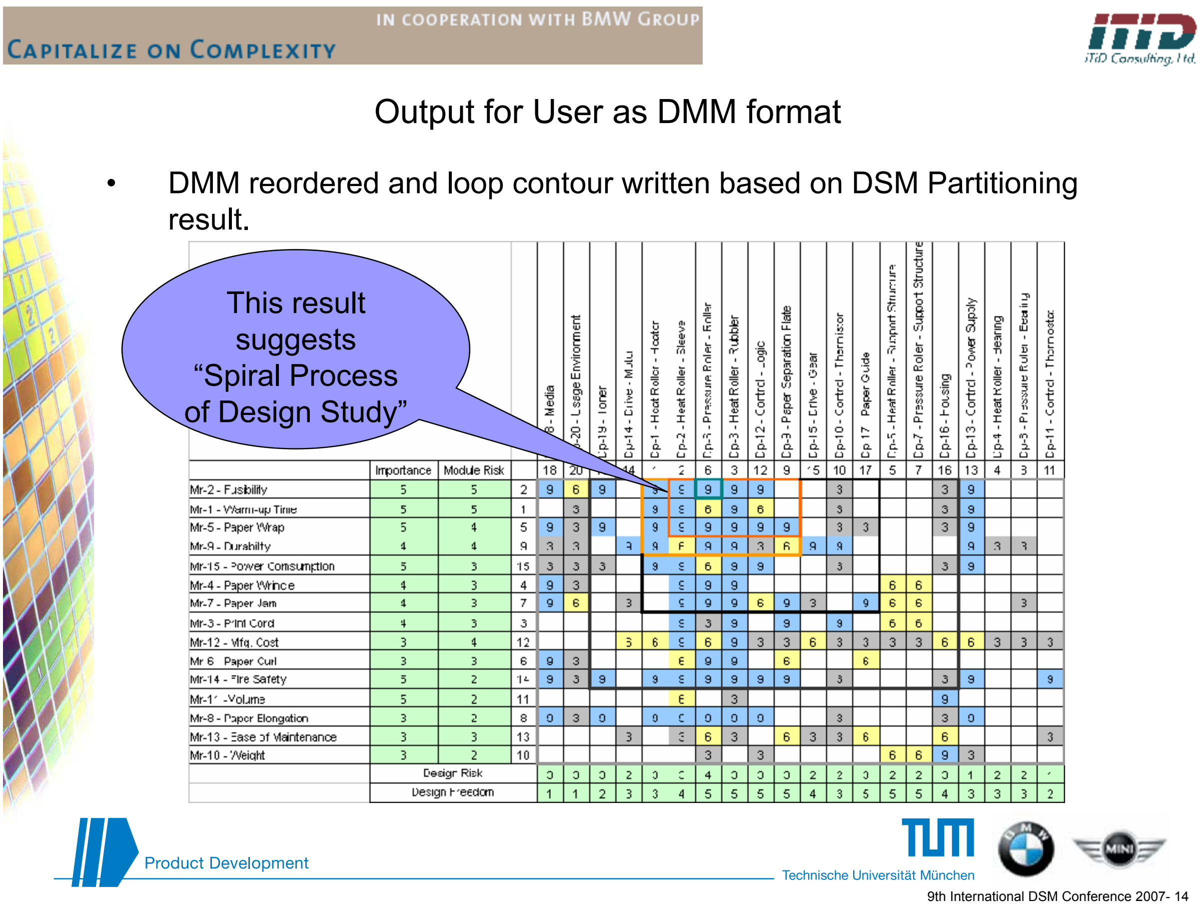

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Output for User as DMM format
• DMM reordered and loop contour written based on DSM Partitioning result.
This result suggests "Spiral Process of Design Study"
Importance
Module Risk
Mr-2 - Fusibility
Mr-1 - Warm-up Time
Mr-5 - Paper Wrap
Mr-9 - Durability
Mr-15 - Power Comsumption
Mr-4 - Paper Wrince
Mr-7 - Paper Jam
Mr-3 - Print Cord
Mr-12 - Mfg. Cost
Mr-6 - Paper Curl
Mr-14 - Fire Safety
Mr-11 -Volume
Mr-8 - Paper Elongation
Mr-13 - Ease of Maintenance
Mr-10 - Weight
Design Risk
Design Freedom
Product Development
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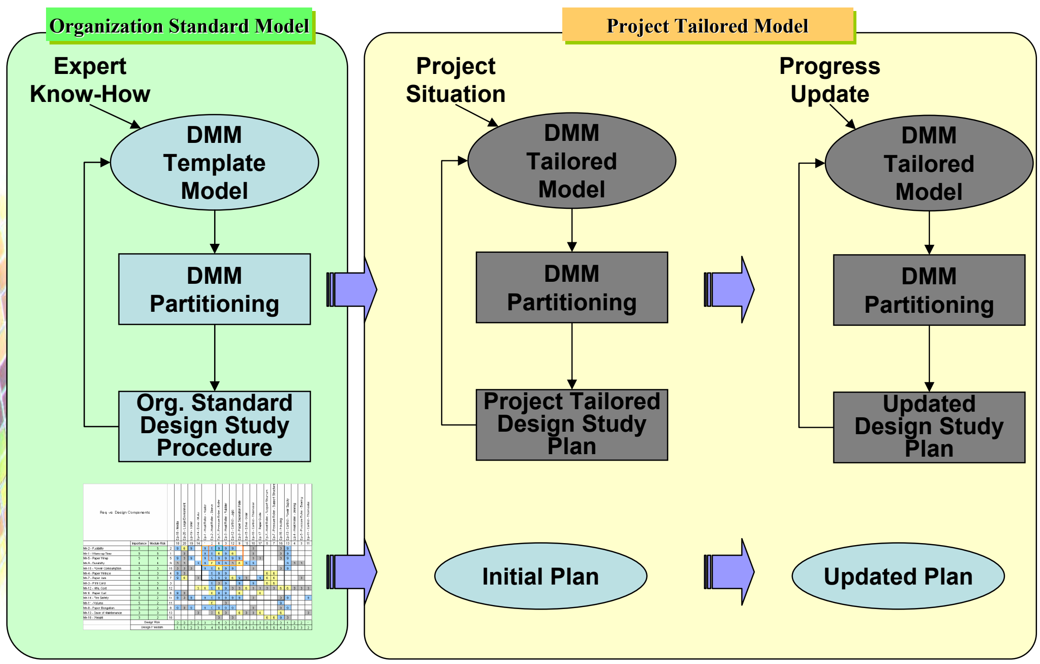
Usage Scene

Typical Usage Scene



Initial DMM (at the beginning of Phase-1)

Loop Level 1
Loop Level 2
Loop Level 3
Loop Level 4
Loop Level 5
Loop Level 7

	Importance	Module Risk		Cp-18 - Media	Cp-20 - Usage Environment	Cp-19 - Toner	Cp-14 - Drive - Motor	Cp-1 - Heat Roller - Heater	Cp-2 - Heat Roller - Sleeve	Cp-6 - Pressure Roller - Roller	Cp-3 - Heat Roller - Rubber	Cp-12 - Control - Logic	Cp-9 - Paper Separation Plate	Cp-15 - Drive - Gear	Cp-10 - Control - Thermistor	Cp-17 Paper Guide	Cp-5 - Heat Roller - Support Structure	Cp-7 - Pressure Roller - Support Structure	Cp-16 - Housing	Cp-13 - Control - Power Supply	Cp-4 - Heat Roller - Bearing	Cp-8 - Pressure Roller - Bearing	Cp-11 - Control - Thermostat
				18	20	19	14	1	2	6	3	12	9	15	10	17	5	7	16	13	4	8	11
Mr-2 - Fusibility	5	5	2	9	6	9		9	9	9	9	9			3				3	9			
Mr-1 - Warm-up Time	5	5	1		3			9	9	6	9	6			3				3	9			
Mr-5 - Paper Wrap	5	4	5	9	3	9		9	9	9	9	9	9		3	3			3	9			
Mr-9 - Durabilty	4	4	9	3	3		9	9	6	9	9	3	6	9	9					9	3	3	
Mr-15 - Power Comsumption	5	3	15	3	3	3		9	9	6	9	9			3				3	9			
Mr-4 - Paper Wrince	4	3	4	9	3				9	9	9						6	6					
Mr-7 - Paper Jam	4	3	7	9	6		3		9	9	9	6	9	3		9	6	6				3	
Mr-3 - Print Cord	4	3	3						9	3	9		9		9		6	6					
Mr-12 - Mfg. Cost	3	4	12				3	6	9	6	9	3	3	6	3	3	3	3	6	6	3	3	3
Mr 6 Paper Curl	3	3	6	9	3				6	9	9		6			6							
Mr-14 - Fire Safety	5	2	14	9	3	9		9	9	9	9	9	9		3				3	9			9
Mr-11 -Volume	5	2	11						6		3								9				
Mr-8 - Paper Elongation	3	2	8	0	3	0		0	0	0	0	0			3				3	0			
Mr-13 - Ease of Maintenance	3	3	13				3		3	6	3		6	3	3	6			6				3
Mr-10 - Weight	3	2	10							3		3					6	6	9	3			
	Design Risk			3	3	3	2	3	3	4	3	3	3	2	2	3	2	2	3	1	2	2	1
	Design Freedom			1	1	2	3	3	4	5	5	5	5	4	3	5	5	5	4	3	3	3	2

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Updated DMM (at the beginning of Phase-2)

Loop Level 1

Req vs Design Components

	Importance	Module Risk		Cp-1 - Heat Roller - Heater	Cp-4 - Heat Roller - Bearing	Cp-8 - Pressure Roller - Bearing	Cp-10 - Control - Thermistor	Cp-11 - Control - Thermostat	Cp-13 - Control - Power Supply	Cp-14 - Drive - Motor	Cp-18 - Media	Cp-19 - Toner	Cp-20 - Usage Environment	Cp-2 - Heat Roller - Sleeve	Cp-3 - Heat Roller - Rubber	Cp 6 Pressure Roler Roller	Cp-9 - Paper Separation Plate	Cp-17 - Paper Guide	Cp-15 - Drive - Gear	Cp-12 - Control - Logic	Cp-16 - Housing	Cp-5 - Heat Roller - Support Structure	Cp-7 - Pressure Roler - Support Structure
				1	4	8	10	11	13	14	18	19	20	2	3	6	9	17	15	12	16	5	7
Mr-1 - Warm-up Time	5	2	1	9			3		9				3	9	9	6				6	3		
Mr-2 - Fusibility	5	2	2	9			3		9		9	9	6	9	9	9				9	3		
Mr-3 - Print Cord	4	2	3				9							9	9	3	9					3	6
Mr-4 - Paper Wrince	4	2	4								9		3	9	9	9						3	6
Mr-5 - Paper Wrap	5	2	5	9			3		9		9	9	3	9	9	9	9	3		9	3		
Mr-6 - Paper Curl	3	2	6								9		3	6	9	9	6	6					
Mr 7 Paper Jam	4	2	7			3				3	9		6	9	9	9	9	9	3	6		3	6
Mr-8 - Paper Elongation	3	2	8	9			3		9		9	9	3	9	9	9				9	3		
Mr-9 - Durabilty	4	2	9	9	3	3	9		9	9	3		3	6	9	9	6		9	3			
Mr 12 Mfg. Cost	3	2	12	6	3	3	3	3	6	6				9	9	6	3	3	6	3	6	3	3
Mr-14 - Fire Safety	5	2	14	9			3	9	9		9	9	3	9	9	9	9			9	3		
Mr-15 - Power Comsumption	5	2	15	9			3		9		3	3	3	9	9	6				9	3		
Mr-10 - Weight	3	2	10						3							3				3	0	3	6
Mr-11 -Volume	5	2	11											6	3						9		
Mr-13 - Ease of Maintenance	3	2	13				3	3		3				3	3	6	6	6	3		6		
	Design Risk			2	1	1	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	1	1
	Design Freedom			3	3	3	3	2	3	3	1	2	1	4	5	5	5	5	4	5	4	5	5

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Summary

Summary

- Analysis Result is Reasonable and Acceptable for User.
  - Validated this analysis results with our consulting clients. (copier, automotive and other industry clients)
- Easy to Model Information Dependencies
  - Appx. 1/4 (2 domains case) to 1/20 (3 domains or more case) description load compared to the conventional way.
- Easy to Update Information Dependencies
  - This approach maintains eigen information dependencies (sensitivities) and status information of each item (risk and design freedom) separately.