KEYWORDS › Global product development project › Multi-domain matrix (MDM) › Communication process › Communication process map › Technical communication

MULTI-DOMAIN MATRIX AS A FRAMEWORK FOR GLOBAL PRODUCT DEVELOPMENT PROJECT PROCESS

ABSTRACT

The global product development (GPD) project is complex and there is a need to integrate a specific communication process among teams involved in the project. In each stage of a GPD project, effective and efficient communication becomes a core issue. The purpose of this paper is to introduce a multi-domain structure matrix (MDM) enables the systematic identification of interdependencies, explores the teams communication process in GPD. This paper presents a tool to identify efficient communication process map and technical communication for each function of the overall project. The outcomes of this process are identifying teams' communication process as an efficiency requirement for a GPD project, and MDM analysis as a methodology of managing complex process structure.

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1. Introduction

The costs, expressed in money as well as time, associated with communication process in GPD projects, may become prohibitive. Communication, between team members in the GPD project, and costs constraints may create a high degree of resource uncertainty related to the availability level of the GPD project *(Lindstrom et al., 2012)*. To stay on the top of this challenge, the adequacy of available communication process, timely shared and understood, is vital in GPD projects to reduce uncertainty, ambiguity and complexity.

Considering communication between teams in GPD projects, communication must be effective, that is, an information source must be able to codify knowledge and to locate the relevant teams receivers on information *(Hung et al., 2008)*. Second, communication must also be efficient, that is given the effectiveness requirements, the cost of communication must be minimized and information leaks must be avoided.

There are numerous approaches available to support communication process, and many different process models have come up to depict various aspects of costs management. This paper explores how to model the communication process in GPD projects based on communication process map and technical communication, and how to analyze it using the Design Structure Matrix *(DSM)* and the Multi-Domain Matrix *(MDM)*.

2. Teams communication process in GPD projects

Five functions are of core importance for almost each PD project: concept generation, product planning, product engineering, process engineering and production process *(Clark and Fujimoto, 1991)*. This typically requires that members of product development team communicate with others, either within or outside the development team, in order to accomplish their development activities. The degree of task interdependence, described in each function in GPD project, shows the degree of tasks requiring the collective action *(Wageman, 1995b)*. This is consistent with previous research that has shown that a greater degree of task interdependence leads to greater communication *(Adler, 1995b; Crawford and Haaland, 1972)*.

Using communication process map as shown in **Figure 1**, we can sketch the development process underscores the importance of communication teams at detailed the five functions of GPD project. This simplified model of product development process has shown relatively generic activities for each function. For purpose of this paper, every work package is done by one team and is considered as a sub-project. For example, the function of process engineering translates detailed product design communication team into process design, and ultimately into actual shop-floor production processes. Process design team communication created in the upstream part of this function includes overall plant design team, hardware design team, software design team, and work design team. The communication map give critical linkages across the five functions of GPD in terms of teams work. However, the vertical links show step-by-step a refinement of key communication assets down through the functions; the horizontal links suggest problem-solving cycles within each function. For each problem-solving cycle, boxes to the left represent alternative solutions; boxes to the right denote evaluation results of those alternatives, and the boxes in between represent technical communication that may be used to estimate costs generated in each function of the GPD process. Hence, the vertical links determine the effectiveness of teams communication exchange across functions, which is reflected in how well the early function stimulate actual production and market conditions and how well the later functions implement the designs and plans developed earlier.

The timing and integration of multiple teams communication linkages may greatly affect overall lead time, cost and productivity of GPD project. **Figure 2** shows the elements of an effectively run virtual product development team *(Tavcar et al., 2005)*.

We identify the type of technical communication *(Sosa et al., 2002)* associated to each interaction between teams, and, related cost to this interaction. For example, we apply the different types of technical communication sharing at the level of product planning team according to the communication map in **Figure 1**. The technical communication is expressed by five types incorporated in GPD project *(Sosa et al., 2002)*: procedures *(including instructions and manuals)*, memos, packaged media *(electronic texts, internet web page, intranet web page, printed matter, training sessions)*, proposals, and reports *(including quick reference cards)*.

3. Dependency analysis in GPD projects using MDM

The Design Structure Matrix *(DSM)* is an effective way to analyze complex system. Interdependencies between activities are defined the exchanged information to fulfill functions of GPD project.

A simple extension of the single-domain DSM model is achieved by labeling the DSM elements according to their relationship with elements in a secondary domain. Each individual domain modeled with an appropriate DSM. This represents a typical scenario in GPD process, because each function of the process dependent on others functions due to data transfer. The network of teams in each function of the overall process can be acquired without regarding a second domain. The technical communication must be added to draw dependencies between the functions and the teams of the GPD project. The intra-domain network for analyzing dependencies between three different DSM is shown in **Figure 3**. The multi-domain matrix *(MDM)*, as an inclusive term, is a rectangular matrix mapping between DSM domains. The process-based DSM represents the dependencies between the five functions of GDP project. The organ-

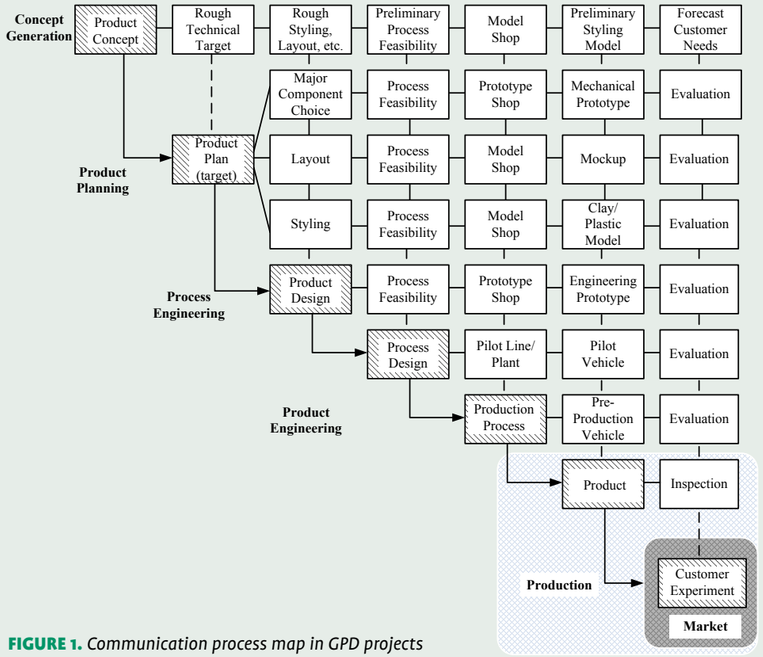

FIGURE 1. *Communication process map in GPD projects*

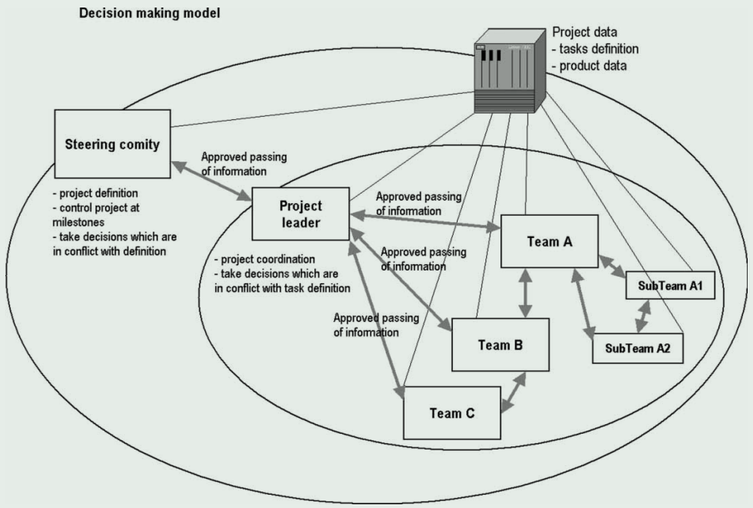

FIGURE 2. *Virtual communication teams process in GPD project*

ization-based DSM represents the dependencies between the teams in charge of each separate activity of the functions. The parameter-based DSM represents the distributed dependencies between different types of technical communication sharing between teams.

For example, the function of product planning *(composing the process DSM)* translates the function of product concept into specifics for detailed product design, including styling, layout, major specifications, investment and cost targets, and technical choices.

The key problem at this function is to come up with a plan that reconciles competing objectives and requirements. Through most of technical communication *(composing organization DSM)* created at this function is still intangible *(shown in figure 1)*; teams, in charge, may employ physical models for styling evaluation mockups for layout evaluation, and early stage prototypes to evaluate styling and layout and test advanced components. The product planning represents the first opportunity to interpret the product concept in physical form. Hence, the Domain Mapping Matrix *(DMM)* design the efficient technical communication in each function of GPD process.

The meaning of the dependencies is noted in the five matrices. This acquisition of dependencies in the MDM is represented **Figure 4**. The domain in a row is mapped to the domain in a column. For example, a function of GPD project process determines other functions of the process, whereas the same function can change the team communication process and determine which type of technical communication is selected. This figure indicates how a team charged in one function can influence the results and change the work-team in another function.

Regarding the nature of the overall process and its management, we can infer that the GPD process needs to be updated. This means that the desired results may be reached by different ways with varying costs and time requirements. The consequences are that there are no ways to specify in advance a procedure that will guarantee the desired outcomes of GPD project. However, teams communication process framework provides tools that are useful for detailed analysis shown in **Figure 1**. The key communication assets must be managed to improve the process in terms of effective communication in appropriate teams for overall GPD process.

4. Case study

Cavanna Packaging Group is a worldwide leader in integrated solutions for food and non-food flow-wrapping. Their product has evolved from a device in the 1960s for the Italian market in the food and pharmaceutical industries. The group has approximately 300 employees, of which 70 work in the R&D department, 3 operating plants *(2 in Italy and 1 in Brazil)*, 1 foreign distributor, and 42 agencies covering 58 countries in Europe, North and South of America, Asia, Australia and Africa.

The Italian operating plants concentrate technical and production skills in the major application stores *(e.g., bakery, confectionery, fresh food and cosmetic)*, including the specific fields of accumulation, conveying and orientation lines for bakery, fresh products and frozen food. The Brazilian plants operates in the manufacturing, commercialization and technical assistance for flow-pack entry level packaging systems and acts in the development of flow-wrapping solutions and of automatic lines with loaders and latest generation. **Figure 5** shows the flow-pack packaging system.

In 2013, Cavanna Packaging Group underwent an organizational change on the flow-pack packaging system. The new organization comprised resources fully owned by company Beta and drawn from multiple functions and different countries. Although, the development of teams included resources belonging for: 1) the sales, technical production, and logistics department, 2) the product engineers, process engineers and supply chain professionals. Each of these are located parallel in Italy as well as in Brazil. Cavanna Packaging Group' GPD generated cross-functional team structures and technological software.

4.1 Data collection

The scope of our data collection included all departments concerned with the flow-pack packaging system product development process *(e.g., R&D department, project management department, machine tool department, assembly department)*. Three DMMs were built:

- 1) - Visualize how the flow-pack packaging process could change the organization of teams communication process in the two concerned countries;
- 2) - Identify suitable technical communication for adjusting and supporting the flow-pack packaging process;
- 3) - Identify suitable technical communication process related to the cross-functional team structures.

4.2 MDM process reference model

Cavanna Packaging Group' GPD process comprises five stages: the fabrication, the pre-assembly, the pre-test, the system assembly, and the test-run.

Product engineers, in charge of the design of the flow pack packaging system modules, belonged to the technical department and were based both in Italy and in Brazil.

Process engineers, in charge of the design of mechanical fabrication and assembly processes, belonged to the production department and were based both in Italy and in Brazil.

Supply chain professionals, in charge of the design of the flow-pack packaging system supply chain, belonged to the logistic department and were located both in Italy and Brazil.

The project leader, responsible for the coordination of the global development project across functions and operating plants, and the project manager, responsible for the planning and the monitoring of development activities, were based in Italy at the operating holding plant.

A complementary perspective on the GPD strategies and goals across the GPD organization was ensured through the pre-design meeting during which project goals were clearly set and shared to everyone involved in the GPD process acting as common divers towards which product engineers, process engineers and supply chain professionals converged on trade off decision.

Figure 5 provides an outline of the GPD process as it summarizes the system modeling process for teams and technical communication *(before and after clustering)*.

By regrouping GPD process, team communication process and technical communication of Cavanna Packaging Group with high interdependencies into nine clusters (**Figure 5**), engineers and managers can more easily identify and examine interfaces between the clusters. For example, in process DSM, the pre-test, the system assembly and the test-run are mutu-

Process DSM (GPD project process) **p x p**	**Process-Organization DMM p x o**	**Process-Parameter DMM p x n**
	Organization DSM (Teams communication process) **o x o**	**Organization-Parameter DMM o x n**
		Parameter DSM (Technical communication) **n x n**

FIGURE 3. *Structure of the overall MDM model*

	GPD project process	Teams communication process	Technical communication
GPD project process	Determine	Can change	Determine
Teams communication process		Influence	Can change
Technical communication			Influence

FIGURE 4. *Basic MDM mapping for GPD project process*

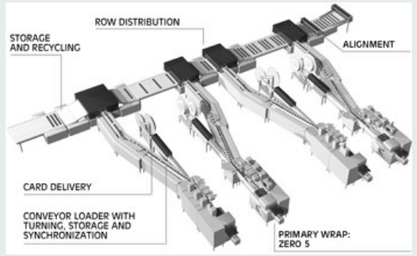

FIGURE 5. *Flow pack-packaging system*

MDM Input		Projcrt Stage					Coordinative Commication					Technical communication		
		Fabrication	Pre-assembly	Pre-test	System assembly	Test-run	Supply chain teams	R&D team	Project management team	Machine tool team	Assembly team	Packaged media	Design software	Project management software
Projcrt Stage	Fabrication	1		X		X								
	Pre-assembly	X	1		X									
	Pre-test		X	1										
	System assembly	X		X	1									
	Test-run	X		X	X	1								
Coordinative Commiication	Supply chain teams						1		X					
	R&D team						X	1						
	Project management team						X	X	1					
	Machine tool team						X		X	1	X			
	Assembly team								X	X	1			
Technical communication	Packaged media											1		
	Design software											X	1	X
	Project management software											X	X	1

FIGURE 5A. *MDM related with Cavanna Packaging Group' GPD project (before and after clustering)*
MDM BEFORE CLUSTERING (MDM INPUT)

MDM Output		Project Stage					Coordinative Commiication					Technical communication		
		Fabrication	Pre-test	System assembly	Test-run	Pre-assembly	Supply chain teams	Project management team	Assembly team	R&D team	Machine tool team	Packaged media	Design software	Project management software
Project Stage	Fabrication	1	X		X		X	X		X		X	X	X
	Pre-test		1	X				X	X		X	X	X	
	System assembly	X	X	1					X		X			X
	Test-run	X	X	X	1		X	X	X	X		X	X	X
	Pre-assembly	X		X		1		X					X	X
Coordinative Commiication	Supply chain teams						1	X				X	X	
	Project management team						X	1		X		X	X	
	Assembly team							X	1		X	X		
	R&D team						X			1		X	X	
	Machine tool team						X	X	X		1	X	X	X
Technical communication	Packaged media											1		
	Design software											X	1	X
	Project management software											X	X	1

FIGURE 5B. *MDM related with Cavanna Packaging Group' GPD project (before and after clustering)*
MDM AFTER CLUSTERING (MDM OUTPUT)

ally dependent. For this reason, in process-organization DMM, the project management team, the assembly team and the R&D team can determine the flow-pack packaging process. The suitable set of technical communication process is determined by the packaged media, the design software and the project management software simultaneously.

After clustering, MDM allows decoupling design activities and exploiting GPD practices which determines a system of pooled interdependent activities. MDM configures the integration process on communication preserving the need of mutually share information between teams to perform design work packaging separately.

5. Conclusion

The methodology for MDM application to align teams communication flow, together with guidelines for analyzing the resulting costs, reduce assumptions and uncertainty in product development. The use of MDM allows for improved data acquisition, because complex dependency logics can be split up into easier ones. Relevant network teams can be derived automatically with more efficiency.

Further works needs to look into how interaction with such models can be used to widen cost management process, through teams communication process, for each stages in GPD functions process. To reflect on the dynamics and uncertainty that change over time interdependency analysis by the MDM approach have to be repeated regularly.

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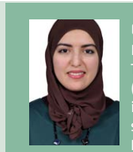

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