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Project-Driven Concurrent Product and Processes Development

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1. Introduction

When entering the global market, companies encounter several difficulties, the most severe being long product development times and too high costs of sequential product and process development. In order to overcome this problem, the companies will have to make a shift from sequential product and processes development (which is wasteful regarding time and costs) to a project-driven concurrent product and processes development as soon as possible.

"Customer is the king!" is becoming the motto of the global market. In the competition between suppliers of products only those companies will survive, which can offer innovative and individual products of good quality, produced in shortest possible time and at the lowest price (Eversheim et al., 1995).

Strong competition, existence of the market of customers and increased complexity of products and processes are the characteristics of today's competition.

Fast product and process development, combined with timely participation of customers and suppliers, together with entering the market at the right time, seem to be the decisive criteria for the market success of a product. The first supplier of a new product on the market has an advantage over the competition and thus he has the possibility of a faster return of product development investments (Duhovnik et al., 2001).

The company has to switch from sequential to concurrent product and process development (i.e. from sequential to concurrent engineering) in order to reduce product and process development time, reduce development costs and ensure quality of the product according to the customer's wishes (Prasad, 1996).

The paper presents a procedure for project-driven concurrent product and processes development by taking into account three strategic management methods: parallelness, standardisation and integration of product development processes. Also presented are the changes in organisational concept of the company, organisation of processes, organisation of work and organisation of IT, which are required for a transition from sequential to concurrent product and processes development.

Finally, an analysis is presented on concurrent product and processes development teams in a company; this analysis is a prerequisite for a transition to a new method of product and processes development.

2. Integration of project management and concurrent product development

The company that chooses project management of concurrent product and processes development first has to make project management system guidelines: rules of procedure, project management manual and operative instructions for project management, which precisely describe the implementation procedure of project phases from the bid to the end, as well as evaluation of the project.

For each concurrent product and processes development project it is necessary to set up a project dossier – a data warehouse of all data produced in the project lifetime. The project dossier has to be accessible to all project participants via the Internet.

According to the research (Kušar et al., 2008), the process model of project management of concurrent product and processes development has to contain logical sequence of product and processes development project activities and documents that arise from execution of activities (Figure 1).

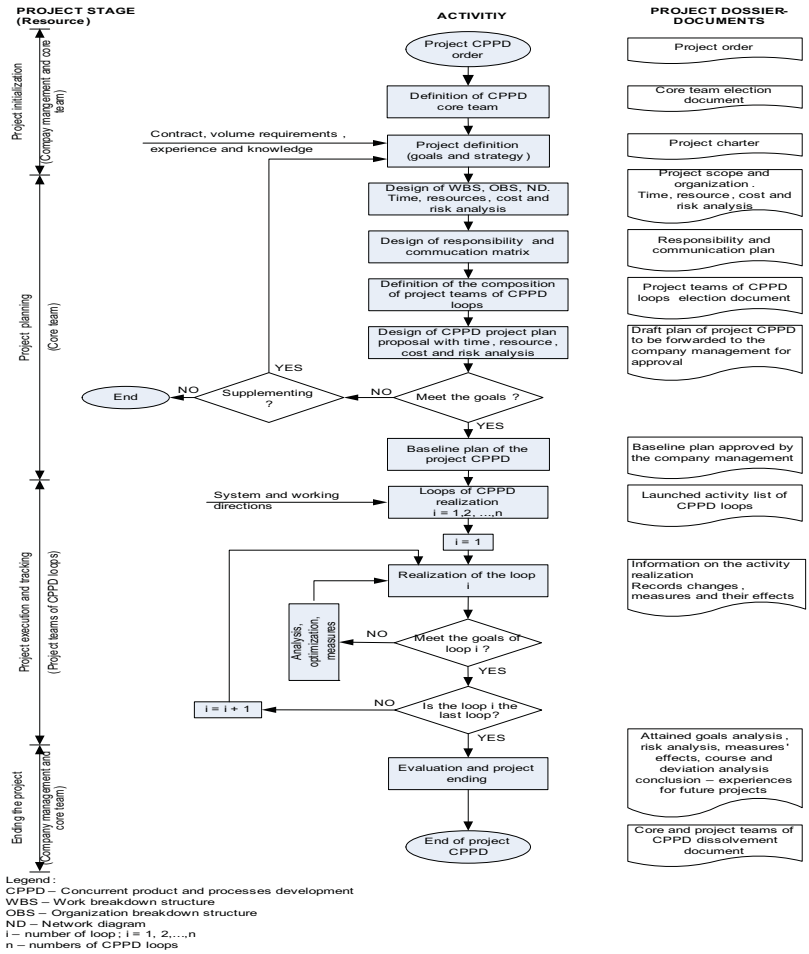

Fig. 1. Process model of project-driven concurrent product and processes development

It can be seen from Figure 1 that the process model of project management of concurrent product and processes development consists of four steps:

Step 1. Definition of objective of project management of concurrent product and processes development – order and definition of the project.

Step 2. Planning the concurrent product and processes development project: planning the WBS / project structure, organisation of project implementation OBS, responsibility matrix, network diagram and basic project activity plan.

Step 3. Execution and monitoring of the concurrent product and processes development project - project manager (via the project management office) takes care of project activity implementation.

Step 4. Completion of the project - when the project has been completed, evaluation is made, including analysis of the results achieved.

2.1 Strategic management during project-driven concurrent product and process development

Prerequisite for a successful project management of concurrent product development requires three levels of strategic management (Bullinger & Warnecke, 1996), i.e. parallelness, standardisation and integration of product development processes, as shown in Figure 2.

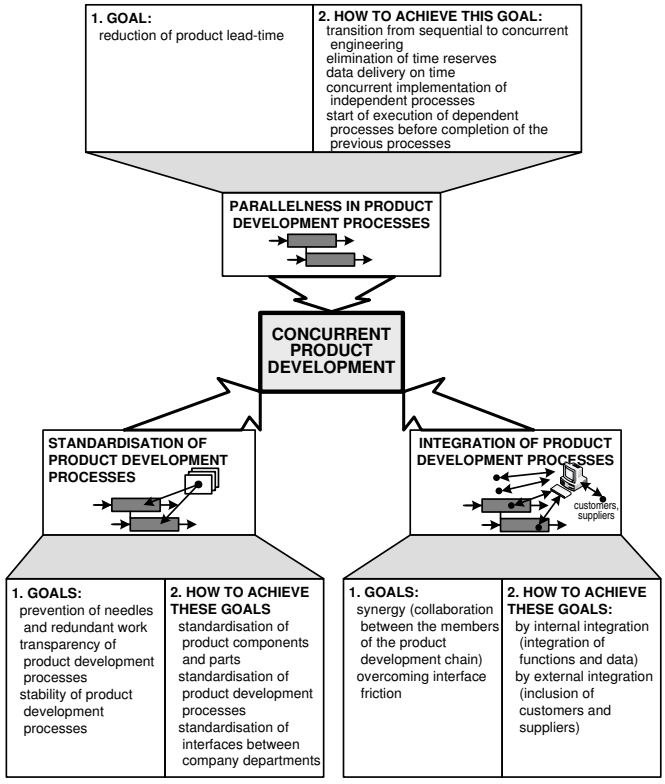

Fig. 2. Strategic management during project-driven concurrent product and processes development

The product and processes development time is reduced considerably by parallelising new product development processes. Independent processes, which are executed one after another in sequential development, are executed parallelly during concurrent development. In concurrent product and processes development the execution of interdependent product development processes starts before the previous processes have been completed, and thus the portion of uncertain and uncompleted data increases.
An advantage of parallel product development processes is fast execution of networked processes, while a disadvantage is increased transfer of data between product-development teams.
Standardisation of product development processes means the description and management of various views on product development processes, which is continuous and independent of individuals and events.
Standardisation applies to: product components (modules, components, parts), processes for manufacturing product components, and organisational plan for the implementation of product components (interfaces between departments, project approach).
By standardising product development processes, redundant and unnecessary work is avoided, higher transparency and stability of processes is achieved and thus more time for execution of innovative and creative tasks is ensured.
All company departments, as well as customers and suppliers should be part of the chain creating the features of the product under development. However, this leads to high interface losses because of uncoordinated scheduling, various interpretations of the roles of tasks and unknown requirements of internal customers.
Integration with direct inclusion of all company departments, customers and suppliers into the product development processes allows for a possibility of overcoming collisions at interfaces. Interdisciplinary work, process-oriented thinking and functioning, as well as creativity and conscious decision-making require integrated product development processes.
The goal of product development process integration is therefore a transformation of separate interfaces into a coherent whole.

2.2 Changes in the company before transition from sequential to concurrent engineering

According to our experience in the field of project management and concurrent product and processes development, a company that wants to make a transition from sequential to project-driven concurrent product and processes development should change the organisational concept of the company, organisation of processes, organisation of work and organisation of IT.
Organisational concept of the company defines the structure and competences of employees, who will be engaged in the concurrent product development – it therefore defines the mode of organisational unit formation and coordination between them.
In sequential product development there is a precisely defined hierarchy of reporting, as well as the procedure and competences of decision-making. Concurrent product and processes development requires a project management of product development process and a transition from individual- to team-work.
The basis of team-work is cooperation between team members and their interdependence (successful communication between team members ensures the team success). Team-work is performed by team members. Their main tool is communication and none of the team members may leave the team until the work has been completed. Team-work is a form of

collaboration between team members who are responsible for the distribution and implementation of tasks, for the solution of problems, as well as for communication within the team and between teams.

Good organisation and implementation of team-work is essential for a successful transition from sequential to project-driven concurrent product and processes development.

Success of concurrent product and processes development depends largely on the planning and management of product development project. During planning and management, a special attention has to be paid to the standardisation of product development processes, information transfer methods and the fastest possible integration of all members of the product development team, including customers and suppliers.

Figure 3 presents changes in the organisational concept of the company that decided to make a transition from sequential to concurrent product development.

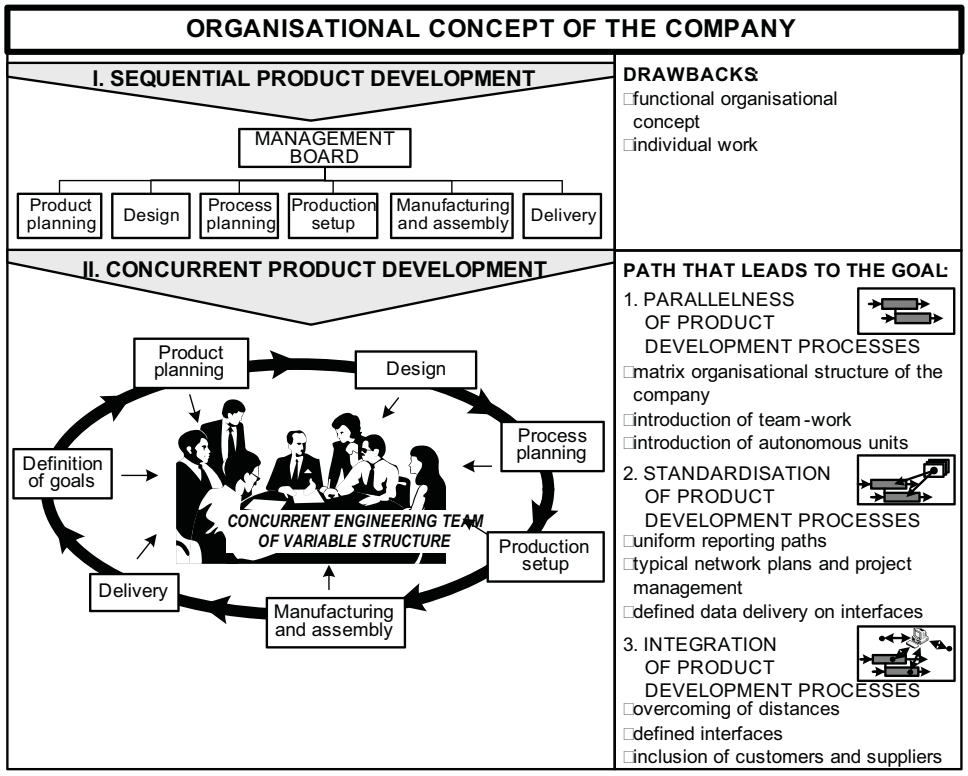

Fig. 3. Changes of the company organisational concept

A specific feature of product development processes is that they are goal- and result-oriented (Eversheim et al., 1995)

Analysis of the current sequential product development processes is a basis for planning concurrent product development processes. The barriers between company departments and between the company and its customers and suppliers can be eliminated if the company mind structures are changed. Standardised process descriptions are essential for parallel execution of product-development-process activities.

All product-development-process data should be prepared in the same way, so that during development of the planned product the results of the previously developed products can be used.

Figure 4 presents changes in organisation of processes in the transition from sequential to concurrent product and processes development.

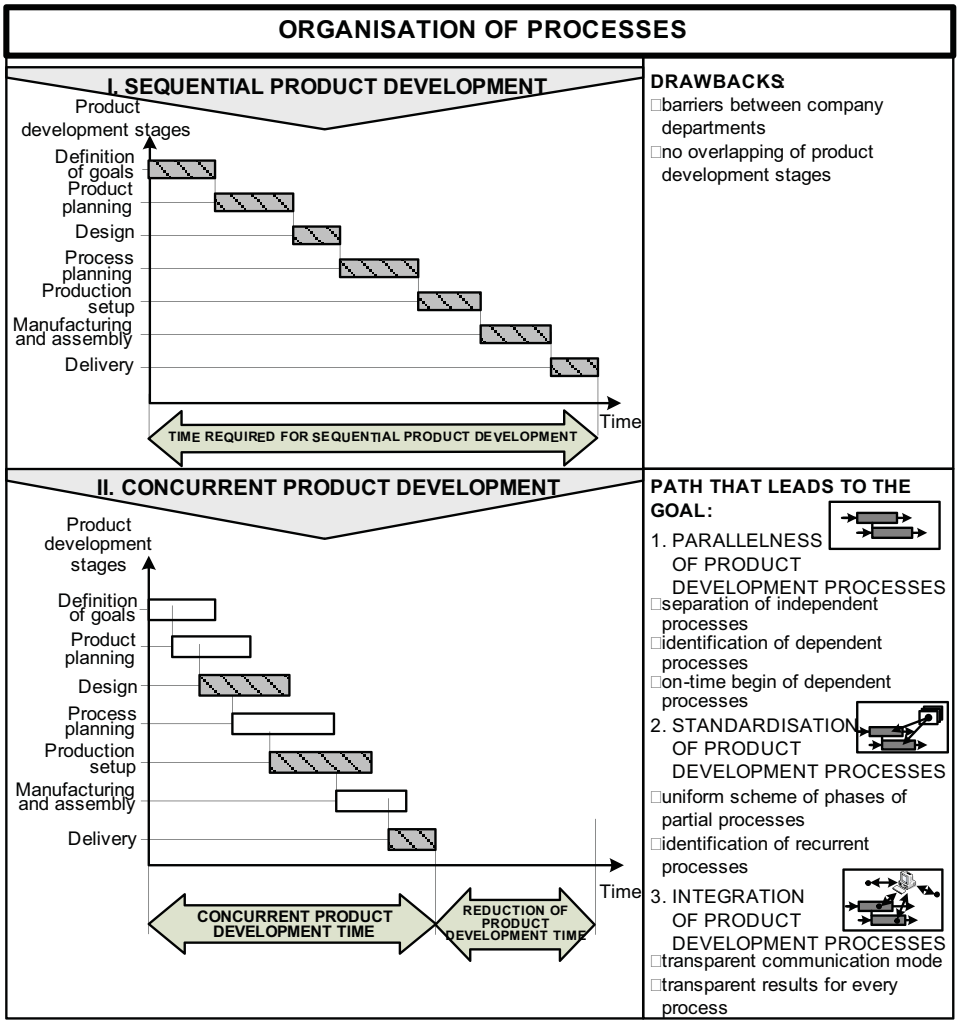

Fig. 4. Changes in the organisation of processes

A company planning to make a transition from sequential to project-driven concurrent product and processes development needs employees capable of team-work and rotation of work.

Team-work is successful when the team output exceeds the sum of outputs of team members, working individually.

According to the recommendations (Lencioni, 2002):

- small team consists of 2 to 25 members;
- large team consists of more than 25 members.

However based on experience of LAPS the upper limit for one team is 15 members.
Figure 5 shows team management methods with respect to suggested team sizes.

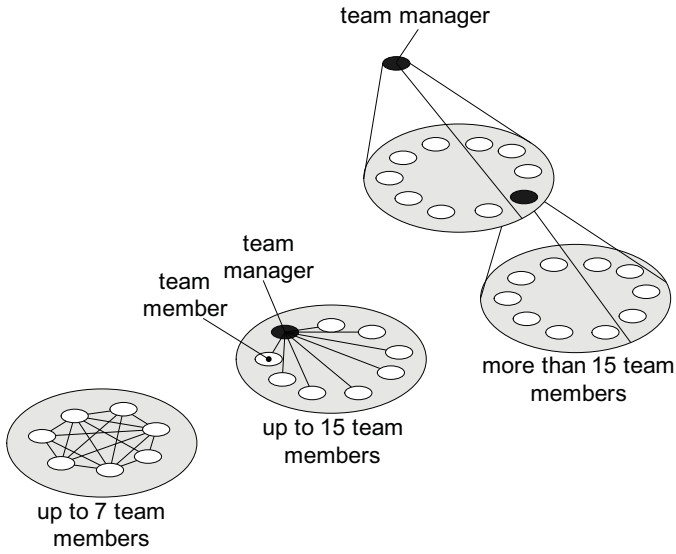

Fig. 5. Team management methods

Team of up to 7 members operates without an appointed team manager – team members manage themselves.
In a team of up to 15 members, a team manager is appointed; (s)he should be a team member.
If a team consists of more than 15 members, it is divided into several sub-teams in order to ensure successful team management. A team manager is not supposed to be a team member – (s)he should work only as a team manager.
If there are up to 7 members in a concurrent product and processes development team, each team member is interconnected with each other. Any team member can start a communication and all team members have the same decision rights. There is close collaboration between team members and they are satisfied with their work.
Capability of team-work means openness in sharing of information and admitting errors, as well as responsibility for decisions, so that individual tasks will be performed at the right time and thus the highest possible parallelness will be achieved.
Team members should have rotational-work capability, which is essential for understanding views of others on the problems encountered (Eversheim et al., 1995).
Figure 6 presents changes in the organisation of work in a transition from sequential to the project-driven concurrent product and processes development.
Transition from sequential to project-driven concurrent product and processes development requires large IT investments.
The data must be accessible on all of the product-development-process locations. This approach allows for faster transformation processes of the most important forwarded data (the push principle) or the data fetched from the databases (the pull principle).

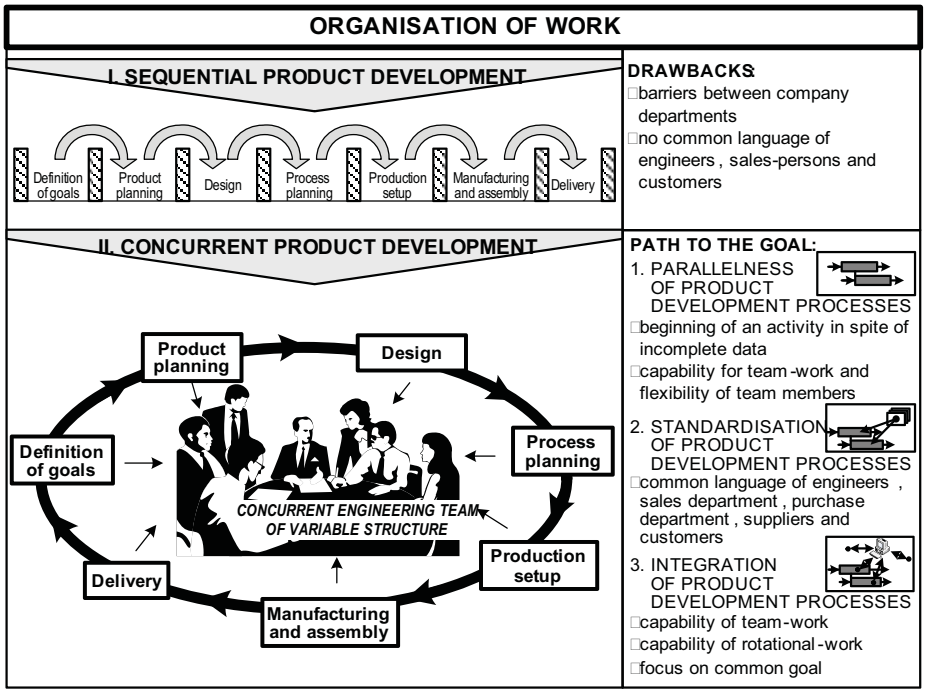

Fig. 6. Changes in the organisation of work

Changes of IT, required by concurrent product development, support parallelness, standardisation and integration of product development processes.
Figure 7 presents changes of IT in the transition from sequential to project-driven concurrent product development.

3. Case study: how is a company prepared for concurrent product and processes development

A company – a component developer and supplier for the automotive industry – decided to perform an analysis regarding fulfilment of the basic conditions for a transition from sequential to concurrent product and processes development.
For this purpose the company hired an external counsellor – the Laboratory for Manufacturing Systems (LAPS) of the Faculty of Mechanical Engineering, Ljubljana, Slovenia – to find out (together with the company management):

- whether the people who will be members of the project-driven concurrent product and processes development team are capable of and motivated for team-work, and whether any of the five team-dysfunctions exist in the team (Lancini, 2002),
- do team members have proper personal value systems for team-work (Ellis et al., 2006),
- are all nine team-roles represented in a team (Belbin, 2003)?

The company management decided that the analysis of the team-work efficiency would be tested in a team for development of a car pedal component (Figure 8). The team consists of eight members, as shown in Figure 9.

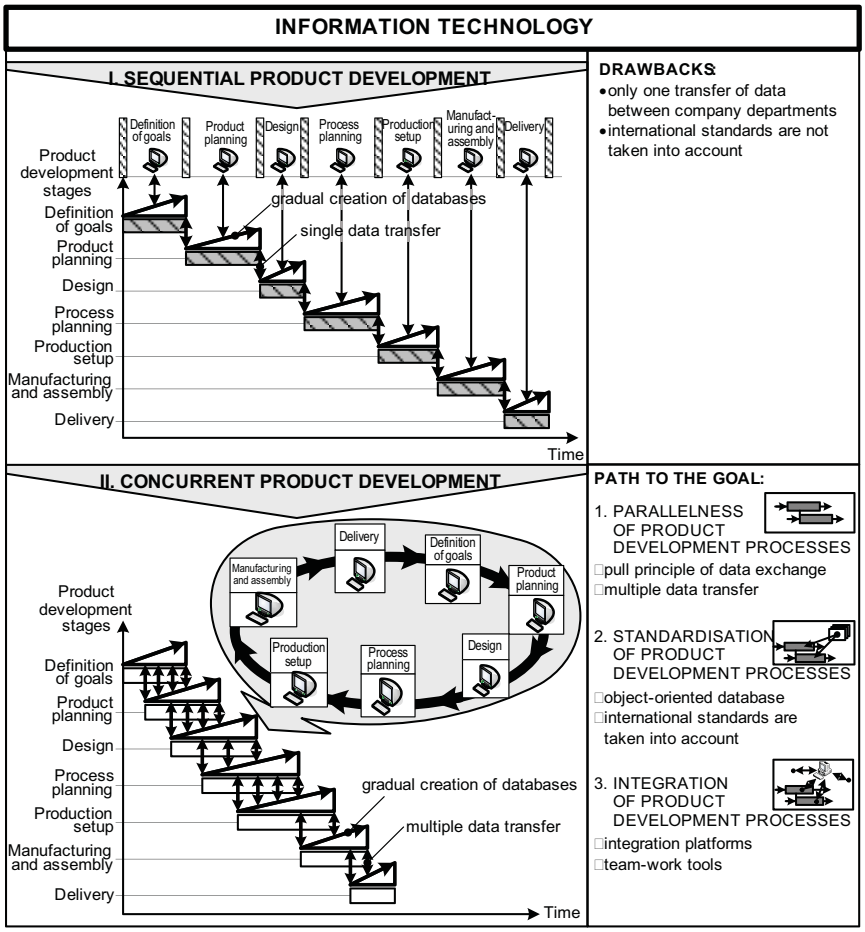

Fig. 7. Changes of IT

Fig. 8. Car pedal component

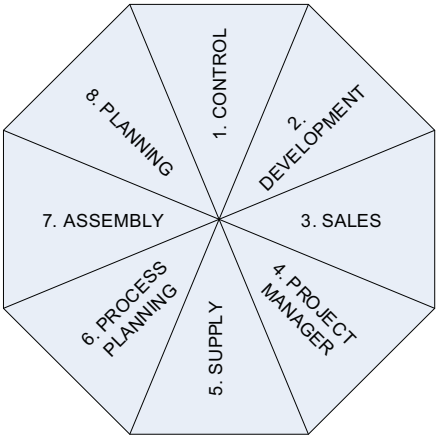

Fig. 9. Structure of the analysed team

3.1 Analysis of team-work capability, motivation and team dysfunctions

In order to find out whether team members who will in future participate in project-driven concurrent development of car pedal component are capable of team-work, the LAPS employees modified the questionnaire created by Lancini (Lancini, 2002) on team-work capabilities (shown in Table 1).

QUESTIONNAIRE 1: TEAM-WORK CAPABILITIES	
1. In a team – do you tend to appropriate to yourself the results of the work performed? …	_____
2. Do you complement other team members regarding knowledge and capabilities? ……	_____
3. Does the team-work facilitate development of communication skills? ……	_____
4. Do team members help each other? ……	_____
5. Is there a constructive criticism in the team? ……	_____
6. Do all team members participate in decision-making? ……	_____
7. Do team members support adopted decisions? ……	_____
8. Does any individual team member get more support? ……	_____
9. Are the solutions of problems that arise in team-work assessed together and analysed critically? ……	_____
10. Are there many ideas collected regarding a problem solution? ……	_____
11. Are the team members capable of adopting compromise solutions of the problem? ….	_____
12. Do conflicts arise between team members? ……	_____
13. Are team members who agree with proposals of the stronger members exposed to any pressure?	_____
14. Is the team under control of an individual? ……	_____
Allocate 1 to 3 points to each answer: 1 point – rarely true 2 points – sometimes true 3 points – usually true	
FINDINGS: • If the total number of points is between 33 and 42 → team member IS CAPABLE of team-work. • If the total number of points is between 24 and 32 → team member IS PARTIALLY CAPABLE of team-work. • If the total number of points is between 14 and 23 → team member IS NOT CAPABLE of team-work.	

Table 1. Team-work capability questionnaire

All eight team members answered to 14 questions regarding team-work capabilities. Results of the analysis are shown in Table 2.
Results in Table 2 indicate that four team members are capable of team-work, the other four ones are only partially capable, and there is no team member who would not be at least partially capable of team work.
Final conclusion: the team is capable of team-work.

No.	TEAM MEMBER	TOTAL NUMBER OF POINTS REGARDING TEAM-WORK CAPABILITY	TEAM WORK CAPABILITY
1.	Control	30	Partially capable
2.	Development	40	Capable
3.	Sales	41	Capable
4.	Project manager	41	Capable
5.	Supply	39	Capable
6.	Process planning	29	Partially capable
7.	Assembly	26	Partially capable
8.	Planning	31	Partially capable
	AVERAGE CAPABILITY	**34.6**	**CAPABLE**

Table 2. Team-work capability

In order to find out whether team members are motivated for team-work the questionnaire in Table 3 was compiled.

QUESTIONNAIRE 2: TEAM-WORK MOTIVATION	
1. Is your work useful?	_____
2. Do you know the purpose of your work?	_____
3. Do you know the results of your work?	_____
4. Do you have good working conditions?	_____
5. Does team manager praise you?	_____
6. Does team manager criticise you?	_____
7. Does team manager give you instructions for work?	_____
8. Do you compete with other team members?	_____
9. Do you actively participate in the team?	_____
10. Does team manager create problems on purpose?	_____
11. Does team manager set work objectives properly?	_____
12. Does team manager take care for solution of conflicts?	_____
13. Does team manager take care for a good team atmosphere?	_____
14. Are you motivated by your salary?	_____
Allocate 1 to 3 points to each answer: 1 point – rarely true 2 points – sometimes true 3 points – usually true	
FINDINGS: • If total number of points is between 33 and 42 → team member IS MOTIVATED for team-work. • If total number of points is between 24 and 32 → team member IS PARTIALLY MOTIVATED for team-work. • If total number of points is between 14 and 23 → team member IS NOT MOTIVATED for team-work.	

Table 3. Questionnaire on team-work motivation

All eight team members answered to 14 questions regarding team-work motivation. Results of the analysis of their answers are shown in Table 4.

No.	TEAM MEMBER	TOTAL NUMBER OF POINTS REGARDING TEAM-WORK MOTIVATION	TEAM WORK MOTIVATION
1.	Control	39	Motivated
2.	Development	40	Motivated
3.	Sales	30	Partially motivated
4.	Project manager	39	Motivated
5.	Supply	30	Partially motivated
6.	Proces planning	39	Motivated
7.	Assembly	27	Partially motivated
8.	Planning	36	Motivated
	AVERAGE MOTIVATION	**35**	**THE TEAM IS MOTIVATED**

Table 4. Team-work motivation

Results in Table 4 indicate that five team members are motivated for team-work while the other three members are only partially motivated.
Final conclusion: The team is motivated for team-work.
The following five dysfunctions can arise in teams (Lencioni, 2002):

- Dysfunction 1: Lack of confidence
- Dysfunction 2: Fear of conflicts
- Dysfunction 3: Non-interoperability
- Dysfunction 4: Rejection of responsibility
- Dysfunction 5: No interest for results.

In order to find out whether any dysfunction (or which dysfunction) exists in our team, the employees of the LAPS modified the questionnaire created by Lancini (Lancini, 2002) shown in Table 5.
All eight team members answered to 15 questions regarding susceptibility to team-dysfunctions. Answers of one of the team members are shown in Table 6.
Analysis of results of all eight team members indicated that the team's dysfunction is "no interest for results". In order to eliminate the sources for this dysfunction in future, it will be necessary to:

- precisely define objectives of team work,
- support behaviour and mode of operation that lead to the defined objectives.

3.2 Suitability of personal value systems for team-work

We used the SDI (Strength Deployment Inventory) method (Ellis et al., 2006) to analyse the personal value systems of eight team members.
This method can be used to find out:

- how an individual team member understands himself and his value system in relation with other team members and other project participants,
- how a team member understands other team members and how he takes this fact into consideration in mutual relations with them,
- how a team member reacts in a conflict situation and how he understands reaction of other team members in a conflict.

QUESTIONNAIRE 3: SUSCEPTIBILITY TO TEAM-DYSFUNCTIONS		
Dysfunction 1: LACK OF CONFIDENCE	1. Team members sincerely apologise for improper words or deeds which may harm the team operation.....	_____
	2. Team members admit their faults and weak points.....	_____
	3. Team members know each other personally and they often talk about their private lives.....	_____
Dysfunction 2: FEAR OF CONFLICTS	4. During discussions each team member openly and honesty says what he thinks.....	_____
	5. Team meetings are exciting and never boring.....	_____
	6. During meetings, not only important themes are being discussed, but also the most difficult ones that are being dealt with openly and common solutions are found.....	_____
Dysfunction 3: NON-INTEROPERABILITY	7. Team members know projects of their colleagues and know the contribution of each individual to the common goal of the team.....	_____
	8. After the meeting, the team members are sure that everyone completely agrees with adopted decisions, although they had different opinions at the beginning.....	_____
	9. Team members finish their discussions with clear and unambiguous results and plans.....	_____
Dysfunction 4: REJECTION OF RESPONSIBILITY	10. Team members remind each other on improper or unproductive behaviour.....	_____
	11. Team members are ready to support their colleagues.....	_____
	12. Team members ask each other on progress of work regarding the plan and their acts.....	_____
Dysfunction 5: NO INTEREST FOR RESULTS	13. Team members are ready to accept limitations in their departments or their fields of work (e.g. budget reduction, responsibilities, number of employees, etc.) if this is in favour of the team.....	_____
	14. Working enthusiasm suffers if common goals have not been met.....	_____
	15. Team members do not expect continuous praises for their achievements; instead they spontaneously praise good results of others.....	_____
Allocate 1 to 3 points to each answer: 1 point – rarely true 2 points – sometimes true 3 points – usually true		
FINDINGS: • If the total number of points for a particular dysfunction is between 8 and 9 → there is a high probability that this particular dysfunction does not cause a problem in the team. • If the total number of points for a particular dysfunction is between 6 and 7 → it is possible that this particular dysfunction may start causing problems in the team. • If the total number of points for a particular dysfunction is between 3 and 5 → the team has to fight against this particular dysfunction because it exists in the team.		

Table 5. Questionnaire on susceptibility to team-dysfunctions

DYSFUNCTION	Answer No.	Answer No.	Answer No.	TOTAL POINTS
Lack of confidence	1. *3*	2. *2*	3. *3*	8 - dysfunction exists
Fear of conflicts	4. *2*	5. *3*	6. *2*	7 - dysfunction may exist
No connections	7. *2*	8. *2*	9. *2*	6 - dysfunction may exist
Rejection of responsibility	10. *2*	11. *3*	12. *3*	8 - dysfunction does not exist
No interest for results	13. *2*	14. *1*	15. *1*	4 - dysfunction exists

Table 6. Susceptibility to team-dysfunctions – member from the DEVELOPMENT team

For implementation of the SDI method a workshop was organised which showed positions of team members in the SDI triangle according to their value systems. All eight team members answered to 20 questions regarding personal value systems in a team-work.
Their answers and their positions in the SDI triangle are shown in Figure 10.

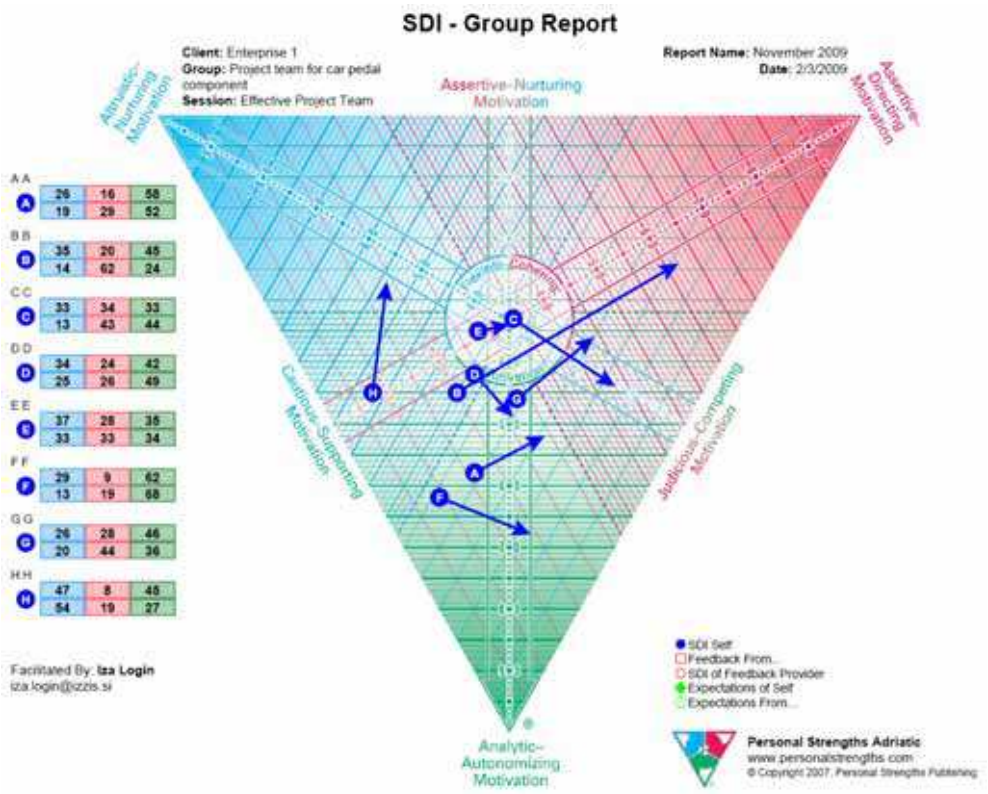

Fig. 10. Positions of team members in the SDI triangle

An arrow is assigned to each team member. The starting point of the arrow defines personal value systems of the team member in a non-conflict environment, while the arrow represents the mode of his/ her reaction in various conflict stages.
Table 7 shows personal value systems of team members, their understanding of conflict situations and their suitability for team- and individual work.

Team member	Personal value system	Understanding of conflict situations	Suitability for team-work
1 Control	Analytic-autonomizing type	When encountering difficulties he first responds with analytical, logical and restraint approach, followed by an unyielding, strong attack, based on logic and planning. If these approaches do not help, he gives up for the sake of harmony, but he chooses this as the last resort.	He functions in the team, although individual work suits him more.
2 Development	Cautious-supporting type	He wants to achieve his domination by competition. If competition does not help, he uses analysis, logic, sense and rules. He selects withdrawal as the last resort.	Good feeling for team-work.
3 Sales	Flexible-cohering type	He does not respond directly to difficulties; instead he uses several strategies for solution. He intelligently works his way to reach the objective, but he gives up in a situation without prospects.	Strong feeling for team-work.
4 Project manager	On the border between flexible-cohering and cautious-supporting type	In difficulties he first takes the position based on logic, order, rules and principles. In next stage of conflict he chooses one of the following possibilities: if the case is important to him, he fights; otherwise he gives up.	Strong feeling for team-work.
5 Supply	Flexible-cohering type	His responses to difficulties and opposition vary considerably. His response depends on situation and circumstances and has no firm sequence.	Strong feeling for team-work.
6 Process planning	Analytic-autonomizing type	He wants to achieve his domination with competition. If competition does not help, he uses analysis, logic, sense and rules. He selects withdrawal as the last resort.	Good feeling for team-work.
7 Assembly	Analytic-autonomizing type	When encountering difficulties he first responds with analytical, logical and restraint approach, followed by an unyielding, powerful attack, based on logic and planning. If these approaches do not work, he gives up for the sake of harmony, but he chooses that as the last resort.	He functions in a team, although individual work suits him more.
8 Planning	Cautious-supporting type	He strives most for harmony and readiness for cooperation. If he does not achieve this, he tries to withdraw and save what he can. If even this is not successful, he quarrels, most probably very explosively.	He functions in a team, although individual work suits him more.

Table 7. Personal value systems of team members

Analysis of results reveals that in this team three members have very strong feeling for team work, two of them have good feeling for team work, while three members function in a team although individual work suits them more.

The prevailing value system of team members is cautious-supporting, bordering on analytic-autonomizing and flexible value system. No team member has either altruistic-nurturing or assertive-directing value system.

3.3 Analysis of representation of team roles

Nine team roles have to be represented in a team for successful team-work (Belbin, 2003): developer, searcher for resources, coordinator, creator, evaluator, co-worker, operator, finisher and expert.

In order to find out whether all nine team roles are represented in the proposed team for project-driven concurrent development of the car pedal component, team members got Belbin test questionnaire.

Answers of team members to four self-evaluation questionnaires and evaluation of team co-workers were used as input data for INTERPLACE software. This software was used to find out which are the natural roles of each team member, which roles can he adapt to and which roles he should avoid (Table 8).

Team member	Team roles								
	DE	SR	CO	CR	EV	CW	OP	FI	EX
1 Control	x		x				x		
2 Development	x	x			x				
3 Sales				x			x		x
4 Project manager			x	x			x		
5 Supply			x		x				x
6 Process planning	x						x		x
7 Assembly					x		x		x
8 Planning						x	x	x	

Legend:

DE – developer	CW – co-worker
SR – searcher for resources	OP - operator
CO – coordinator	FI - finisher
CR – creator	EX - expert
EV – evaluator	x – natural role

Table 8. An overview of the natural roles of eight team members:

It can be seen from Table 8 that all nine team roles are represented in the team. This indicates the capability of the team for efficient team-work in the project of concurrent development of pedal component.
After the presentation of analyses results, the company management decided that the selected and tested eight-member team would start working on the project for concurrent development of pedal component.

4. Conclusion

Global market requires short product development times and low costs, and this forces companies to a transition from sequential to concurrent product and processes development.
Prerequisite for a transition from sequential to project-driven concurrent product development is a successful team-work and strategic management (parallelness, standardisation and integration). In our paper we have therefore focused on checking the efficiency of team-work and integration of strategic management into product development processes.
Results of the analysis of team-work capability, team work motivation, susceptibility of the team to dysfunctions, personal value systems for team-work and representation of team roles led us to the conclusion that we propose to the company management to include the treated and tested team in the project of concurrent development of the pedal component.
Further we analysed changes in a company, which were required by a transition from sequential to concurrent product development, with respect to:

- organisational concept of the company,
- organisation of processes,
- organisation of work,
- IT,
- preparation of product documentation.

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