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Design Management by Project Management

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1. Introduction – Why projects and project management should be used in departments of design?

Design of progressive, dynamically loaded machines requires cooperation of designers-specialists which aim to common goal: to design a machine matching required functions, product cost being in the fixed limits and product documentation being finished in approved time. Cooperation of designers-specialists means joint action of material specialist, specialist in strength calculations of machine components, designer of mechanics, designer of hydraulic and pneumatic systems, designer of electrical drive and automatic control of machine, etc.

It is evidently possible and useful to deal with machine design as with a project. Why is it possible? Machine design can be looked on as a project, since project - equally as machine design - is a creative work targeting a specific goal, and the effort has time- and cost-based limits. These are characteristics defining a project. It is also useful, since project management exploits routine processes management techniques for budget and deadlines, improving not only quality of tasks and people management, but mainly quality of its output – project product. This is very important in machine design and it also answers the question formulated in the section headline.

Frequently the whole development and delivery of some complex product is considered to be a project. Then product design is an individual project or subproject of project planning phase (see fig.1).

2. Managing a machine design project

2.1 Project management phases, processes and procedures

Generally project can be divided into stages or phases determining project lifecycle. It should be differentiated between project lifecycle and project product one. Project lifecycle begins by analytical definition phase, continues by planning phase, where project product plans are developing and project implementation is planned. Next there is running realization, testing, project product disposition in usage, project results summarization and project documentation adaptation using lessons learned is the last project phase. The project lifecycle completion starts project product exploitation – one of phases of the project product lifecycle – when the cost embedded in the project should be returning back to the sponsor. Project product lifecycle begins at the same moment as the project lifecycle and after project lifecycle completion it by exploitation phase and it is finished by product disposal phase (see Fig. 1).

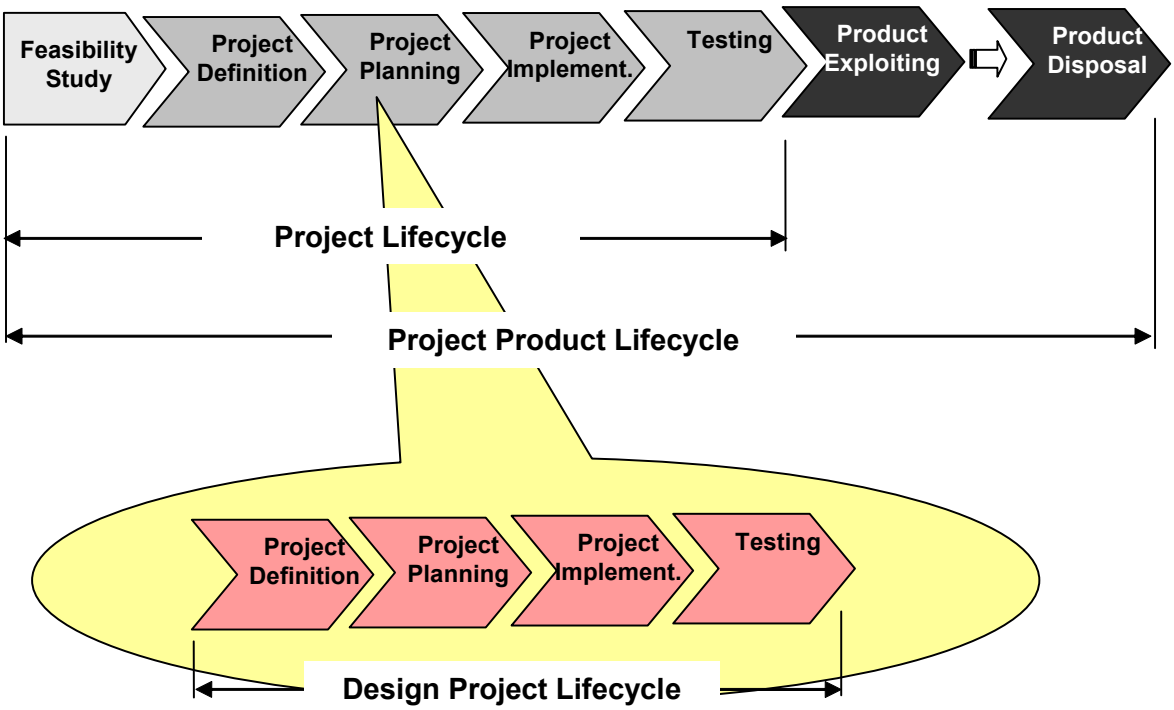

Figure 1. Project and project product lifecycles

As was mentioned aboce, the project product usage begins at the project completion – it is the next phase of project product lifecycle when embedded cost starts to return. The majority of projects should recover not only costs, but also generate profit usual in the relevant industry. Therefore it is important to find out if the project would be profitable before project is launched. Form that reason, the feasibility study should preced the first phase of business project. The feasibility study decides about project "to be or not to be" or about optimal project variant choice should take into account the whole project product lifecycle including product disposal. The feasibility study may be an expensive matter and its financing is sometimes included into the first phase of project. In fact, the feasibility study is not a part of a project since only on the base of its results a project may start.

To implement project management in department of design it is necessary to define processes and procedures to be uses in management of projects. Knowledge of PM processes and procedures is explained in PM books, e.g. [Duncan 2000], , but it is necessary to adapt it to the specific user´s area. Processes may be integrated into groups of project initiation, planning, executing, controlling and ending (see Fig.2). Procedures concern project communication, change management, risk management, quality management and project metrics.

2.2 Organizational structure

Project manager is usually appointed by the department manager. Project manager, having whole responsibility of a project, makes a choice of project team members, prepares a work plan and a budget. The organisational structure of PM is mainly matrix structure. Matrix structure has the following advantage: design project manager usually is not an expert in all necessary areas and he or she may trust leaders of technical groups that they will professionally manage their team members. The assumption of matrix structure's correct functioning is communication and partnership between project manager and managers of technical groups.

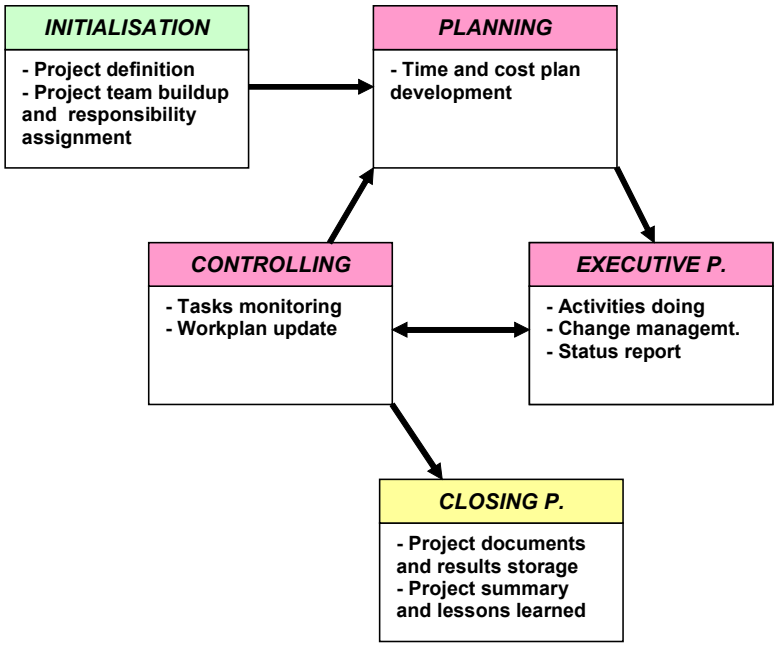

Figure 2. Project management processes groups

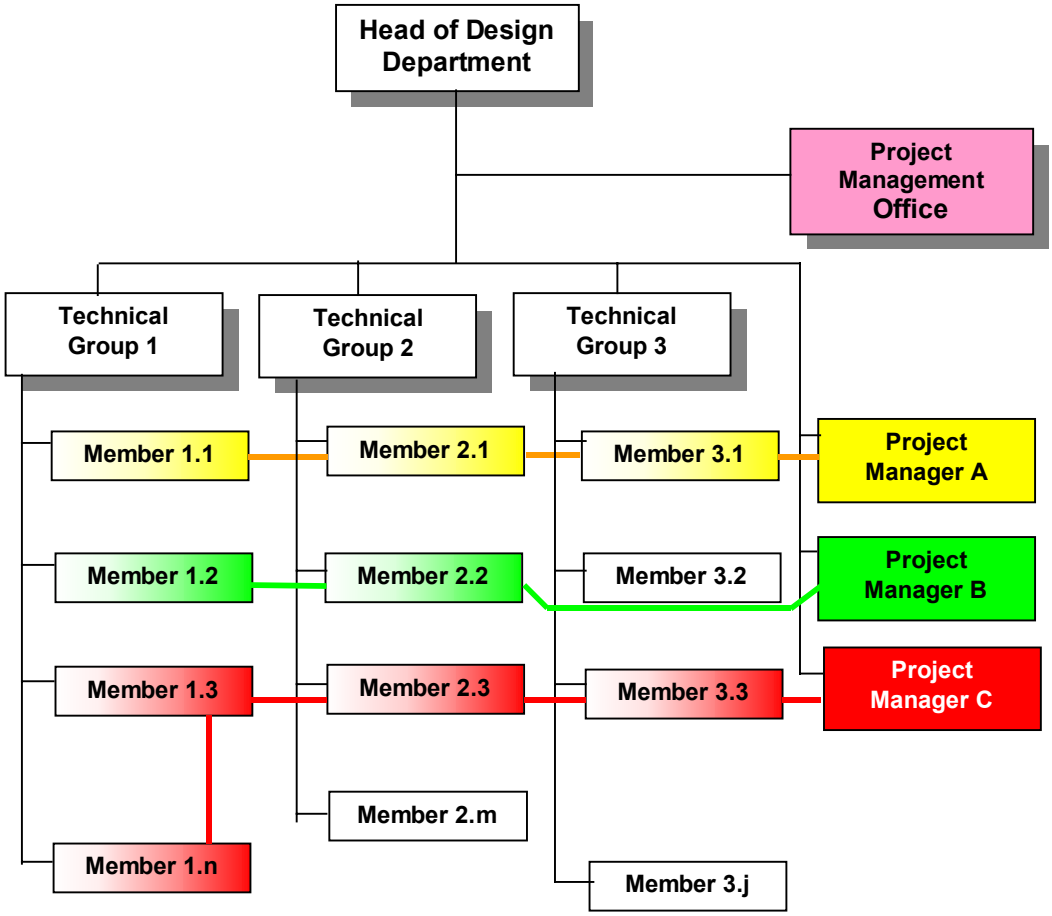

Figure 3. An example of design department matrix structure

Project Management Office (PMO) used to be established in firms whose main business is project management. Initially, only one person in PMO may be in charge of methodology, project managers supervision and their technical career growth. He or she is also responsible for finished projects documentation storage so that the acquired experience is not lost. An example of organizational structure of design department you can see in Fig. 3.

2.3 Project definition and plan development

The first step of project management is project definition. It means to determine project goals and project tasks. The goals should be formulated to be "SMART". This is the abbreviation of:

- **S**pecific
- **M**easurable
- **A**chievable
- **R**ealistic
- **T**ime – based.

The possible tool of a project definition is a logical frame (see Fig. 4). The logical frame helps to define project objectives, outputs and activities, indicators of their achievement, assumptions and risks influencing their accomplishments. Understanding, agreement and explicit project scope definition are important issues. All has to be documented; documented project definition is sometimes called "Project charter". The name of the document accents its significance. Developing time- and cost-based plan is the following step. This part of PM has a great support in computer software. It is necessary to emphasise that project manager should determine the responsibilities of team members for individual tasks. An appropriate tool for it is the responsibility matrix fixing obligations in a written form.

Project goals and activities	*Indicators of Achievment*	*Measurement*	*Assumptions and Risks*
Overall objective	**Measure of achievment of overall objective**	**Sources of information – verify achievments**	
Purpose	**Measure of achievment of purpose**	**Sources of information – verify achievments**	**Assumptions linkage between specific and overall objectives**
Specific objectives - outcomes	**Measure of achievment of specific objectives**	**Sources of information – verify achievments**	**Assumptions linkage between outcomes and specific objectives**
Activities	**Inputs – resources required**	**Cista of human and physical resources**	**Assumptions linkage between činnostmi a výstupy**

Figure 4. Project logical frame

2.4 Project implementation

Project implementation requires from aproject manager a lot of managing and controlling activities. Besides leadership and motivation, project manager should control the project and assess quality and performance of the project. We would like to mention here project control by earned value analysis [Fleming, 2000] and quality and performance assessment by Project Scorecard [www.tenstep.com].

2.4.1 Project earned value analysis

It is not possible to monitor and control the machine design project on the basis of project hours, since project hour value depends on the person doing it and on his or her salary. Therefore it is necessary to use value based method, e.g. earned value analysis. The principle of the method is to assign to the project activities appropriate financial value in order to measure project "health" during project lifecycle. The advantage of the use of this method is not only better control, but also possible analysi of project progress using actual value added; it also functions as the system of early warning for project manager. The objective of this section is not to explain earned value analysis in details, but to point out its advantages and to draw attention to conditions of its exploitation.

The analysis uses accumulated values that represent the sum of costs from the project beginning up to the present time. The analysis uses three basic values:

- budgeted cost of work scheduled (planned cost – PC),
- actual cost of work performed (actual cost – AC) and
- budgeted cost of work performed (earned value – EV).

See Fig. 5.

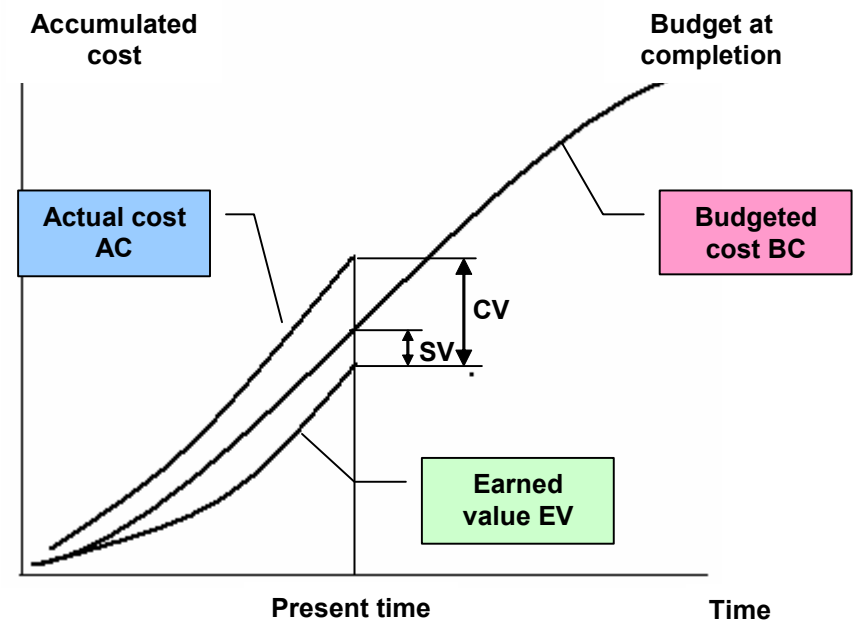

Figure 5. Project logical frame

Earned value (EV) of completed activities corresponds to their budgeted cost, EV of not activities not yet started is zero and EV of semifinished activities corresponds to their budgeted cost multiplied by work-in-progress ratio.

With help of these three fundamental values albeit is possible to determine indices assessing project progress from its cost point of view – cost variance CV (see table 1) and from schedule point of view – schedule variance SV. It is also possible to express the indices in relative form (table 1) as cost performance index CPI and schedule performance index SPI. Index CPI demonstrates how effectively are spent project cost. If CV is positive or CPI larger

than one, the cost effectiveness is good and project is managed well from its cost point of view. For example, if CPI is equal to 1,2, then every spent euro earned 1,2 €. Similar relation may be applied for index SPI, but in relationship to the project schedule. It means, that if SPI equals to 0,8, the project is 20% behind schedule.

Table 1. Table of relationships among EV analysis values

CV = EV – AC
CPI = EV / AC
SV = EV – PC
SPI = EV / PC
ETC = (BAC – EV) / CPI
EAC = AC + ETC EAC = BAC / CPI

Except current project situation assessment, it is possible to create an estimate of its future cost, to estimate probable cost to project (or project phase) completion (estimate to completion – ETC) and total project cost (estimate at completion – EAC, budget at completion - BAC). These estimates are correct under assumption, that the project manager will manage project in future by the same way as in the past (well or badly). It means that the future index CPI will be the same as at present. Table 1 shows relevant mathematical formulas.
The main condition of this method usage is monitoring of all activities in the project accounting. Every activity should have its own cost account.

2.4.2 "Project Scorecard"

Another important task of the project manager and his or her senior manager is the project assessment from the quality and performance point of view. Balanced Scorecard Method used for enterprise performance assessment was transferred and adapted to projects as Project Scorecard Method. Reference [www.tenstep.com] contains common templates which should be modified for design projects.
The Project Scorecard Method consists of the following steps:
Identify criteria for success. Review the objectives and deliverables in the Project Definition. Based on this existing documentation, define what information is needed to show that the project was successful. This can be from two perspectives:
Internal – These characteristics indicate that the project was managed and executed effectively and efficiently.
External – These characteristics indicate that your project objectives were completed successfully.
Assign potential metrics. Identify potential metrics for all success criteria that provide an indication whether or not the criteria are being achieved. These can be direct, quantifiable metrics, or indirect metrics that give a sense as success criteria.
Look for a balance. The potential list of metrics should be subdivided into categories to make sure that they provide a balanced view of the project. In general, look for metrics that provide information in the areas such as:

- Cost
- Effort
- Duration
- Productivity
- Quality of deliverables
- Customer satisfaction with the deliverables produced
- Project team performance
- Business value delivered

Prioritize the balanced list of metrics: Depending on how many metrics you have identified, prioritize the list to include only those that have the least cost to collect and provide the most value to the project. Use no more than one or two per category. In general, look to provide the most information with the least amount of work.
Set targets: The raw metric may be of some interest, but the measure of success comes from comparing actual values against a predefined target. The target may be a single value you are trying to achieve, or it may be a range.
Add workplan detail: For each metric that remains, determine the specific information necessary to add the appropriate activities to the project workplan. This will include:
What specific data is needed for the metrics?
Who is responsible for collecting the metric?
When will the metric be collected and reported?
How will the metrics be reported (status reports, quarterly meetings, metrics reports)?
Table 2 shows examples of metrics and assigning balance categories to them.

Table 2. Table of metrics and assigning balance category

Balance Category	Sample Metrics
Cost	▪ Actual cost versus budget for project, for phase, for activity, etc. ▪ Total labor costs vs. non labor ▪ Cost associated with building components for reuse ▪ Ideas for cost reductions implemented, and cost savings realized ▪ Total support costs for project x months after solution is completed
Effort	▪ Actual effort hours vs. estimated planned hours ▪ Amount of Project Manager time vs. overall effort hours
Duration	▪ Actual duration vs. estimated workplan
Productivity	▪ Effort hours reduced from standard project processes ▪ Effort hours saved through reuse of previous deliverables, components, etc. ▪ Number of process improvement ideas implemented ▪ Number of hours/money saved from process improvements
Quality of Deliverables	▪ Percentage of deliverables going through quality reviews ▪ Percentage of deliverable reviews resulting in acceptance at the first time ▪ Number of defects discovered after initial acceptance ▪ Number of customer change requests to revise scope ▪ Number of hours of rework to previously completed deliverables ▪ Number of best practices identified and applied on the project ▪ Number of risks that were successfully mitigated
Project team performance	▪ The percentage of status reports that are late vs. number of status reports due per month

In table 3 are introduced success criteria, corresponding metrics, their category for balancing and priority. Data in table 3 are derived by the following activities:

1. **Identify criteria for success**
2. **Assign potential metrics**
3. **Look for a balance**
4. **Prioritize the balanced list of metrics**

Table 3. Table of success criteria and assigning potential metric

Int / Ext	Success Criteria *(1)*	Potential Metric *(2)*	Balance Category *(3)*	Priority (H/M/L) *(4)*
Int	Actual project cost in design department should be up to 110% of budgeted cost	Actual cost versus budget for project, for phase, for activity	Cost	H
Int	Overhead cost should be up to 15% of budgeted cost	Total labor costs vs. non labor	Cost	M
Int	Support and realization of improving and innovation ideas including cost reduction	Ideas for cost reductions implemented, and cost savings realized	Cost	H
Int	Support to building components with repetitive usage	Cost associated with building components for reuse	Cost	H
Int	Reduce design man - hours	Actual effort hours vs. estimated planned hours	Effort	H
Int	Reduce time – consumption of design work	Actual duration vs. estimated workplan	Duration	M
Int	Meet the project deadline	The date that the project is formally approved by the sponsor	Duration	H
Int	Raising design department productivity	Effort hours reduced from standard project processes Effort hours saved through reuse of previous deliverables, components, etc. Number of process improvement ideas implemented	Productivity	H H H
Int	Design work quality improving	Number of defects discovered after initial acceptance	Quality	H
Ext	Design work quality improving	Number of customer change requests to revise scope	Quality	M
Int	Design work quality improving	Number of best practices identified and applied on the project	Quality	M
Int	The project team must communicate proactively. All project status reports must be completed on time and sent to the project manager	The percentage of status reports that are late / number of status reports due per month	Project Team Performance	M

The next table 4 represents detailed project scorecard. This table includes balanced metrics of table 3 having the highest priority (easiest to collect / least cost) and is derived from the following:

5. **Set targets**.
6. **Add workplan detail**

Table 4. Detailed project scorecard (only heading)

Metric List the metrics that project team is actually going to collect	**Target** (5) What is project performance target? What is the unit of measure	**Data Needed** (6) What data are needed?	**Metric Gathering** (6) Who is responsible for collecting the metric and how often?	**Metric Gathering** (6) - How is project team going to collect the data?	**Metric Sharing** (6) - How will project manager share the information and how often

3. Conclusion

The purpose of the paper at the AEDS 2004 conference is to draw attention of designers and departments of design to the project management. We hope we succeeded to persuade you about the usefulness of managing the design work as the project.

Acknowledgement

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http:// www.tenstep.com

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