UNIVERSITY OF LATVIA

Christoph T. Staita

INTEGRATION OF AUXILIARY STAFF IN NEW PRODUCT DEVELOPMENT PROCESSES

DOCTORAL THESIS

Submitted for the Doctoral Degree in Management Science (Dr. sc. admin.)
Subfield: Business Management

Riga, 2015

This doctoral thesis was carried out:
at the Chair of International Economics and Business,
Faculty of Economics and Management, University of Latvia
from 2011 to 2015.

The thesis contains the introduction, five chapters, conclusions and recommendations, the reference list and appendixes.

Form of the thesis: dissertation in Management Science, subfield Business Management.

Supervisor: *Dr.oec.*, prof. Inesa Vorontchuk, University of Latvia / Riga, Latvia.

Reviewers:

1) Henrijs Kaļķis, *Doc. Dr. oec.*, University of Latvia
2) Kārlis Ketners, *Dr. oec.*, professor, Riga Technical University
3) Klaus Kellner, *Dr. oce.*, professor, University of Applied Sciences Augsburg (Germany)

The thesis will be defended at the public session of the Promotional Council of the Management Science and Demography, University of Latvia, at 12.00 on June 19th, 2015, 5 Aspazijas blvd 5, Riga.

The thesis is available at the Library of the University of Latvia, Raina blvd. 19, Riga.

This thesis is accepted for the commencement of the Doctor's degree in Management Science on March 20th, 2015 by the Promotional Council of the Management Science and Demography, University of Latvia.

Chairman of the Promotional Council — Professor *Dr. habil.oec.* Juris Krūmiņš

Secretary of the Promotional Council — M.b.a. Kristīne Bērziņa

ANNOTATION

Numerous research and practical publications in business administration, economics, sociology, psychology and information sciences have been dealing with the topic of New Product Development (New PD) team performance, especially with modern development theories such as concurrent / overlapping engineering, coherent, task based division of labour, the application of theories of competence diversity, of constraints, of motivation, of job satisfaction and cognitive dissonances in New PD under the aspects of economic and socio-psychological efficiency improvement. In contrast to the majority of investigations in the area of New PD concentrating on the question of how to optimise lead time, cost and quality by reducing the diverse constraints in the cooperation of the various operational business disciplines / functions concerned with the process of New PD (e.g. Ehrlenspiel, 2007; Wittenstein, 2007; Kliesch-Eberl & Eberl, 2009; Haon et al., 2009) this issue provides a specific approach to analyse the efficiency potential within the individual working units of Mechanical Development Departments (MDD). The empirical evidence of unbalanced task allocation in this nucleus of New PD due to overrated Software (SW) tool capabilities on the one side and the insights received from intensive literature review and extended theoretical analysis on the other side encouraged the author to propose and discuss a model of Integration of Auxiliary Staff (IofAS) within Mechanical Development Teams (MDT) in contrast to a model almost without any task related support, characterised with the well know term of job enrichment.

The model of efficiency improvement by task and competence based IofAS, the overarching topic of the present proposal to compose and apply coherent teams in New PD, is approached by the discussion of selected, model relevant efficiency increase measures within New PD processes related to task and competence based team composition and teamwork.

The aim is to identify the relevant condition, i.e. a framework to compose and use a coherent IofAS in New PD projects and to develop recommendations for the design and use of coherent, task and competence based team structures in commercial systems. The proposed cause effect relations between the IofAS as an independent variable and the economic and socio-psychological efficiency as dependent variables are analysed with the action research method and with an ex-post data collection conducted via questionnaires for 130 selected experts. The presented study resulted in cause-effect relations between various degrees of the IofAS and the economic and socio-psychological efficiency at a significant high level. A careful application of the empirical findings for the model of IofAS in single operating units (SOUs) in Mechanical Development Departments is advisable. More research is

recommended for a relaxation in the restrictions in this review as well as for an inclusion of the socio-psychological impacts on the auxiliary staff‘s (AS) job satisfaction to get further hints for a more general application of the proposed model.

Keywords: New Product Development, economic/socio-psychological efficiency, team composition, teamwork, competence diversity, concurrent/overlapping engineering, cognitive dissonance, causal model.

CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

LIST OF ABBREVIATIONS

3D CAD	Three Dimensional Computer Aided Design
AS	Auxiliary Staff
CC	Correlation Coefficient
CAD	Computer Aided Design
CD	Coefficient of Determination
CogDis	Cognitive Dissonance
DoL	Division of Labour
IofAS	Integration of Auxiliary Staff
HR(M)	Human Resource (Management)
KSA	Knowledge, Skills and Abilities
MD	Mechanical Development
MDD	Mechanical Development Department
MDT	Mechanical Development Team
MRA	Multiple Regression Analysis
MSC	Medium Sized Company
New PD / NPD	New Product Development
OPF	One Piece Flow
Q	Questionnaire
R	Response
RC	Regression Coefficient
Sig.	Significance Level
SOU	Single Operating Unit
SPSS	Statistic Package for the Social Sciences / Superior Performing Software System
SW	Software
TOC	Theory of Constraints
TCD	Theory of Cognitive Dissonance

GENERAL DESCRIPTION OF THE PROMOTION THESIS

Actuality of topic

Recent analyses of the work processed in Mechanical Development Departments (MDDs) under 3D CAD conditions (Three Dimensional Computer Aided Design) revealed that at least one third of the working hours are related to supporting activities, to distributable work, which is mainly concerned with product documentation (Wittenstein. 2007, p. 166 sqq., p. 189; Ehrlenspiel. 2007, p. 277 sqq.). And sad to say, this part is not automatically performed by the powerful 3D CAD software (Roh & Lee, 2007, p. 540) as expected in the beginning of the 3D CAD revolution by all parties concerned, by scientists as well as by practitioners, by managers as well as by students. The engineer is, in the most extreme case, responsible for doing everything, which belongs to the process of transforming the received information concerning the requirements for a new product into the information necessary to produce the new product. The time for the actual development of new products is therefore drastically restricted and concepts proven in practice, which offer with given resources the best possible solution are often preferred (Ehrlenspiel, 2007, p. 241 sqq.; Kliesch-Eberl & Eberl, 2009, p. 2). From his own experiences especially in medium sized companies (MSC) within a 3D CAD engineering environment the author fully complies with the assessments of Kliesch-Eberl & Eberl and Ehrlenspiel (amongst many others). Although by the introduction of 3D CAD in MDDs the development time and referred costs as well as the expenditure through almost automatic drawing up of product documentation should have been reduced decisively, the actual working conditions for engineers had become even more complicated - by the SW system's possibility to "produce" more variants and by the customer's increased demand for more variations. Also the working process had become more time consuming because as a result of the 3D CAD introduction the job of the technical auxiliary staff has broadly disappeared; and it is the engineer of MDDs who nearly produces the whole product documentation, at least in MSC. The actual existing chance of shortening development time which is today the dominating problem of development processes - where all members of staff, every company, all hierarchical positions and every line of business meet (Ehrlenspiel 2007, p. 27) - was dropped. And in addition a second vital dimension for corporate success and its innovation capability - apart from the time factor - the availability of qualified personnel in the area of development and construction had automatically suffered and the shortage of highly educated professionals, discussed in general (Strategy & Marketing Institute, 2005, p. 5, Ehrlenspiel 2007, p. 241 sqq.), collaterally increased. The management of MDDs seem to have - endogenously, self-imposed - intensified the deficit of qualified

employees due to an over assessed and over challenged implementation of the 3D CAD SW. Integrated software packages such as 3D CAD cannot replace the use of AS completely. (This assumption might be used as a simple but not really justified base for calculating the return of the SW investment.) The example of 3D CAD shows that the potential of that software can only be exploited adequately with AS integrated coherently in a New PD process. There is obviously an urgent need for an appropriate rectification of the exaggerated changes in the personnel structure and - a good chance to considerably improve the efficiency of New PD. This is outside the scope of the decision competences of the individual working units in the development departments. It is subject to the range of responsibility of the human resource management (HRM) to provide effective features and work environment (Jetter, 2006, p. 12), to find flexible solutions for urgent organisational problems (Legge, 2005, p.23) and to contribute to a success promising job attitude (Absar et al., 2010, p. 38 sq.). Whereas the working unit in MDDs is concentrating all its efforts to develop innovative, competitive and successful products and services in time, the human resource management is, apart from others, responsible to create the positive environment to enable that success. This should be realised by managers noting that they are a part of the success related interactions not outside of it (Stacey, 2010, p. 35 sqq.). To promote that understanding the author is introducing with this proposal a model of an adequate IofAS (e.g. technical draughtsmen, technical system planer, technical product designer) in MDDs to relieve the engineer from supporting activities - especially product documentation - with the aim to increase the economic and socio-psychological efficiency in this commercial area.

The model of efficiency improvement by task and competence based IofAS, the overarching topic of the present proposal to compose and apply coherent teams in New PD, is approached by the discussion of selected, model relevant efficiency increase measures within New PD processes related to task and competence based team composition and teamwork.

By applying the interdependent decision criteria, the economic cost efficiency (Pareto, 1897) and socio-psychological efficiency, the evaluated degree of satisfaction and acceptance of all involved in the commercial process (Neuert J., 2009, p. 67), the model can be proven respectively falsified. With the replacement of the exaggerated job enrichment by the model of IofAS the management is in the position to bring one of the essential tasks of an engineer in mechanical development projects, the design of new products in time, back into the focus of the nucleus of New PD again. This research demonstrates that a reversion to the meanwhile at least partially outdated theories of the humanisation movement as efficiency improvement by motivation based on job enrichment threatens or even prevents the use of the efficiency potential lying in modern development techniques such as overlapping of task/activities, a

proven method to compress schedules in New PD. In opposition to the theoretical basis for these unsound working conditions the author elaborates his model of a coherent, task and competence based IofAS in New PD processes. This model / theory of task and competence based IofAS provides a synthesis of the insights of the related theories and research results about division of labour, theory of constraints, team composition, teamwork, overlapping of activities and of job satisfaction and cognitive dissonances in order to identify the major mechanisms related to economic and socio-psychological efficiency improvement in the basic working units of New PD. The context between the theoretical and empirical findings and the relevant empirical evidence - the working conditions in MDDs – leads to a system of hypothesis / propositions to be examined. A causal model is created, the variables used are defined and the boundary conditions are described. To verify the hypothesis / propositions a research design is prepared, a research is performed and evaluated and the conclusions are discussed. The proposed cause effect relations between the IofAS as an independent variable and the economic and socio-psychological efficiency as dependent variables are analysed with the action research method, with an ex-post data collection conducted via questionnaires (Q) for 130 selected experts. To get clear indications of the value of the new model, the projects are sampled out of a carefully restricted scenario of the execution phase of variant construction projects within a 3D CAD environment in mechanical development departments. This method is applied to measure and examine empirically the impacts of IofAS determinants on selected efficiency indicators, to analyse the result and findings, to draw conclusions and to develop suggestions for business organisations of how to improve the efficiency of New PD processes - in general - by using the potential of the model of IofAS adequately.

Novelty

The basic idea of this paper is to point at the failure of overrated SW systems which, in the attempt to integrate several or all business disciplines / functions into a compound SW package, traditional a central goal of business informatics (Müller 2004, p.1), do not take into account the single operating units (SOUs) adequately. The challenge to link the complete product cycle within a SW system, from the idea respectively customer demand to dispatch and in-service support has caused not only efficiency improvements in all fields concerned. (As 3D CAD is the dominant SW of that kind in the area of MDDs, this research paper is referring to 3D CAD.) At this stage the gap is localised and the research starts. The dissertation addresses the approach that the theory of an efficient, task and competence based division of labour is still valid, not only in the age of globalisation within international co-

operations, within different functional units of a company, but also for the smallest operating units as for instance in MDDs presented in the selected environment of that study.

The following aspects represent the novelty of that research study:

- **The model of a task and competence based IofAS**

The model of a task and competence based IofAS in MDDs - to relieve bottleneck employees, the engineers, from documentation activities, to improve the efficiency in New PD noticeably - represents the novelty, by confronting the benefits of the new model with the actual working conditions of SW-driven and SW-forced job enrichment with a reduced division of labour to a minimum.

- **The identification of a critical gap**

The research identifies a critical gap between the scientific knowledge on efficient team composition and teamwork and the actual human resource practice. In this way, the presented proposal attempts to address one of the aims of the scientific community, to deepen the understanding and the application of scientific findings (Neuert, 2010b, p. 3). This implies for the presented research, to circulate some of the findings and insights of modern product development, more broadly, i.e. also into the centre of MDDs of MSCs, and to verify respectively falsify them in this specific environment, as in that area they had - consciously or not - been pushed into the background - at least as far as the basic working units are concerned - with negative effects on efficiency and innovation capability.

- **The constitution of a substantial cause-effect relation**

Finally, the promotion thesis constitutes substantial cause-effect relations between the degree of AS integration and socio-psychological efficiency, measured by the indicator job satisfaction; thereby this promotional work goes beyond the results of the studies so far conducted to identify factors influencing job satisfaction in organisations, as they have mainly correlation statistical character (Kappagoda, 2012; Rosenstiel, 2003, 1988, 1975; Weinert, 1998; Semmer & Udris, 1995).

Aim of research

The purpose of the dissertation is to find out if it is possible to improve Mechanical Development Department's (MDD`s) work organization using task and competence based integration of auxiliary staff.

Empirical findings should demonstrate a method to design and use coherent, task and competence based team structures and compositions, coherent degrees of a compatible IofAS,

which significantly and sustainably can improve the economic and socio-psychological efficiency in MDDs in contrast to the "old" model almost without any task related support.

Tasks of the promotional work

In order to achieve the aim of the dissertation, the following tasks were defined:

- to examine and measure empirically the impacts of IofAS determinants on selected economic and socio-psychological efficiency indicators with a defined action research procedure,
- to analyse the result and findings,
- to draw conclusions and
- to develop suggestions for business organisations to improve the efficiency of New PD processes in general by using the potential of IofAS adequately.

To get clear indications of the value of the new model, the research is based on development projects in the execution phase of variant construction within a 3D CAD environment of MDDs (Annex 1).

Research object

Work organization of Mechanical Development Departments (MDDs)

Research subject

Compatibility of Mechanical Development Department's (MDD`s) work organization with new technology – 3D CAD environment.

The single steps are:

- The findings from the literature review are used to formulate hypothesis / propositions about the impacts of auxiliary staff integration on the economic and socio-psychological efficiency.
- The hypothesis / propositions constitute the basis for the causal analytical model of the assumed cause-effect relationship between the independent variable IofAS and the dependent variables economic and socio-psychological efficiency within these projects.
- In order to test the set of hypothesis / propositions, the author applied the method of action research with the ex-post data collection via questionnaires – related to the carefully restricted area of MD defined in Annex 1.
- The questionnaires are used to collect empirical data for statistical analyses.

- Means, medians, standard deviations and relative frequencies of the variables involved were calculated and outcomes from the correlation analyses (correlation coefficients CC, coefficients of determination CD), the 2-tailed significance levels and the (multiple) regression analyses (MRA) were used to falsify or tentatively substantiate the hypotheses and to draw conclusions.
- Based on these results suggestions for business organisations are developed to improve the efficiency of New PD processes in general by using the potential of task and competence based IofAS adequately.

Hypothesis / Propositions

Basic Hypothesis HB:

HB: The higher the degree of task and competence based Integration of Auxiliary Staff, the higher the economic and socio-psychological efficiency of project outcomes.

The basic hypothesis is specified in detail by the following compound propositions (P_1-P_6) illustrating for each proposition the observable determination indicators for IofAS (X_1, X_2) causing the observable effect indicators of the expected project outcomes (Y_1-Y_6). The independent determinant of the set of hypothesis / propositions, the IofAS, is established by the variables X_1, the creation of the drawing sets, and X_2, the additional supporting documentation activities.

Theses to defend

P_1: The higher the degree of task and competence based IofAS (X_1, X_2), the higher the possibility of meeting the project deadlines (Y_1).

P_2: The higher the degree of task and competence based IofAS (X_1, X_2), the higher the possibility of reducing the project costs (Y_2).

P_3: The higher the degree of task and competence based IofAS (X_1, X_2), the higher the possibility of reducing the drawing set errors (Y_3).

P_4: The higher the degree of task and competence based IofAS (X_1, X_2), the higher the engineer's contentment with the tasks (Y_4).

P_5: The higher the degree of task and competence based IofAS (X_1, X_2), the higher the acceptance of engineers and auxiliary staff with the project progression (Y_5).

P_6: The higher the degree of task and competence based IofAS (X_1, X_2), the higher the possibility of utilisation of engineer's competences (Y_6).

Used methods

Using scientific databases, the author identified the following main areas of recent scientific discussions, theories as well as related investigations, relevant to the presented research, the identification of the essential conditions for a coherent, task and competence based IofAS in New PD projects: a modern application of division of labour in conjunction with the theory of constraints, functional respectively competence diversity in teams, overlapping of development activities and cognitive dissonance theory. The structure of the discussion of these areas is designed in the style of the normal performance of a New PD process, which is a continuous agglomeration starting from broad based information about the requirements for a new product to the final state with very precise information, necessary to produce this new product; the applied structure is comparable with a hopper/funnel from a large diameter (begin of the activity) to a final point (Krishnan et al., 1997, p. 437). The way of the discussion of the theories and related researches (in chapter 1 and 2) is a continuous narrowing from a vague description of assumptions to a clear formulation of the research hypothesis / propositions for the presented new model. Starting with the relatively imprecise, spacious, but nevertheless fundamental theme of division of labour the ongoing proceeding receives a first refinement by the discussion of the topics team composition, teamwork, competence diversity and familiarity. With the subsequent extensive treatment of overlapping of development activities this literature research concentrates on the central subject of that work and achieves its final focus by adding the relevant socio-psychological aspects, especially the theory of cognitive dissonance. Thus the relevant main success criteria are addressed and empirical evidence together with the theoretical findings lead to the system of hypothesis / propositions and the causal model for this new model of IofAS. In order to test the set of hypothesis / propositions, the method of action research with the ex-post data collection is conducted. A questionnaire (Q) is used to get empirical data for cause-effect analyses between the impact of auxiliary staff integration in variant construction projects and economic respectively socio-economic efficiency within these variant construction projects. To analyse the empirical data the following statistical methods are used: Descriptive statistical

methods to determine the location parameter and distributions like the mean value and standard deviation etc. supported by graphical and table methods and correlation, significance level and multi regression analyses in order to prove dependences between model parameters (variables).

Approbation of results of research (publications, conferences)

Several steps during the development of the dissertation were presented and discussed within the following international business conferences:

1. Staita, Christoph, COHERENT DIVISION OF LABOUR IN A THREE-DIMENSIONAL CAD NEW PRODUCT DEVELOPMENT (NPD) ENVIRONMENT, Global Business Management Research Conference, Dec. 02-04,2011, Fulda, University of Applied Science Fulda, Germany.

2. Staita, Christoph, COHERENT TEAM STRUCTURE IN A THREE-DIMENSIONAL CAD NEW PRODUCT DEVELOPMENT (New PD) ENVIRONMENT, New Challenges of Economic and Business Development Conference, May 10-12,2012, Riga, University of Lativa, Latvia

3. Staita, Christoph, PERFORMANCE IMPROVEMENT BY FUNCTIONAL RESPECTIVELY COMPETENCE-DIVERSITY IN NEW PRODUCT DEVELOPMENT (New PD), International Business and Economics Conference, August 03-05, 2012, Kufstein, University of Applied Science Kufstein, Austria

4. Staita, Christoph, COHERENT TEAM STRUCTURE IN A THREE-DIMENSIONAL CAD NEW PRODUCT DEVELOPMENT (New PD) ENVIRONMENT, 71st UL scientific conference session “Economic and Business Impact of Globalisation”, January 30, 2013, Riga, University of Latvia, Latvia

5. Staita, Christoph, COHERENT TEAM STRUCTURE IN A THREE-DIMENSIONAL CAD NEW PRODUCT DEVELOPMENT (New PD) ENVIRONMENT – RESEARCH DESIGN, International Business and Economics Conference, November 29, 2013, Kufstein, University of Applied Science Kufstein, Austria

6. Staita, Christoph, INTEGRATION OF AUXILIARY STAFF IN NEW PRODUCT DEVELOPMENT (New PD) PROCESSES, ISSWOV International Society for the Study of Work & Organisational Values Conference, June 29-July 2, 2014, Riga, University of Latvia, Latvia

7. Staita, Christoph, INTEGRATION OF AUXILIARY STAFF IN NEW PRODUCT DEVELOPMENT PROCESSES, Economics, Finance, MIS & International Business Research Conference, July 10-12, 2014, London, The Journal of American Academy of Business, Great Britain

8. Staita, Christoph, TASK AND COMPETENCE BASED TEAM COMPOSITION – ECONOMIC AND SOCIO- PSYCHOLOGICAL ANALYSIS OF AUXILIARY STAFF INTEGRATION IN NEW PRODUCT DEVELOPMENT (New PD) PROCESSES -, ABA 2014 International Conference, August 6-10, 2014, Florence, Academy of Business Administration, Italy

Publications:

1. Staita Christoph (2012). Coherent Team Structure in a Three-Dimensional CAD New Product Development (New PD) Environment. In: *New Challenges of Economic and Business Development Conference Proceedings*, Riga, Latvia, pp. 657-667

2. Staita Christoph (2013). Job enrichment, task satisfaction and socio-economic efficiency: A research in socio-psychological theories related to dissonances in development departments of medium-sized companies. In: *Journal of Economics and Management Research 2*, pp. 106 -117.

3. Staita Christoph (2014). Performance improvement by functional respectively competence diversity in New Product Development (New PD). In: *Expert Journal of Business and Management,* Vol. 2, No. 2, 62-71.

4. Staita Christoph (2014). Coherent Division of Labour in a Three-Dimensional CAD New Product Development (New PD) Environment. In: Expert Journal of Business and Management Vol. 2, No. 2, pp. 54-61.

5. Staita Christoph (2014). Coherent Team Structure in a Three Dimensional CAD New Product Development (New PD) Environment - Research Design. In J. Neuert (Ed.), Contemporary Approaches of International Business Management, Economics, and Social Research (Vol. 1, pp. 104-114). Berlin: epubli GmbH.

6. Staita Christoph (2014). Integration of Auxiliary Staff in New Product Development (New PD) processes. In: *ISSWOV International Society for the Study of Work & Organisational Values*, Riga, Latvia, 280-287

7. Staita Christoph (2014). Integration of Auxiliary Staff in New Product Development Processes. *The Journal of American Academy of Business, Cambridge, 20* (1), 176-183.

8. Josef Neuert, Staita Christoph (2015). Task and Competence Based Team Composition – Economic and Socio-Psychological Analysis of Auxiliary Staff Integration in New PD Processes -. In: *Journal of Global Economics, Management and Business Research*, 2 (4),190-200

Content of dissertation

The doctoral thesis consists of an introduction, five chapters divided into 22 subchapters, conclusions and suggestions.

The theoretical basis for the research is reviewed in the first two chapters. The main success criteria to increase economic and socio-psychological efficiency in New Product Developments related to task and competence based team composition and teamwork are discussed and conceptual directions to the new model of Integration of Auxiliary Staff are analysed. The literature review reveals that the fundamental idea of the new model of task and competence based team composition and teamwork via division of labour, competence

diversity, overlapping procedures between engineers and auxiliary staff increases the economic and socio-psychological efficiency. Furthermore, the review of the relevant literature suggests the assumption that a higher conformity of self-image with task content leads to a higher task satisfaction. In addition, with the theory of constraints methods to relieve bottleneck situations are proposed. Hypothesis / propositions are derived from the literature review, which constitute the basis to create a causal analytical model, illustrating the cause-effect relationship between the dependent variables economic and socio-psychological efficiency within variant construction projects and the independent variable auxiliary staff integration within these projects.

The practical part of the dissertation is covered in chapters 3 and 4. The third chapter focuses on the empirical research carried out in an ex-post facto study. The fourth chapter describes the details of the validation methods used and the major findings aligned with the empirical research. The dissertation ends in chapter 5 with a general discussion of the conclusions and suggestions for the implementation of the research findings in business contexts. The doctoral thesis consists of 156 pages without appendices and includes 20 illustrations and 37 tables. The thesis refers to 178 sources of literature used and has 6 appendices covering 9 pages.

Discussion of research results

More research to identify additional factors, e.g. the intensity and quality of permanent training and education programs, which characterise the degree of AS integration in the execution phase of variant construction projects within a 3D CAD environment, is recommended.

This research project is restricted to the execution phase of a variant construction project within a 3D CAD environment in MDDs. Further investigations into the application of the model of IofAS in phases 1 and 2 of a development process and in other areas of new PD such as adjustment development and innovation development projects, electrical development or SW development disciplines are suggested as comparable promising results are expected.

Main results of the research

Based on correlation analysis according to Spearman and a significance level test of the manifest measurement of the latent exogenous variable volume of drawing generation (X_1) which is an indicator for independent variable auxiliary staff integration and the manifest measurement of the latent endogenous variables meeting of project deadlines (Y_1) and drawing set errors (Y_3) which are indicators for the dependent variable economic efficiency

the empirical data do provide essential results to tentatively substantiate the

propositions PY_1X_1 and PY_3X_1.

When it comes to socio-psychological efficiency project outcomes in the execution phase of variant construction projects the correlation analysis according to Spearman and a significance level test of the manifest measurement of the latent exogenous variable volume of drawing generation (X_1) and additional supporting activities (X_2) which are indicators for the independent variable auxiliary staff integration and the manifest measurement of the latent endogenous variable engineer's contentment with the task (Y_4) which is an indicator for the dependent variable socio-economic efficiency

the empirical data do provide essential results to tentatively substantiate the proposition PY_4X_1 and PY_4X_2.

Based on correlation analysis according to Spearman and a significance level test of the manifest measurement of the latent exogenous variable volume of drawing generation X_1 which is an indicator for independent variable auxiliary staff integration and the manifest measurement of the latent endogenous variable instrumental use of engineer's competences (Y_6) which is an indicator for the dependent variable socio-psychological efficiency

the empirical data do provide essential results to tentatively substantiate the proposition PY_6X_1.

Main conclusions

The results of the empirical and theoretical findings combined with the research results and theoretical interpretations lead to the following conclusions in respect of the basic hypothesis and the related propositions:

Overall, the basic hypothesis, the higher the degree of task and competence based IofAS, the higher the economic and socio-psychological efficiency of project outcomes, is tentatively supported, particular as far as the dominant criteria time (Y_1) and quality of New PD (Y_3) and, in consequence, engineers' contentment (Y_4) plus the instrumental use of engineers' competences (Y_6) are concerned.

However, taking the results of the CD (r^2) analyses and of the MRA into account, it has to be considered that various additional independent variables do have an impact on the set of dependent variables related to the project success in New PD processes. This insight leads to additional theoretical considerations, concerning other influencing variables on the project success in economic and socio psychological terms.

Used sources

The literature review is built on various success criteria related to New PD to get a general

overview about the specific efficiency mechanism in the selected area of PD, using scientific databases. The model of efficiency improvement by task and competence based IofAS, the overarching topic of the present proposal to compose and apply coherent teams in New PD, is approached by the discussion of selected, model relevant efficiency increase theories within New PD processes related to task and competence based team composition and teamwork. Main authors of the literature review are Absar et al., 2010; Aronson et al. 2008; Bogus et al., 2011; Cooper & Kleinschmidt 1995; Dahlin et al. 2005; Ehrenspiel, 2007; Haon et al., 2009; Hollenbeck et al., 2004; Hubka, 1976; Kappagoda, 2012; Kliesch-Eberl, & Eberl, 2009; Krishnan et al., 1997; Marujo, 2009; Mayer, 1988; Neuert, 2009; Pena-Mora & Li, 2001; Roh & Lee, 2007; Rosenstiel, 2003; Stacey, 2010; Ulich, 2001; Weiber & Mühlhaus, 2010; Wittenstein, 2007; Zwikael & Globerson, 2006.

1. REVIEW OF RELATED LITERATURE CONCERNING THE OPERATING ENVIRONMENT OF NEW PRODUCT DEVELOPMENT

The empirical evidence of unbalanced task allocation in the nucleus of new PD due to over-rated SW tool capabilities on the one side and the insights received from intensive literature review and extended theoretical analysis on the other side encouraged the author to propose and discuss a model, a theory to improve the efficiency of New PD in MDDs by a task and competence based IofAS in contrast to a model almost without any task related support for engineers, characterised with the well know term of job enrichment, driven by the 3D CAD implementation in MDDs. In chapter 1 of this proposal the review of the relevant literature is detailed. Scientific databases are used to elaborate the topic success criteria relevant for the establishment of coherent team structures, coherent IofAS into MDDs. The term coherent is used to comprise task as well as competence based integration.

The model of efficiency improvement by task and competence based IofAS, the overarching topic of the present proposal to compose and apply coherent teams in New PD, is approached by the discussion of selected, model relevant efficiency increase measures within New PD processes related to task and competence based team composition and teamwork.

The theoretical basis of this new model is specified and discussed starting with the relatively imprecise, spacious, but nevertheless fundamental theory of division of labour. The ongoing proceeding receives a first refinement by the discussion of the topics team composition, teamwork, competence diversity, familiarity and shared mental model. With the subsequent extensive treatment of overlapping of development activities this literature research concentrates on the central subject of that work and achieves its final focus by adding the relevant socio-psychological aspects, especially the theory of cognitive dissonance. Thus the major mechanisms related to economic and socio-psychological efficiency improvement by the model of IofAS are addressed - with a particular view on possible implications on basic operating units in MDDs. The idea is to point at those overrated SW systems in general which, during the attempt to integrate several or all business disciplines / functions into a compound SW package, traditional a central goal of business informatics (Müller 2004, p.1), are not adequately taking single operating units into account. The challenge to cover the complete product cycle within a SW system, from the idea respectively customer demand to dispatch and in-service support has caused not only efficiency improvements in all fields concerned. As 3D CAD is the dominant SW in the area of the development of new products, this research paper is referring to 3D CAD.

1.1. Basics of Economic Efficiency Increase in the Process of New PD

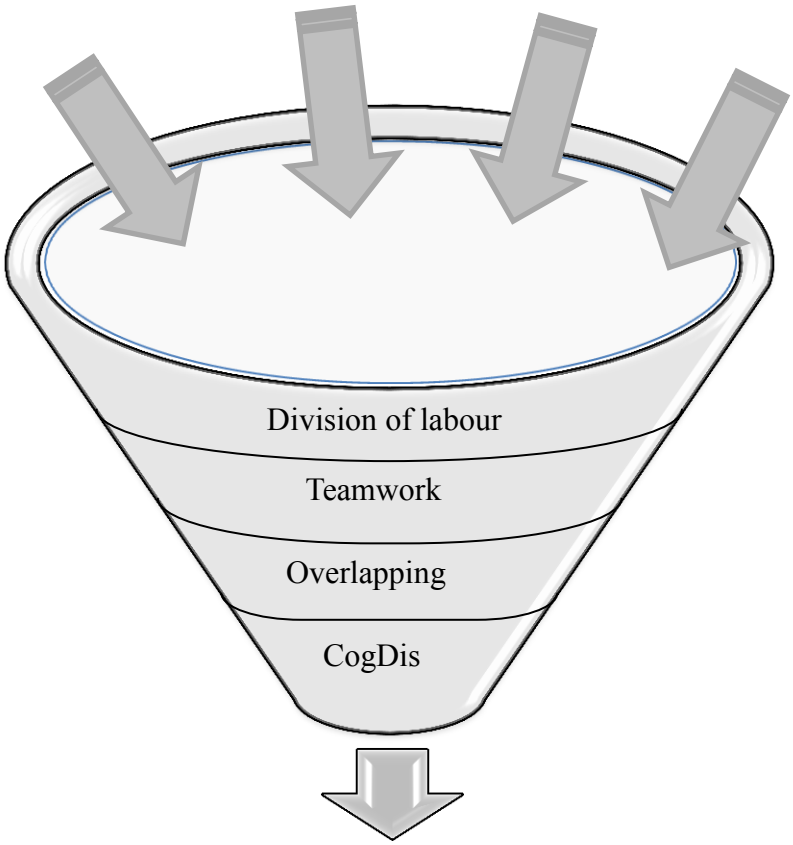
Efficiency and effectiveness/effectivity are very common terms, not only in the context of business affairs. In general, an activity is effective, if it produces the intended result; i.e. according to P. Drucker, if the right things are done related to a defined goal. In comparison, an activity is efficient, if it is performed with the least waste of resources, time, cost or man power, i.e. again according to P. Drucker, the classicist of modern management theories, if the things are done right, without any waste (Drucker, 1993, p. 1 sq.). As the author intends to evaluate in the presented model of IofAS both, the effectiveness in terms of target achievement and the performance, both terms are workable in this context and the author follows the simplification, also applied in other scientific papers, by consistently using the technical term "efficiency" (e.g. Neuert, 2009, p. 246 sq.).

The economic efficiency dimension subsumes primarily objective cost-benefit ratios while the socio-psychological component of efficiency subsumes all indicators, related to the individual and / or collective satisfaction based on the subjective assessment of all participants (Neuert, 2009, p. 250). The concept of economic efficiency is a decision criterion, which from several equally effective environmental measures selects the one that is associated with the least economic cost, also called cost efficiency (Pareto, 1897)

Socio-psychological efficiency is a decision criterion for all areas of human actions, transactions and interactions, interpersonal relationships and leisure and is analysed by evaluable variables, such as satisfaction, acceptance, and others. The intension is to combine the economic terms (cost aspects) with the evaluable variables of sociological, psychological and socio-psychological provenance and to undertaking cost-benefit analyses (Neuert J., 2009, p. 67).

Improvement of economic efficiency in the process of New PD is achievable by shortening of downtimes and of processing time and by a reduction of the consumption of material and other efforts during the development phase. As far as the time factor is concerned, an integral component of this paper, the means of choice are better co-ordination between efficiency units (indirect rationalisation), optimisation of the processing operation (direct rationalisation) or/and the combination of indirect and direct rationalisation. The main branches of economic and socio-psychological efficiency increase measures within the development of products are relief of bottlenecks, job satisfaction, scheduled capacity planning, standardisation, cross-functional teams, overlapping task strategies, division of labour (Ehrlenspiel, 1995, p. 243 sqq.; Wittenstein, 2007, p. 22 sq.; Fischer, 2008, p. 2) etc. In the following, the main efficiency improvement measures are being controverted in order to transfer relevant findings

to the object of this study, to analyse the supposed dominance of the presented model of a task and competence based IofAS in MDDs compared with the application of a SW-forced job enrichment model. The evaluation of the research resulted in the structure, visualised with figure 1.1.



Model of task and competence based IofAS

Figure 1.1: Efficiency improvement in New PD by task and competence based IofAS - Agglomeration of model-relevant theories

Source: Staita, 2014, p. 281

The discussion of the theories (and related researches) is a continuous narrowing from vague assumptions to a clear formulation of the basic idea for the presented new model. Starting with the relatively imprecise, spacious, but nevertheless fundamental theme of the division of labour for efficiency improvement the ongoing proceeding receives a first refinement by the discussion of the topics team composition, shared mental model, teamwork, competence diversity and familiarity. With the subsequent extensive treatment of overlapping of development activities this literature research concentrates on the central subject of this work. After all, the final focus is achieved by adding the relevant socio-psychological efficiency

aspects, especially the theory of cognitive dissonance (TCD), giving the importance of behavioural economics in explaining economics (Cammerer et al., 2004, p. 4) an adequate place in the presented work.

These selected theories are analysed in chapter 2 by referencing to results of studies connected to the current subject and by deducting hypotheses relevant for the proposed model of efficiency improvement in New PD by a task and competence based IofAS.

1.2. Theoretical Background of Success Criterion Division of Labour

With the implementation of 3D CAD the world of engineers seemed to become a completely new and fascinating one in which the engineer is a 100% creative part of an innovative company – with all supporting activities taken over by marvellous software, automatically and completely. However this did not work and speed and innovation, the keys to success are at risk.

It is commonly agreed in theory as well as in practice that speed and innovation are the key points for success in commercial competition (Abolhassan, 2003, p. 1 sq.; Hirzel, 1992, p. 19 sqq.; Anagnost, 2005, p. 14) and that the development departments are one of the greatest bottlenecks in the turbulent, fast-moving business environment (Ehrlenspiel, 2007, p. 241 sqq.). There is actual a basket of methods available to overcome the pressure on engineers in development departments and to improve its efficiency, e. g. project management, process oriented approaches or division of labour and standardisation. According to these ideas companies have established worldwide their procedures since decades, partially since more than 100 years, until a “revolution” dramatically changed at least the organisation of MDDs, the 3D CAD. With the new SW generation the engineers in these companies have more or less lost their “right-hands”, the technical auxiliary staff, and the massive drawing documentation work was creeping towards the engineer. This over-reaction was initiated by the fulsome praise of the software development companies, was - unconsciously - fostered by the universities in the course of the qualification of engineers and was put into operation by the management of commercial companies in expectation of substantial reductions of lead time and cost. But one tricky outcome of that SW revolution was that even with the new design system the possibility to “produce” more variants and the customer demand for more variations increased essentially, with a rather negative impact on the workload of the engineers. In this context Wildemann (2003, p. 7) found that from 1980 till 1997 the number of variations in the receipt of orders exploded within growing markets by 410% whereas the number of orders increased only by 240% and this trend continued unbroken and even more extensive in stagnating markets.

Recent analysis of the workload of development engineers revealed - unsurprisingly - that at least one third of the working hours are related to supporting activities, to distributable work (Wittenstein. 2007, p. 166 sqq., p. 189; Ehrlenspiel. 2007, p. 277 sqq.). Time for the actual development of products is drastically restricted, especially in MDDs. Owing to the mentioned developing engineer's enforced multi-functionality, i.e. the already addressed SW-driven job enrichment, concepts proven in practice which offer with given resources the best possible solution are often preferred (Ehrlenspiel, 2007, p.241 sqq.). These exploitation processes with their unsound fixation to existing solutions is one big hurdle for innovation (Kliesch-Eberl & Eberl, 2009, p.2) and according to BMBF (2007, 2011) the capability to innovation of small and medium sized companies is strongly related to the availability of sufficient qualified and experienced members of staff.

There is obviously a considerable need to apply proven organisational basics in order to utilise valuable resources adequately.

1.2.1. 3D CAD vs. Division of Labour

The features and benefits of the new SW generation are described by the SW development companies as follows: Superior product differentiation and manufacturability by powerful parametric design capabilities, fully integrated applications allowing the use of a single application for the entire development cycle - from concept to production, automatic onward transfer of design changes to all downstream delivery components for increased confidence in the construction work, comprehensive functions for virtual simulation, improved product performance and an even higher product quality, automated generation of associated tooling design and manufacturing deliverables (e.g. PTC Product & Service Advantage, 2013). This is according to those companies combined with a remarkable cost saving potential, e.g. productivity jump in the ratio of 4:1 (= personnel cost minus 75%), minimised alteration service due to reduced error rate by 90%, reduced tooling costs by more accurate and more complete information, less waste, less inspection effort, fewer test runs in development (e.g. Solid Edge/Siemens, 2000). This is not the place to analyse all these promised benefits of a really mighty SW in detail (cf. e.g. Busson, 2005, p. 50; Songer et al., 2001, p. 189; Bernard, 2005, p. 416); they are actually realised also in MDDs to a certain extent. However, what is most critical for the daily practice in these companies was the "promise" of full integration from concept to production and the remarkable personnel cost saving potential, which was obviously taken as the signal to change the team structure of MDDs dramatically by nearly quitting the commitment of auxiliary staff. Furthermore the components which are to be constructed have become much more complex (DFA-extensive functional integration,

deterministic finite automation) and free-form surfaces, which had not been possible so simply before the new SW generation was invented, led to a higher level of complexity - amongst others - also within the drawing up of technical documentations. As a matter of fact the software is not efficient enough to work them out automatically (Beckert, 2000, p. 419; Roh & Lee, 2007, p. 540) and it is the engineer in MDDs who creates the drawings / product documentation usually these days. In an empirical study (Kessler & Chakrabarti, 1999, p. 231 sqq.), found that clear time-goals, longer tenure among team members, and parallel development all could increase speed, whereas design for manufacturability, frequent product testing, and computer-aided design (CAD) systems decreased speed. Moreover, they also found that some factors speed up radical innovation (e.g. concept clarity) and slow down incremental innovation. Actually for that study it is important to mention that there is already empirical evidence that CAD decreases speed in new product development. That is completely contrary to the promises of the software development companies. As already explained, it is not at all the intention of this paper to query the investment decision for the implementation of 3D CAD, because it is really a strong tool and - today New PD is no longer imaginable without 3D CAD. However the paper intends to demonstrate that these companies have good chances to increase their efficiency considerably by using it adequately, which is to manage the aspects of organisation, information and communication and production technologies sensibly (Bernard, 2005, p. 419); and one special concern of that investigation is to go back to the application of the basic ideas of efficient organisation, to a coherent division of labour.

1.2.2. Coherent, Task Based Division of Labour and Standardisation

Convinced of a solvable imbalance in respect to the allocation of personal resources, the next step must be, to examine in detail the discussion on division of labour, which is rated as the prerequisite for the presented model.

Since the beginning of the industrial revolution at the end of the 19th century up to the 60s of the 20th century the concept of Taylorism, the scientific management was the dominant system for the organisation of operating procedures in order to achieve maximum productivity (Taylor, 1911; Heinen, 1974 p. 449). The headstone was already laid down more than 100 years before by Adam Smith with his proposal to increase productivity by specialisation via a process of deepening division of labour extensively (Smith, 1776). According to these ideas productivity will increase by reduced work training, learning effects, higher speed of completing one's task, clear assignment of responsibility for any possible faults, reduced burden and less labour cost (Kieser & Walgenbach, 2003, p. 81). While A. Smith concentrated

his researches on macro-economic aspects of the division of labour, F. W. Taylor studied the micro-economic ones. F. W. Taylor's merits can be seen in the relief of work operations from their deficits lying in the workers, the tools and the materials by a systematic and methodical analysis. The result should be a re-connection of these operations with increased efficiency by deactivating all random inefficient events (Gutenberg, 1966, pp. 144-146).

The present work will especially follow up the arguments of achieving more speed and lower cost by a systematic and methodical analysis of work operations.

The completely mechanical point of Taylor's view had to make way for the social welfare and human relation movement (Heinen, 1974 p. 451 sq.) for various reasons: the workman is condemned to monotonous routine and thinking, initiative, work satisfaction and joy are denied and individuality and innovative spirit are destroyed. Insights about the extensive socio-psychological disadvantages of a division of labour are described many times (Kieser & Walgenbach, 2003, p. 81 sq.; Ehrlenspiel, 2007, p. 184 sqq.). According to these insights and accompanied by an overall change in values and even individualisation, science of work has turned since the 70s of the 20th century to establish humane working surroundings. Re-integration of previous eliminated labour contents is one of the basic attempts to design integrative tasks in a way to get rid of the negative effects of the division of labour. The motivation of members of staff should get improved by job enrichment, use of different abilities, social interaction, areas of independent decision making and personal development (cf. Kieser & Walgenbach, 2003, p. 82 sqq.). But even task integration as well as specialisation are limited in respect of motivation improvement and Weltz & Bollinger (1987, p. 52 sqq.) called for a task and job based specialisation. Kühn et al. (2006, p. 154) noted a rising integration of tasks by specialised experts, of tasks, which could easily been done by people with different (or lower) level of expertise, competences or education. These are notable hints on economic as well as socio-psychological inefficient operations and Mayer (1988, p. 159 sqq.) demands in the year 1988 a cooperative division of labour with a specialised expert at the centre. At this stage a reference is made to actual, longitudinally conducted studies that confirm strongly this theory and which is analysed under chapter 2.2 with the aim to adopt the theoretical findings for the model of IofAS and the associated hypotheses under discussion.

There are no definite determinations concerning the way and level of division of labour in the development of products. Different kinds of division of labour can simultaneously be seen within just one company or even just one project. The concrete distinctness depends on the level of the complexity of a project as well as on the size of the company. Within product development a task can in principle be divided sequentially - in different single steps, worked

on one after the other - or parallel - divided according to quantities or objects - (Ehrlenspiel, 2007, p. 162 sqq.). In addition a horizontal division - in tasks equal in ranking - and a vertical division - in managing and performing tasks must be under consideration (Scholz, 1995, p. 99). Of these, the vertical variant of division of product development tasks is the subject of this thesis with the characteristics of preparation, creative and executive, routine activities. On the basis of the 3 new PD phases mentioned under Annex 1, the preparation (1), the creative (2) and the executive (3) phase Hubka (1976, p. 14) distinguishes five different kinds of tasks in the area of development / construction:

- Skilled labour in terms of technical and scientific considerations to think ahead of a mechanical system (phase 1 and 2, remark of the author).
- Activities associated with the description of the mechanical systems (phase 3, remark of the author).
- Skilled labour, but no direct contribution to the design of mechanical systems (phase 3, remark of the author).
- Supporting work, e.g. copy, cut and archive of drawings (phase 3, remark of the author).
- Management activities.

Based on this structure Mayer (1988, p. 80 sqq.) raises the question how the coordination between experts and supporting members of staff must be designed. Vertical division of labour proves itself so long as coherent as it does not lead to uneconomic use of (high) qualification. Wittenstein (2007, p. 98) substantiates this demand with what she calls “Sinnvoll verteilbare Arbeitseinheit”, “practically distributable task package”. One of the essential influencing variables for a practicable distribution, and also one of the k.o.-criteria, is the ratio of effort of time for distribution of a work unit vs. the temporal scope of effort of the work unit to be distributed; the smaller the ratio is, the better is the suitability for distribution (Wittenstein, 2007, p. 136). The time for distribution is strongly related to the degree of standardisation. And it is just the automatic onward transfer of information about the design characteristics and changes offered by 3D CAD which simplifies to meet that criterion.

In this context a brief discussion of standardisation is inserted, followed by further success promising approaches outlined with the aim, to determine verifiable procedures for establishing coherent packages of tasks. The analysis should result in a discharge of the development engineer and in respect to motivation autonomous work packages should be created for both, engineer and auxiliary staff in a modern MDD environment; thus the efficiency of the development departments should increase - without losing flexibility in

highly competitive markets.

There is a wide range in the discussion of division of labour and standardisation depending on the subject of the respective considerations and investigations. According to Mobius and Schoenle the organisation of work for mass production requires standardisation to exploit the economies of scale. More customised products are subject to trends and fashions which make production tasks less predictable and a strict division of labour impractical (Mobius & Schoenle, 2006, p. 1 sqq.). Against that Pottier found that present trends in the organisation of multinational division of labour show that the criterion of the degree of standardisation of activities tends to substitute that of the degree of labour skill (Pottier, 2007, p. 299 sq.). As far as the current subject is concerned, the development of variant constructions, it is helpful to consider the statement of F. Taylor given in 1911 in this context: "Under our system a worker is told just what he is to do and how he is to do it. Any ‚improvement' he makes upon the orders given to him is fatal to his success" (Taylor, 1911, p. 21). By that a strong relation between division of labour and standardisation is indicated, even if the philosophy behind is not at all present, i.e. the understanding of a coherent organisation of work. But this statement demonstrates that the intention of standardisation is the forming and describing of processes for repeatedly occurring tasks; this is also called coordination through programs (Kieser & Walgenbach 2003, p. 115 sqq.). A standard describes the simplest, easiest, safest and fastest way to do something (Thompson 2000, S. 54-57; Bieber 2001, p. 30). With the standardisation of repeatedly occurring tasks, i.e. with consistently defined routine activities, with programs, a company is relieved from single case-oriented coordination. In addition the possible reactions on particular situations are speeded up and a problem appropriate procedure is supported by standards. Mental capacities stay free for tasks which require new, individual proceedings. Through standardisation the work content is more easily comprehensible for third parties, the current knowledge is documented and training of new members of staff is facilitated, best practise is made available. Standardisation can contribute to an increase of productivity relieving planning activities and setting of quality standards which can be the basis for improvements. Furthermore it can create comparability as a basis for an assessment of performances. A detailed description of the effects through standardisation gives by Thompson (1997, pp. 51-78). The operative and strategic potentials of the use of standardisation are described by Feldmayer and Seidenschwarz (2005, p. 14 sqq.) within their theory of process standardisation.

Clues for task orientated forms of standardisation in the area of development of new products are presented by Nippa and Reichwald (1990, p. 73) through their theory of process chains of development type A and B, the adjustment and variant constructions respectively innovations,

which require different kinds of strategies of standardisation. This is also Ehrlenspiel's point of view and he recommends various rationalisation strategies for the constructive handling or the construction progress depending on the respective traits of the project under consideration (Ehrlenspiel, 2007, p. 286 sqq.). As this paper is centred to Nippa's and Reichwald's development task of type A, the variant construction, it is necessary to define a standardised model which is created during the construction phase by the engineer. This standardised model has among others to be particularised to a standardised drawing set - without further capacity commitment. Integrated SW packages such as 3D CAD facilitate the establishment of clear standards related to the quality of information, to responsibilities and authorities and clear rules for cooperation. These compatibility standards, which in general should realise and simplify the interactions (Müller, 2004, p. 5), are understood to be one of the conditions enabling the coherent division of labour as envisaged by the project. The thesis will demonstrate that the statement "there is no detailed argumentation required to prove the effect of increasing productivity / efficiency by division of labour" made about 50 years ago by (Gutenberg. 1966, p. 144) is still valid under the current working conditions in MDDs, which are mastered by modern sophisticated software systems. Therefore the author pursues the idea that it is even today possible and necessary to define an optimal team structure - also in this particular environment. In addition the author does not hesitate to stress the importance of division of labour, which may be seen self-evident, because he feels division of labour belongs to the category of "right things" which actually must be done (in the sense of P. Drucker - as referred to in sub-chapter 1.1). The further proceedings of this paper are built on this basement and are subject to the category of doing the things right (following P. Drucker verbalisations). The question of how to organise that coherent division of labour leads right to the discussions among scientists and practitioners about team composition.

1.3. Theoretical Background of Success Criterion Teamwork

Performance improvement by functional- respectively competence-diversity in New PD

This paragraph illustrates the research results concerning the relationship between team composition in New PD and project respectively team performance. The aim is to support the basic hypothesis of the author with the theories of recent scientific publications: "The higher the degree of task and competence based Integration of Auxiliary Staff, the higher the economic and socio-psychological efficiency of project outcomes".

Besides studying standard references, a systematic inquiry, using the scientific databases was performed to study team composition, cross-functionality and competence diversity in New

PD. The study of various scientific databases revealed that the degree of functional diversity in development teams which is supposed to promote performance is an inadequate variable. Essential to compose successful teams are at least competence diversity and familiarity. This paper selects these essential areas to establish efficient development teams, the functional and competence diversity, for a diligent review of relevant scientific literature on the one hand and for the placement, tracking and evaluation of these aspects in the cause-effect model, analysed under chapter 2 and the following of that management project on the other hand. The intention is to consider competence diversity not only for companywide teams but also within SOUs in MDDs. The team composition discussions follow the designed procedure of the project outlined in sub-chapter 1.1. with a first refinement of the basics of division of labour by team related theories in order to advance towards the proposed model of IofAS.

1.3.1. Team Composition: General Considerations

Talking about team composition is talking about assembling and combining two or more persons to perform collectively a task with a defined goal. As scientists have concentrated their researches on the perceived multiple manifestations of teams you can nearly find as many team composition guidelines / recommendations in scientific literature as teams in business life. Actually these guidelines often seem to be contradictory. A few statements may demonstrate that range. For example: The most important attributes of a team member are individual knowledge, skill and ability. Or: Team success or failure is determined by generic teamwork skills (above individual skills). Another example is: Teams are most efficient if every team member applies his individual style. Or: Shared mental models / approaches (cognitive consensus) increase team performance. J. Hollenbeck et al. (2004, p. 353-366) collected these and various other examples and demonstrated the complexity of team composition with references to the results of recent researches made to get more reliable answers. Mello and Ruckes (2006, pp. 1019-1039), to cite another example, conclude teams composed of individuals with different characteristics have the potential to reach better decisions because they access more varied information sources. But they also note that “members of heterogeneous teams are more likely to diverge in their preferences with respect to courses of action, which is reflected in lower effort”. According to L. Pelled (1996, pp. 615-631) demographic diversity “tends on the one part to increase turnover” but ”its effects … are more mixed, sometimes enhancing performance and sometimes impairing it”. And in this context Hollenbeck et al. (2004, p. 357) state, “demographic diversity is actually less important to team performance than psychological diversity, especially over time”. These research results are the subject of chapter 2, the analysis of the theoretical findings and their

application in the course of deriving a set of qualified hypothesis / propositions for the project in discussion. Team composition is to be considered in two ways: One is to identify the relevant variables determining team composition; the other way of examination is to explore variables which are determined by team composition. Both points of view are taken in the process of modelling a coherent IofAS, the subject of this project. The general proceeding for team composition (and monitoring) is analysing the task and the required outcomes, looking for suitable members for the task, changing the qualification of members (training) or selecting different members and changing the task (Hollenbeck et al., 2004, p. 363).

Characteristics of tasks are e.g. additive tasks (each member contributes to the task in proportion to his or her expertise/competence/education/ability), creative tasks, executive tasks, conjunctive tasks (task progress depends on the weakest member), disjunctive tasks (problem solving tasks – performance depends on the best member), routine tasks, changing tasks, desired outcomes etc. (Hollenbeck et al., 2004, p. 356). Characteristics of team members are e.g. individual level of knowledge, skills and abilities (KSAs - Hollenbeck et al, 2004, p. 355), personality factors, values, degree of instrumental use of competences, job-relatedness, preference for working in groups, individual traits such as conscientiousness or extroversion, social awareness, demographics, tenure (length of employment), individual traits of interest for a particular task, core role holder trait, independency, openness to experience etc. Horx for example combined all these facets with his terms “skills, smarts and talents” (Horx, 2001, p. 49). Characteristics of teams are e.g. teamwork KSA - identified by Hollenbeck et al. (2004, p. 355) as providing feedback, cooperation, communication, team spirit and morale, adaptability, coordination, and accepting feedback - , team adaptation, average, minimum, maximum or variety of specific traits in the team, team context, (effective) planning, homo-, heterogeneity, shared mental model / cognitive consensus, etc. Jonker et al. explain, “in order to be able to interact with the world, humans must have some internal representation, a mental model of the world”. Related to teamwork, “team members have a shared understanding of the task that is to be performed and of the involved teamwork”. … “The idea is that shared mental models help team members predict what their teammates are going to do and are going to need, and hence they facilitate coordinating actions between teammates. In this way, mental models help explain team functioning” (Jonker et al., 2010, pp. 1-2). After all, the diversity of characteristics is further extended by the rules of decision making in teams, e.g. unanimity decision rules, majority rules etc.

The central question behind all the scientific debates and theories related to team composition is whether a more homogeneous or heterogeneous shape of the particular variables in consideration are in favour of a success related team performance. The author believes that

heterogeneity is slightly preferred (see also Steffens et al., 2012, pp. 727-743). In summary "the mix of individual traits within the team context is critical, and the appropriateness of a particular mix is dependent on the individual traits of interest, the nature of the particular task, and the desired team outcome" (Hollenbeck et al., 2004, p. 357).

Bearing in mind the diversity of possible combinations of team composition related characteristics there is little chance to develop a general model for team composition based on task, members and teamwork, the simple components of team composition, as already addressed. The author takes the decision to go into the depth of that mater to an extent that supports his project to design and use a coherent model of IofAS in MDDs. In addition this diversity of characteristics and combinations do confirm the author's concept of designing a field research in the carefully restricted area of variant construction projects in MDDs, explicitly in the execution phase in a 3D CAD environment to relieve bottleneck employees (engineers) from side tasks. This approach reduces the number of possible variables and facilitates the control of those variables relevant for the model. This way may just contribute another modest piece to the mosaics of a general theory of team composition. The further review of related theories and theoretical findings follows this aspect. The next paragraph examines the development of the organisation of new PD from the traditional department organisation to cross-functional and competence diversity teams.

1.3.2. Traditional Organisation, Cross-Functional Teams and Competence Diversity in New PD

The humanisation movements in the first half of the 20th century created with the attempts to overcome the negative consequences of Taylorism by job enrichment (job enlargement, use of different abilities etc.) led to a change in the business climate which in the second half of the 20th century imposed new roles for business organisation and style of leadership. This reconsideration of the business structures had to follow nearly inevitably the new understanding of humans in the working environment and the so far rigid organisational structures obtained practical and scientific interest. We find - not coincidentally - in the year 1966 in one of the standard references of business administration in the section "Formen kooperativer Zusammenarbeit", patterns of cooperation, a link to American management literature, discussing cross functionalisation or cross contacts since the early 50s (Dale 1952, Peterson et. al. 1953, cited in Gutenberg 1966, p. 262 sq.). Scientists as well as practitioners quickly hypothesised that there is much more potential to reveal by using human diversity adequately in success related processes. By taking the process of design and new product development (New PD) - a common application in praxis and theory for demonstrating the

changes in business organisation - the initial situation is described in detail by Ehrlenspiel (1995, p. 119 sq.) You can hardly better start the discussion than to look at Ehrlenspiel's figure 4.1-22, p. 148 (see Annex 2: Bild 4 1-22 Mental walls obstruct the flow of information between departments and result in expensive products). He shows in a highly simplified way the process of building new products in a conventional, functional organisation. Although every task within a department may be/is optimised the idea of the final outcome, a competitive product ready for the market, is not really at the centre of the respective minds and the activities, a shared mental model, as referred to in paragraph 1.3.1, does not really exist in this respect. According to Ehrlenspiel this attitude, he calls it “Mauerdenken”, is the main reason for waste of time and for quality and cost problems in companies. Just the simple locating of project teams physically close together has already been seen to be a measure to speed up development projects (Carbonell & Rodriguez, 2006, p. 227). Nearly all members of staff, every company, all hierarchical positions and every line of business are of the same opinion: the dominating problems of the development process are project durations and deadlines (Ehrlenspiel, 2007, p. 27). Not surprising that this ranking leads to the faster competitor as a new category of challenge in a harder global competition (Beingpoint, 2013; Boehe, 2008, p. 4). In this context G. Stalk writes: “You must set the pace of innovation in your industry or a competitor will“ (Stalk, 2006, p. 21).

Ehrlenspiel addresses a whole bundle of reasons for time, quality and cost problems: vague definition of aims, inadequate communication, operation scheduling and coordination, insufficient use of methods (e. g. market analysis, risk analysis), disregarded individual human behaviour (e. g. small communication of introvert persons etc.).

One of the major points is an adequate flow of information and any disturbance leads inevitably to an increase of changes with its inevitable additional cost and time and possible loss in quality. What must become the subject of greatest attention in New PD is, apart from the normal procedure, the feedback of relevant information at the right time. To put that in operation and to bring again the final outcome, a high-class product, into the centre of all activities of a company there is an urgent need to tear down the department walls by establishing a new integrated, innovative thinking, a change of the formal organisational structure and in addition an adjustment of the style of leadership (Ehrlenspiel, 1995, p. 148 sq.).

High intensity of the flow of information, downstream as well as upstream, the feedback, ideally must be allowed in general for a successful building of new products. (Ehrlenspiel, 1995, p. 156; see Annex 3: Ehrlenspiel’s Bild 4.2-4. The product life cycle with information loops respectively feedback controlled loops). Core feedback information comes from the

market and the production area. Due to the great effects on production cost resulting from R&D, close coordination in respect to best available production facilities (machinery, skill of employees etc.) is to be cultivated. Tight cooperation with the market area makes sure that the requirements of the customers are regarded adequately - without losing the benefits of standardisation. These balancing processes about possible but not literally necessary traits of a new product are of high priority in respect to product cost, as the variable costs of up to 80 % are determined in the development departments (Ehrlenspiel 1995, p. 555); and these balancing processes are deeply simplified in an environment of close cooperation and communication - upstream and downstream.

However, even with this new understanding and the high intensity of information flow, downstream as well as upstream, the demand for more transparency of the process of building new products is not satisfied at all. The trouble is that with the conventional, functional organisation the flow of information is regimented by a huge number of official points of intersection (interfaces) creating a huge number of documents, cost and - waste of time.

According to an assessment of the management consultant A. D. Little, one third of the total costs arise to overcome the official points of intersection. And furthermore, the aggregated time for transfer, the idle periods and the break-in time amount up to 90 % of the complete lead time of an order (Ehrlenspiel 1995 p. 157 sq.).

Therefore the next step must be to reduce the flood of information transport and documents by a radical change of the organisational structure accompanied by an adequate style of leadership and to establish a team with team members from all relevant functions, a cross-functional team. The composition of the team, a genuine management function, may differ, depending on the individual characteristics of the project in general and with the progress made (e. g. a lawyer must not always be available). The consequent and radical transition from all the individual operational functions is made in figure 1.1, the information flow in a cross-functional team: The necessary information can flow directly from expert to expert within the team and without the bulk of official documents. There is only one essential feedback left, the information from the market, from the - potential or actual - user of the new product.

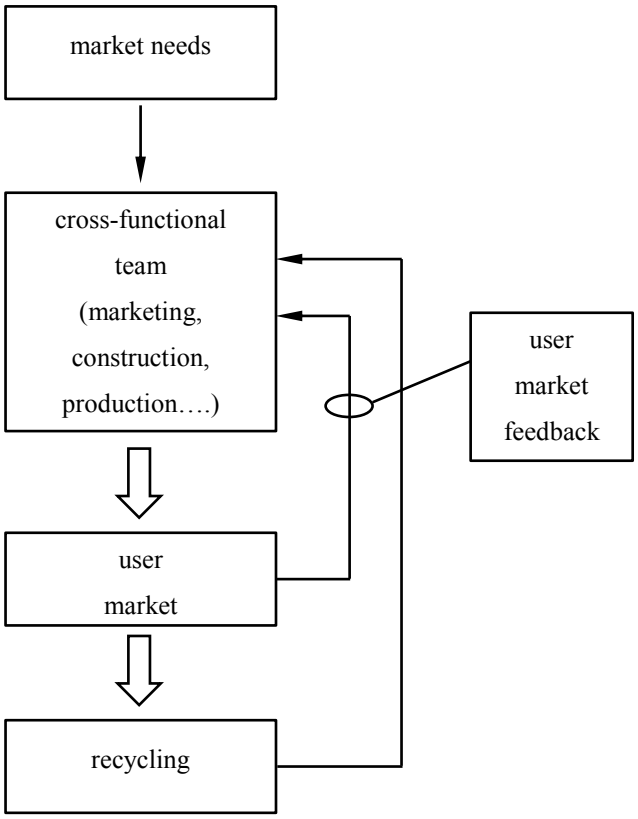


Figure 1.2: Information flow in a cross-functional team
Source: Ehrlenspiel 1995, p. 157

As already elaborated first ideas to create teams to overcome many obstacles within companies can be found about 60 years ago. The commencements can be seen in councils, committees, commissions for temporary meetings of members with different background, different functional experience, different organisations etc. with the intention to solve a special problem (Heinen 1974, p 157 sqq.). The expectation is that these kinds of groups have better chances to create new solutions for a given task due to the diversity of competences, due to short, quick flow of information and due to better coordinated and balanced decisions.
In the meantime these ideas have become more popular in commercial organisations using the expected benefits as indicated already under paragraph 1.3.1. Subjects of cross-functional teams are company strategy, cost saving programs, implementation of new technology etc., but the key application area for cross-functional teams is - as elaborated above - in design and New PD (see also Haon et al., 2009). Both need creativity, input from a wide range of competence and vision to reduce cost, product development time and time to market in a way that preserves flexibility towards market changes.

1.3.3. Effects of Competence (Cross-Functional) Diversity on Performance of New PD – and the Function of Leadership

Haon et al. (2009) analysed eighteen surveys made to observe direct effects of functional diversity on the performance of New PD during the years 1988 and 2005. These surveys examined about 2000 projects/teams and more than 1400 managers were interviewed.

The results were heterogeneous as well as ambiguous. The overall conclusions range from "Projects developed by cross-functional teams have a higher success rate than those from a single company function" (Larson & Gobeli, 1998) over "Diversity has a direct negative effect on the performance perceived by members of the team itself and on product innovation" (Ancona & Caldwell, 1992) to "Cross-functionality is associated with a higher success rate of new products" (McDonough, 2000). For details see Annex 4.

To get a deeper understanding of the causes behind that heterogeneity Haon et al. (2009) decided to perform further surveys. What is obviously important for the success of cross-functional teams is not only the functional diversity as such; various conditions must be met to make a cross-functional team successful. Only the number of functions represented in a team is slightly meaningful. The diversity of information and perspectives which companies want to use is to a large extent a result of competence diversity. However competence diversity cannot necessarily be achieved by pure functional diversity. Individual competence, a cross-functional human property by nature (Javidan, 1998, p. 61 sqq.), and a mixture of origin, cultural background, education, life career and professional career, experience and expertise, may differ largely within a functional department and may be relatively similar from members of different ones. With that understanding the notion diversity is extended to a compound term of functional, educational, experience and expertise diversity (Haon et al., 2009, p. 77); this - extended - diversity has a positive influence on information and knowledge available in a team and enables the team for deeper thinking and the creation of a broader range of perspectives considered to make decisions (e. g. Dahlin et al., 2005 p. 1110).

Though the discussion under paragraph 1.3.1. showed also different opinions in respect of homo- and heterogeneity the author follows the assessment especially for the area of New PD that under these conditions the possibility to develop a higher amount of different concepts exists (Schroeder et al., 1985, p. 25 sqq.). On that broad base the team should be capable of a better instrumental use of success related information to solve specific problems. In the specific context of New PD, the three main types of success related information are information about customers, competitors and technology (Henard & Szymanski, 2001, p.362).

All this describes a more technical say - from the engineering point of view - the mechanical

aspect of possible success with teams, the potential embedded in teams. But as teams are constructs of individuals the socio-psychological aspect of teamwork and team leadership need adequate respect in order to make actually use of that huge potential. People tend to work/cooperate with others who are - subjectively perceived - similar to themselves, who have - subjectively perceived - complementary skills, who have - subjectively perceived - instrumental skills relevant to the group task and with whom they have already worked successfully in the past (Hinds et al., 2000, p. 226 sqq.). Therefore diversity in a team is not by nature really qualified to establish the intended collaborative climate. Being aware of the negative implications of group dynamics, team rules are helpful and commonly agreed at the very beginning of the activities. Such rules can be found in any groupings, political, commercial or sports and the rules in general consist of: be a good team mate, be part of the solution not the problem, professional conduct on and off the floor, total mutual support, put the team first (e. g. see FCB Basketball-Section-OVB 09.02.2012) and clarify goals and deploy them to all team members etc. (Kotelnikov, n.d.). These rules, obviously elements of the variety of team composition characteristics already elaborated, are subject to a careful management by a team leader, well-resourced with social competences - as well as by the human resources management. The motivation of the team members to achieve a common goal gets first priority. The question is, has the leader the personality and the leadership skills that make team members want to follow his way. When looking at the range of possible styles of leadership from the one extreme of commanding to the other extreme of a cooperative leadership (Heinen, 1974, p 529), there is obviously a more participative (cooperative) style of leadership required, playing more a role of boundary spanning actor.

What is helpful – apart from others - to overcome possible obstacles in respect to trust, generous share of information, open communication, reduced fear of peer judgement, easy, tacit understanding etc. is to a certain extent familiarity (Hinds et al. 2000, p. 226 sqq., Haon et al., 2009, p. 79). Also a study executed by Janssen et al. (2009, p 162 sq.) indicated that higher familiarity leads to more critical and exploratory group norm perceptions, and more positive perceptions of collaboration. The use of these psychological findings in conjunction with the required competence diversity in a team building process is expected to form the sound base which enables teams to solve their specific problems by an efficient instrumental use of success related information. In the specific context of New PD in the executive phase of variant construction projects within a 3D CAD environment, the main success related information for the basic single operating units are the specific - different -experiences with modern PD methods to create new product ideas and to transfer these ideas into operational concepts - analysed in detail under chapter 2.

1.4. Theoretical Background of Success Criterion Modern Product Development Methods

Overlapping Activities: An Appropriate Method to Manage the Challenge of Man Power Constraints

Positive attitude to collaboration is a good breeding ground for the use of modern engineering methods as Product Lifecycle Management Systems, Concurrent Engineering, Simultaneous Engineering, Multi-disciplinary Simulations or Overlapping Activities. All these methods have - at least partially, but not only - the goal to shorten the development processes. This is one main concern of the present research. It concentrates on approaches and methods to overcome the bottleneck situations in New PD. The author expects most positive effects especially of the application overlapping activities between auxiliary staff and engineers in the executive phase of variant construction projects within a 3D CAD environment, examined in the field research conducted for this project.

With this sub-chapter the further refinement in the designed line of argumentation - according to the process of agglomeration of relevant theories, described under sub-chapter 1.1 - is made and the preparation of the theoretical basis of the proposed model of IofAS and the subsequent analyses under chapter 2 sqq. continue.

Prior to a discussion of the overlapping method in detail some basic considerations related to the scientific approaches to project management and bottleneck situations will be outlined.

1.4.1. Bottleneck Theory respectively Theory of Constraints

Project management within the development of new products serves as a method to transfer the functional type of organisation with its interface problems (see paragraph 1.2) into an object respectively process orientated organisation.

To reduce downtimes in projects, the inherent weakness of functional organisations, Goldratt (1990) contributed to the project management approach with his concept of the critical chain. He based this concept on his Theory of Constraints (TOC), also known as bottleneck theory, a coherent management theory for running an organisation. Goldratt based this theory on system theoretical considerations after which the permeability of any system is only determined by a limiting factor, the bottleneck. An improvement of the permeability can only be possible if the general system, radiating from the limiting factor, is optimised all in all (Goldratt, 2001; Goldratt, 1990, p. 161; Shams-ur, 1998, p. 336 sqq.). The approach is a combination of a systematic investigation and analysis of the bottleneck situations and the creation of solutions for these problems - and the working principle of on-going improvement, taking note of the dynamic traits of constraints (changing within the current analysis and over

time). Types of limiting factors, types of constraints, are the equipment, the people and the policy. Goldratt compares his approach of the critical chain with the classical concept of the critical path. The critical chain describes the shortest possible project path under diligent consideration of the demands and the availability of resources. He shows that not the shortest possible, chronological sequence of events, the critical path, determines the efficient proceeding of a project.

To provide for the risk of uncertainties buffer time should be inserted and shifted towards the end of a project or supply process, where it is actually needed. This can prevent wasting that time contingency at every process step tacitly (Romberg & Haas, 2005, p.154 sq., Techt, 2004, p. 20). To avoid downtimes between different steps of processing operations Goldratt relies on the intensive communication between predecessor and successor, as already mentioned with the remark to positive attitude to collaboration. This kind of relay race principle describes a form of bilateral synchronisation which depends strongly on the mutual co-ordination and which requires certain time expenditure. Interesting in this context is to find a form of synchronisation which automates this co-ordination and which relieve the single person from his/her additional expenditure. This would mean creating a standardised interface between predecessor and successor (e.g. engineer and auxiliary staff) where all necessary information is stored. As soon as different working parcels (for instance either those which lie on the critical path or those which do not) contest for the same resources at the same time this often results in conflicts; either the member of staff reacts with multitasking, which means the parallel work on different tasks whose negative effects are describe (Rubinstein et al., 2001, p. 763 sqq.; Meyer, 2005; Meyer, 2012, p. 28) or he/she gives priority according to his/her own priorities or with the agreement of their colleges (Romberg & Haas, 2005, p.144). The task is delayed at both kinds of procedures - either with all or only with the lower priority tasks. However the critical path in both cases, either direct or indirect, is in danger through delays on supply paths. This is why Goldratt proposes to avoid multiple resource occupation (bottlenecks) already during the planning of the project (single- or multi project view) and to plan according to the critical chain. Through Goldratt's work it is made clear which significance the control of bottlenecks has on the fast progression of the project. It is here that the work has to begin because the need to relieve the development engineers from side lines (drawing or documentary tasks) is clearly perceivable.

Thomas (1991, p. 153 sqq.) and Grubb (1998, p. 20 sqq.) also stress the importance of a one-piece-flow (OPF) for the lead time of product development projects. Especially, because the already described process-orientated concepts for project management are mainly dedicated to bigger, more complex projects with a high level of innovation that approach should also result

in positive effects for development tasks with an even higher level of repetition where the typical characteristic of processing is more obvious (Nippa, 1996, p. 54; Nippa, 1988, p. 87 sqq. / p. 186 sqq.; Ehrlenspiel, 2007, p. 286 sqq.).

Useful for the further analysis of this work is the insight that it should be possible to achieve the wanted effective relief of bottlenecks by removing the constraint of man power, by employing auxiliary staff for documentary purposes, as well as by a "stop (of - inserted by author) multitasking" (Meyer, 2012), by avoiding multiple resource occupation (i.e. employing the concept of OPF).

1.4.2. Overlapping Activities: A General Management Method

Scientific papers on overlapping processes often concentrate their research on New PD activities as these are commonly understood as crucial for the success of a company in a rapid changing market and the cause-effect relations by overlapping activities in this area are of great interest; but the method is not at all restricted to these commercial processes.

An important direction of New PD are the attempts strongly influenced by the Japanese way of proceeding to shorten development times of products through overlapping development activities for a product and the overall New PD processes. In addition to the avoidance of downtime further potentials in proceeding time have been identified and harnessed in this way.

It is possible to link pairs of activities by starting first actions of a succeeding activity even with only incomplete information received from its prior activity and to avoid delaying rework through intensive co-operation in interdisciplinary teams. Simultaneous Engineering, Concurrent Engineering and Integrated Product Development use this method of overlapping procedures. Overlapping, defined as the partial or full parallel execution of tasks and functional interaction with varying degrees of information shared between business functions became more and more popular for many companies which act in a fast moving environment. With the new overlapping mode of New PD activities, these companies feel to have a substantial advantage in lead time. However, in practice the flow of information and the process execution is largely sequential, with information being generated and finalised by the upstream activities before being absorbed by the downstream development activities (Krishnan et al., 1997, p. 437). This means in New PD - first (upstream) the preparation phase, - then downstream to the creative phase - and at last downstream to the execution phase.

But also within the three New PD phases the different sub-tasks can be done sequential or overlapped by allocating various components to one engineer (sequential) or to various

engineers (overlapped); they can be done by transferring finalised (constructed) part-information to auxiliary staff for documentation progressively (overlapped) - or not (sequential). In fact managers frequently make ad hoc decisions to overlap the normally sequential activities in order to overcome delays / bottlenecks, thereby reducing delivery times. However concurrent engineering theory is capable to provide a formal process to realise cost and schedule savings by a systematic overlapping design activity (Ancona & Caldwell, 1992, p. 321 sqq.; Bogus et al., 2011, p. 950 sqq.). At a first glance the overlapping mode seems to be faster; actual researches concentrate on various selected aspects of overlapping, such as on dynamic rework in overlapped schedules (Marujo, 2009, p. 90 sqq.), on acceleration models for projects with known rework fraction caused by overlapping (Gerk & Qassim, 2008, p. 590 sqq.), on measurement of the coupled strength of tasks (Zhang & Qiu, 2006, p.305 sqq.), on a systematic approach to reduce costs and risks (Bogus et al. 2006, p. 829 sqq.; Bogus et al., 2011, p. 950 sqq.) or on determination of corresponding cost and time trade-offs (Ancona & Caldwell, 1992, p. 321 sqq.). All these papers are more or less based on the seminal work on overlapping strategies by Krishnan et al., "A Model-Based Framework to Overlap Product Development Activities" (Krishnan et al., 1997). They provide a framework to help designers and managers to decide when and how to overlap pairs of activities with the intention to reduce product development lead time and to ensure at the same time that adverse effects on product quality and development effort are minimised.

It is commonly agreed in theory as well as in practice that speed is the key point for success in commercial competition (Scheer. 2003, p. 180; Hirzel, 1992, p.19 sqq.) and the "intense competition forces manufacturing firms in many industries to develop new, higher quality products at an increasing rapid pace" (Krishnan et al., 1997, p. 437). The ability to transfer new ideas to commercial products in a timely manner is an important competitive factor with high influence on the corporate success today. As it is also an established fact that projects are almost always behind schedule (Ehrlenspiel, 1995, p. 147), "overlapping product development is an important component of concurrent product development that can help firms to develop products faster" (Krishnan et al., 1997, p. 437). Imai et al. observed that faster product development processes are more overlapped (Imai et al., 1985, p. 337 sqq.), but they do not give any explanation how to overlap New PD processes. Furthermore, they imply that all activities can be carried out concurrently. Clark and Fujimoto recognised that frequent face to face and bilateral communication of preliminary information makes overlapping easier (Clark & Fujimoto, 1989, p. 49 sqq.) - instead of reserved handling with incomplete information. "However, since product development activities may be coupled in complex ways, overlapping interrelated activities can present many difficulties. Without a careful

management of the overlapped product development process the development effort and cost may increase and product quality may worsen" (Krishnan et al., 1997, p. 437). These are undoubtedly serious concerns in respect to overlapping in any project processing, as e.g. in the area of marketing, capital investment etc. Therefore Krishnan et al. designed a model which goes beyond the common recommendation to simply overlap activities as much as possible. They describe four types of overlapping based on two determining properties of a design process. The first property is "evolution", a measure for the speed of upstream information generation - and the second is "sensitivity ", a measure for additional downstream efforts due to changes of upstream information already received (Krishnan et al., 1997, p. 440) - and they illustrate the model with industrial applications. These terms "evolution" and "sensitivity" and the four types of overlapping, the Iterative Overlapping, the Divisive Overlapping or Non Overlapping, the Pre-emptive Overlapping and the Distributive Overlapping (Krishnan et al., 1997, p. 448) must be explained. Possible analogies to the development tasks between engineers and auxiliary staff respectively creative and routine activities will then be analysed in chapter 2 in order to define the main hypothesis and the causal model related to the model of IofAS.

1.4.3. Fast and Slow Evolution respectively High and Low Sensitivity in New PD Information Processing

From the information processing point of view "individual development activities are themselves viewed as information processors, receiving input information from their preceding activities, and transforming this input information into a form suitable for subsequent activities. … The sequential process assumes that the upstream-generated information is available for downstream use only at the completion of the upstream activity" (Krishnan et al., 1997, p. 440). During the upstream activity the development process continuously narrows and refines the information from an initial rough assessment of a design parameter to a final value. For that refinement process from the preliminary to the final value, Krishnan et al. use the term evolution (Krishnan et al., 1997, p. 437). In the metaphorical sense they compare the information processing progress with a hopper/funnel from a large diameter (begin of the activity) to a final point, which represents the exact information for the downstream and subsequent New PD activity. The performance of this process can vary from fast to slow, depending on the character of the individual development project. The term fast evolution explains a redesign respectively a variant construction development project. The components and the technology are mostly known. That means information in the creative and the design phase of New PD can be generated fast. In other words - major changes

happen early, the exchanged information rapidly gets close to its final form and can be frozen and passed downstream early in the upstream process without much quality penalty for the upstream activity. The term slow evolution on the other hand explains an innovation, a product using new components and technology. In this case the generation of information starts slowly at the beginning of the creative and the design phase and increases rapidly to the end of that phase. The modification of the interchangeable information increases as the upstream activity progresses. In this case, finalising upstream information early in the upstream process either would be impossible or would entail a huge quality penalty for the upstream activity (Krishnan et al., 1997, p. 442 sqq.).

In the overlapped process, the upstream activity shares preliminary upstream information at defined breakpoints with the downstream activity (Figure 1.3), depending on the special evolution character of the project. The downstream activity begins to perform its normal development iteration using the exchanged information. This iteration process is to be repeated after the next releases of the meanwhile improved information of the upstream activity until the final value is available. Under this aspect the downstream activity has - as Krishnan et al. call it - a particular sensitivity, ranging from high to low. If substantial changes can be accommodated quickly by the downstream activity the downstream sensitivity is understood to be low and if the incorporation of changes in contrast is joined with large, time consuming rework the downstream sensitivity is understood to be high.

Whether overlapping can be installed as a measure for improving lead time etc. depends on a careful assessment of the particular project; this is argued in detail in the next section. Due to more communication and iteration the duration of the individual activity may actually increase with overlapping, while the total project lead-time can decrease by the concurrent work on different activities significantly (Marujo, 2009, p. 90 sqq.); to compress schedules by overlapping is very likely.

The four extreme situations of overlapping which can occur are fast or slow upstream evolution and high or low downstream sensitivity - as illustrated with figure 1.3.

Iterative Overlapping (1): When upstream evolution is slow and downstream sensitivity is low, “it is possible to commit downstream resources based on preliminary upstream information” (Krishnan et al., 1997, p. 448). Even large changes in the - slow - upstream exchanged information have no or marginal influence on the downstream activity. In the slow upstream evolution major changes happen late in the upstream process and the information cannot be finalised until the completion of the upstream activity. Early information finalisation of the upstream activity may result in a large quality penalty for the upstream activity. This means, when information is finalised early and committed to the downstream

activity, there is no possibility to transfer better concepts to the downstream activity. However as downstream sensitivity is low iterations for changed parameters are easily performed (Krishnan et al., 1997, p. 448). This development situation appears, when a completely new product comes into existence, for example manufactured with known technologies or when an engineer designs a new part, for example manufactured with a defined method.

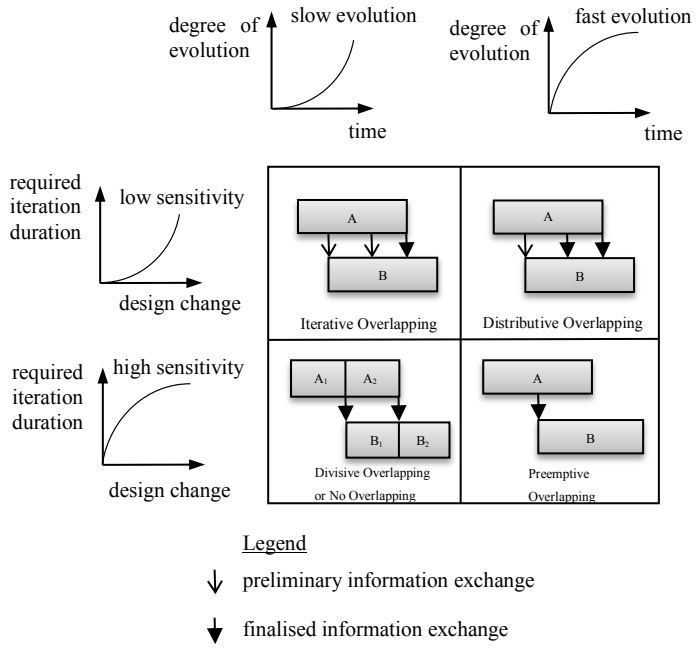


Figure 1.3: Iterative overlapping, distributive overlapping, divisive overlapping or no overlapping and pre-emptive overlapping

Source: Krishnan et al., 1997, p. 448

Divisive Overlapping or No Overlapping (3): When upstream evolution is slow and downstream sensitivity is high, it is not desirable to start downstream activity with preliminary information, because major changes happen late in the upstream process and the duration of iteration loops in the downstream activity is too high. This development situation appears, when a completely new product comes into existence with new manufacturing technologies or when an engineer designs a new part, for example manufactured with a non-defined method. An exception might be the possibility of dividing the complete upstream activity and identifying within the slow process parts of fast evolution (Krishnan et al., 1997, p. 448).

Pre-emptive Overlapping (2): When upstream evolution is fast and downstream sensitivity is high the upstream information can be finalised early - parts of the problem solving are accelerated - without much quality loss. This situation would help to reduce development time

by starting the downstream activity earlier in time with preemptively frozen information of the upstream activity. This development situation appears when a product redesign with new manufacturing technologies is generated or when an engineer redesigns a part, for example manufactured with a non-defined method (Krishnan et al., 1997, p. 448).

Distributive Overlapping (4): When upstream evolution is fast and downstream sensitivity is low, it is possible to start downstream activity with preliminary information (no need for freezing early) and continue with the onward progress of the New PD process with preemptively finalised upstream information, as large changes in the upstream process happen early and finalised information - before the end of the upstream activity - do not lead to huge quality losses in the upstream process. The low sensitivity means, that large changes in the magnitude of the upstream information exchange do not entail large iteration loops. Both activities, the upstream and the downstream, are contributing to an efficient overlapping process; the involvement is distributed (Krishnan et al., 1997, p. 448 sq.). This situation is the most favourable for overlapping. This development situation appears when a product redesign with known manufacturing technologies is generated or when an engineer redesigns a part, for example manufactured with a defined method (Krishnan et al., 1997, p. 448 sq.).

Based on the above theoretical findings many additional researches followed to define the determinants of evolution and sensitivity more precisely, to design mathematical models to cope with uncertainty in respect of the degree of the sensitivity, the extent of the evolution and the probability of rework (Onwubiko, 2000; Roemer et al., 2000; Pena-Mora & Li, 2001; Bogus, 2004; Bogus et al., 2011).

These discussions continuously increased the positive perceptions of the advantages of overlapping by practitioners (by engineers as well as by managers) and the transition from an ad-hoc to a systematic application of overlapping in various industrial areas is considerably promoted.

The thesis that overlapping can reduce lead time and cost within certain restrictions were verified by Krishnan et al.. The great success potential of overlapping processes could be proven as amplified and analysed in chapter 2 provided it is applied adequately. Essential conditions are a diligent identification of the characteristics of the project in preparation, the availability of qualified man power, a prerequisite of particular importance for SOPs, a favourable cooperation climate, intensive face-to-face communication etc., conditions which are already elaborated under chapter 1.1 to 1.3. There is at least still one further area to be reviewed - and in addition intensified - resulting from socio-psychological considerations, in order to achieve the desired success on a permanent basis. This aspect already slightly addressed in the context of team composition, teamwork, competence diversity and leadership

deserves another inclusion due to its remarkable effects on success.

1.5. Theoretical Background of Success Criterion Job Satisfaction

Job Enrichment, Task Satisfaction and Socio-Psychological Efficiency -

A research / an excursion in socio-psychological theories related to dissonances in MDDs.

Modern product development is hard to imagine without the use of 3D CAD software. It is even more difficult to imagine that the implementation of this versatile software resulted in additional workload for engineers. This conflict is caused by a reduction in auxiliary staff within mechanical development teams as a consequence of an overrating of the capabilities of the integrated SW package. Under the described situation - to have the qualified and motivated employees available according to the particular requirements - , it is reasonable for managers and team leaders to note that they are a part of the success related interactions (Stacey, 2010, p. 35 sqq.; Stacey, 2007, p. 292 sqq.) and to consider more seriously how an ambitious, dedicated engineer would deal with the disparity between his professional expectations and his professional reality. Special attention is required for his organisational commitment, the identification with the values and goals of the organisation, the execution of extra effort on its behalf, the representation of his company, the recruitment of partners for his company, the loyalty to his company or - the readiness for a change. This section examines the relevant literature in respect to social-psychological efficiency aspects with the aim to set a basis to formulating hypotheses for this problem area. This part of the study revealed a strong dependence / correlation between task content and self-image and is understood to form the final refinement of the literature review relevant to establish and to analyse the scientific basis of the proposed model of IofAS.

1.5.1. Sociology, Psychology and Socio-Psychology - Delimitation of the Theories

At several stages of this paper the conflicting role of an engineer in MDDs has already been demonstrated. From the historical point of view those engineers appear to be the “victim” of a humanisation process which started in the second half of the 20th century with the aim to hand back individuality to humans engaged in commercial systems. The positive intention has to some extent changed into a negative one, and efficiency has suffered. The explanation is given by the review of current discussions in sociology and psychology.

Sociology analyses society as an accumulation of humans, the subject of social class stratification, the social structure of the society and the establishments. Psychology is seen as an empirical science (Aronson et al., 2008, p. 10 sq.), describing and explaining the

experience and the behaviour of humans (Rohracher, 1988, p. 1 sqq.). Experience is understood as a result of conscious processes, for example perceptions, thoughts and emotions. The definition of psychology as a science of human experience and behaviour is unambiguous, but there are different paradigms: psychology is viewed as an exact natural science, as a humanistic science, as a social science and as a specific component of biology. However psychology, whatever direction, is defined as the science of experience and behaviour (Rosenstiel, 2003, p. 5).

Aronson et al. set a basis for the concept of social psychology as the concentration on social influences on experience and behaviour (Aronson et al., 2008, p. 4 sqq.). They made us aware that we all get influenced by other people. There are countless attempts of direct social influence, for instance, advertising campaigns or election campaigns. These attempts of direct social influence are one part, but social influence goes beyond observable behaviour. Social influence also concerns our cognitions and emotions. Besides the attempts of persuasion, we are all influenced by the presence of others and - also by their absence. On different levels everybody is involved in a social and cultural context. Social psychologists analyse how and why our cognition, our emotions and behaviour are influenced and shaped by the total social environment. When we take into account all these factors, social psychology can be described as the scientific study of the modality in which cognitions, emotions and behaviour of humans are influenced by others who are de facto present or absent (Aronson et al., 2008, p. 4). Social psychologists analyse individuals in the context of social situations. The aim of social psychology is to find general valid properties of human nature which make everyone receptive of social influence independent of social classes or culture. In a specific scientific analysis it is actually impossible to discern between the individual and the situation and therefore context variables must be recorded. Context variables are included in the object of psychological research. However the centrepiece should always be the experience and the behaviour when the analysis regards psychology. The boundaries to related science are often blurred and in organisational psychology it is particularly obvious. While psychology is the science of experience, behaviour and actions of humans, organisational psychology is the science of experience, behaviour and actions of humans in all kinds of organisations (Rosenstiel, 2003, p. 6).

1.5.2. Social Psychology Embedded in the Organisational Context

The organisational / industrial psychology goes back to the industrial revolution where Taylorism, the scientific management, was the dominant system for the organisation of operating procedures in order to achieve maximum productivity, and the leading and

celebrated idea was division of labour – discussed broadly under paragraph 1.2. The workman was not seen as a group member and the willingness to work was understood to depend only on economic stimulations. The wage system, especially the individual incentive wage was the focus. Efforts were made to analyse the task completion process and to use the energy of humans in an efficient way. Work behaviour was recorded in the smallest detail (Rosenstiel, 2003, p.9 sqq.). Insights into the disadvantages of division of labour were described by Münsterberg, emphasising the risk of emotional damage and atrophy during active labour. "Die wirtschaftliche Experimentalpsychologie hat in der Tat vielleicht keine höhere Aufgabe, als diese Anpassung der Berufstätigkeit an die seelische Eigenart der Individuen, mit dem Ziel, das übervolle Maß seelischer Unbefriedigung an der Arbeit, seelischer Verkümmerung und Bedrücktheit und Entmutigung aus der Welt zu schaffen" (Münsterberg, 1912, p. 181. I.e.: The economic experimental psychology has in fact perhaps no greater task than this adjustment of employment to the spiritual nature of individuals with the aim to eliminate this overflowing level of emotional dissatisfaction at work, mental atrophy and depression and discouragement.). Frey mentioned the macro-economic harm and the damage to society as a whole (Frey, 1920). A turnabout was heralded with research in the Western Electronic Company in Hawthorne, USA from 1924 to 1932, initially a Tayloristic oriented examination. These industrial, psychological examinations revealed that the effects of social interaction and, therefore, social psychological variables had more influence on the individual performance than the incentive wage system. The work c o n t e n t came into the spotlight of humanistic oriented psychologists, who concentrated their efforts on work motivation (Ulich 2001, p. 39 sqq. – with references to pioneers such as Maslow A.H., Herzberg F., Mauser B., Snyderman B.). The empirical recorded tendency of working people to find self-realisation at their workplace led to some extent to a reversal of division of labour. Different research areas developed in industrial psychology, as it is not generally proven that humans are searching for satisfaction in work content. The terms are "well-being", "mental health" (Kornhauser, 1965, p. 11), "physical health" (Udris, 1982 p. 78 sqq.), or "qualification and personality development" (Hacker W., 1998). The development of industrial psychology is explained by the model of implicit personality (Schein, 1965, Bögel & Rosenstiel, 1993, p. 12 sq.). The initial phase has two aspects. First point of view, a human as "homo oeconomicus", is only oriented to achieve maximum profit. Second point of view, human as "l´homme machine", is seen as a technical device and is used energy-efficiently and maintenance-free unrelated to what he is producing. In the second phase of the development of industrial psychology humans are seen as social beings and satisfaction is not coming from the work itself, but from the relationships with other humans. In the third phase the assumption is made

that workmen strive towards self-realisation and, therefore, areas of independent decision making must be arranged in order to use individual abilities; job enrichment is to be organised. In the last phase there is a more equal co-existence of different concepts, and Schein E. H. (1965) speaks about the "complex man" (Rosenstiel, 2003, p.12 sq.). Details of the views of humans in organisations from Taylorism up to the present are also made very comprehensively by Kirchler et al. (2004). In the context of this literature review work satisfaction is expected to be one of the keys to improve the economic and socio-psychological efficiency of New PD.

1.5.3. Work Satisfaction and the Theory of Cognitive Dissonance

Work satisfaction is normally recorded by an anonymous survey. Rosenstiel characterises work satisfaction with the three elements, the analytical unit - individual, the analytical element - labour, and the type of measurement - validation (Rosenstiel, 2003, p. 422). The reviews analyse mean values and scattering and are referred to departments, subsidiaries and total organisations. Since the beginning of the humanisation of working life, work satisfaction is an indicator for humanisation. Robbins (2003) defines job satisfaction as a subjective measure of worker attitudes, that is, an individual's general attitude to his or her job. Job satisfaction is the attitude to work and to the work situation with different aspects, the evaluated comments to one's work or work elements. In this context Rosenstiel points to Locke (1976) who describes work satisfaction as a pleasant and positive emotional state that follows from the evaluation of the own work or work experience (Rosenstiel, 2003, p.424). This search for equilibrium is one of the possible approaches to a classification of the various theories of work satisfaction, the classification into concepts which are needs oriented, incentives oriented, humanistic and cognitive oriented (Rosenstiel, 2003, p. 427)

In the needs oriented approaches the organism seeks internal equilibrium. If the internal balance is disturbed, needs are recognised with the aim to act towards that internal equilibrium. Incentive oriented approaches assume that work satisfaction is the highest, when the most pleasurable emotions are available to the individual. The focus of the incentive oriented approaches is to determine those traits of the organisation that influence work satisfaction to a particularly high extent. Humanistic approaches claim that the aim of human action is self-realisation and intellectual growth. Satisfaction arises through facing challenges, which leads to new experience and connotation. These concepts investigate the way of human life fulfilment in respect to how the individual can cope with existence and therefore are hard to operationalise. Cognitive equilibrium approaches deal with the cognitive concept of people who try to match the perceived environment with their designed cognitive plan. Disturbances

are recognised as tension and imbalance and they lead to dissatisfaction. Decreasing tension leads to satisfaction as a consequence of the emotional reaction. Satisfaction is found when the perceived conditions of the workplace optimally match the perceived own role (Rosenstiel, 2003, p. 428; Aronson et al., 2008, p. 163). In this context Ulich talks of the primacy of the task (Ulich, 2001, p. 197 sqq. "Vom Primat der Aufgabe"). Demands and individual suitability, personal performance and wages should correspond to each other (Brophy, 1959; Brehm & Cohen, 1962). The question of how to handle disturbances/non-correspondences, such as imbalanced team structures in MDDs, leads to the cognitive dissonance theory. The starting point of the theory is that most humans see themselves as reasonable, moral and intelligent, and therefore information and situations, which in some way make us look irrational, immoral or naive lead to violent discomfort. This discomfort, triggered by an action, which our positive self-image runs counter, is cognitive dissonance (Aronson et al., 2008, p. 163). Cognitive dissonance is an essential factor of human thinking. Festinger was the first to investigate and summarise this phenomenon in the most important and provocative theory of social psychology - the cognitive dissonance theory. Initially the social psychologists believed that cognitive dissonance appeared as any two contradictory thoughts and opinions (Festinger., 1957; Festinger & Aronson, 1960, p. 214 sqq.). Later research made clear that not every cognitive inconsistence is equally disturbing. Social psychologists recognised that cognitive dissonance works most strongly, when humans act in a way that threatens their self-image. The big gap between, what we think we are and the de facto behaviour is the reason for hard discomfort (Aronson, 1968, p. 5 sqq.; Aronson, 1969, p. 1 sqq.). Cognitive dissonance always creates discomfort and the reaction is to reduce that discomfort. There are three elementary different strategies to reduce discomfort:

(1) the change of the dissonant behaviour to bring it in line with the self-image;
(2) the change of the dissonant cognition by justifying the behaviour; and
(3) the adding of additional cognitions.

The engineer in the above described situation of imbalanced team structures in MDDs will feel extreme discomfort, as his self-image is violated; this is a real case of cognitive dissonance. His own cognition - the urge to be a reasonable and experienced human is strongly dissonant with the effort spent just to do time consuming product documentation work, which is far from the conceptualisation of future systems - the task the engineer was educated for. If this person applies the second strategy (2) of coping with cognitive dissonance this person would suggests to himself that, for example, the preparation of a drawing set is an important work, as that document is the main output of a development department at the end of product development processes, which is required in every plant worldwide for building

that new product (e.g. Beckert, 2000, p. 419). Actually, the document itself is important, but it should be generated by those team members who have been educated for this task, the auxiliary staff. They are better trained for this type of work and cost less. Returning to the engineer - he is motivated to see his work as something valuable and tends to interpret the ambivalence more positive. The strategy to see things that need hard effort as more positive is called justification of effort by modern psychologists (Aronson et al., 2008, p. 172). Some engineers probably reach cognitive comfort again by suggesting to themselves that the generation of the drawing set and the documentation handling to market maturity is very important work (3); i.e. to achieve consonance the engineer could live with the dissonant working conditions by finding some new arguments, by applying strategy three. However, this strategy might not necessarily be working for a dedicated engineer, and he could, in the worst case for the company, according to the strategy one, look for better conditions - in a new employment (1). Depending on the individual and the job market conditions, there could emerge an undesired tendency of an increased fluctuation, especially among key personnel respectively core role holders, caused by permanently imbalanced working conditions. The - potentially high - organisational commitment which socio-psychology scientists define as the way people feel and think about their organisations, as the attitude that reflects the nature and quality of the linkage between an employee and an organisation has lost its positive impact under this specific condition (Kappagoda S., 2012, p. 23) and option one applies. Remarkable, in respect to strategy (2) is that the attempt to reduce the dissonant cognition by justifying the behaviour is not only a serious option for those working in unbalanced situations but also for those responsible for (organisational) imbalances and the induced dissonances. According to the dissonance theory the individual way of dealing with cognitive dissonances is not only influenced by individual characteristics of the persons concerned. Social scientist have analysed the relation of rewards respectively penalties and justification and change of behaviour. The identified effects are notable and demonstrated in figure 1.4.

Small rewards respectively penalties lead to internal justification, an internal cognitive stimulation, that the - so far unpleasant - action is right. Such cognitions lead many times to a sustaining change of attitude. However, great rewards respectively penalties will only generate temporary changes of spirit, according to this theory, which call this case an “external justification” situation (Aronson et al., 2008, pp. 176).

Apparently HR-managers have some space for promoting the desired social behaviour in situations of dissonance as cognitive dissonance theory predicts that a decision - possibly supported by small rewards - once made leads to a more favourable attitude and perception (Aronson et al., 2008, p. 180 sq.).

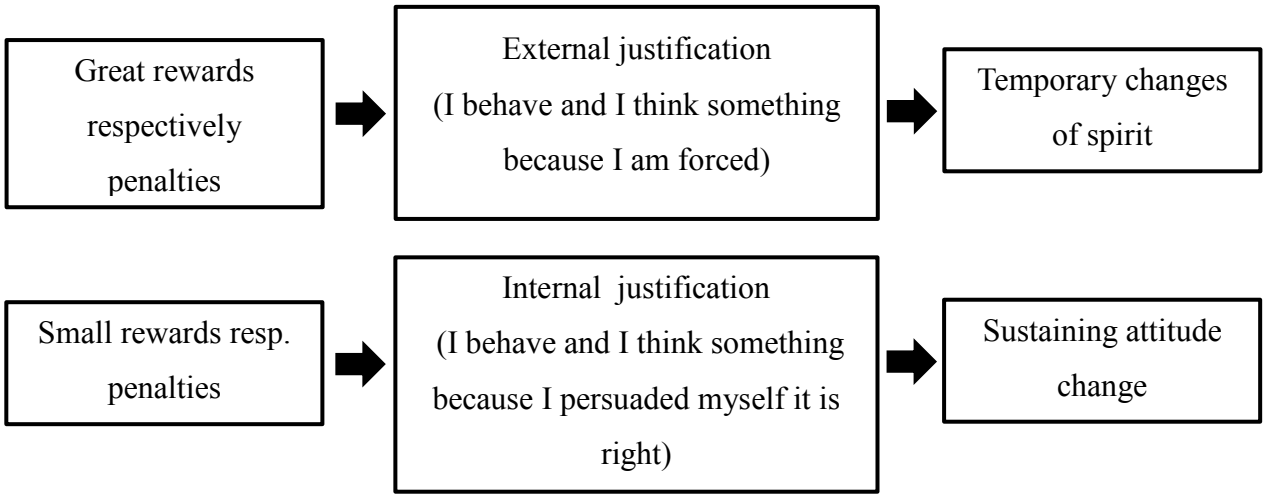


Figure 1.4: The amazing effects of insufficient justification
Source: Aronson et al., 2008, p. 181

The question is will the research in preparation reveal changes of the minds of probands under certain - manipulated - conditions in MDDs?
Without prejudice, the dissonance theory can give a few hints: In the case of not fulfilling his obligations, i.e. insufficient task performance, in the current unbalanced team structure environment the engineer must in general reckon with warning or dismissal, with hard penalties, the external justification situation. To get consonance the engineer could either live with the dissonant working conditions by finding some new arguments or look for better ones - in a new employment. Depending on the individual conditions the threat to accept the external justification is quite different. A young engineer is normally more flexible than an engineer with various obligations (family, house, etc.).

1.6. Summary of the Literature Review

With the socio-psychological considerations under para 1.5 the procedure designed under paragraph 1.1 is completed and with this element the “biggest disturbing factor”, at least from a mechanistic point of view, the human being with its not really transparent and predictable behaviour is introduced adequately into the model relevant aspects of this literature survey.
Chapter 1 reviewed the scientific literature concerning the topic success criteria relevant for the composition and use of coherent team structures in MDDs, the theoretical basis to develop

the proposed model of a task and competence based IofAS– in contrast to the present SW-forced job enrichment in the nucleus of New PD. The major findings supporting the author's idea of a coherent solution for the imbalanced allocation of human resources are:

- Division of labour is the vital organisational theory not only in companywide practice or international in globalised co-operations but also in single operating units (SOUs), provided economic efficiency basics are not ignored (cf. Smith, Taylor, Gutenberg etc.). As 3D CAD cannot take over all supporting activities, especially the preparation of documentation, automatically (Roh & Lee, 2007, p. 540) DoL is to be further examined in MDDs of MSCs working under 3D CAD conditions. Mayer (1988, p. 159 sqq.) demanded already 1988 a cooperative division of labour with a specialised expert in the centre and Kühn et al. noted 2006 the low progress made, as the integration of tasks by specialised experts, of tasks, which could easily been done by people with a lower level of expertise (Kühn et al. 2006, p. 154) even increased. Wittenstein (2007, p. 98) substantiate the demand for a coherent division of labour with her model of a "Sinnvoll verteilbare Arbeitseinheit – SVAE – a practically distributable work unit".
- Following the need of DoL also within the SOU of MDDs, the subject of this thesis, the composition and deployment of coherent teams has to take note of those theories relevant especially for SOUs. i.e. the models, transferring traditional organisation to cross-functional teams in New PD (cf. Ehrlenspiel, 1995) and the further development of team building theories based on competence diversity and familiarity (Haon et al. 2009; Hollenbeck et al. 2004; Jansen et al., 2009) and its effects on the instrumental use of information for the development of new products.
- In the very centre of economic efficiency improvement considerations of this paper there are theories and models related to modern product development methods. Provided AS is available (DoL is not disputed) the method of overlapping of activities should result in remarkable positive outcomes for SOUs if careful attention is given to the various pre-conditions in respect of evolution and sensitivity of the individual project parts to be linked (Krishnan et al., 1997; Onwubiko, 2000; Roemer et al., 2000; Pena-Mora & Li, 2001; Bogus, 2004; Bogus et al., 2011).
- Finally the extent of the success of the measure to be taken on the basis of the above presented relevant theories and models is not at least dependent on the sustaining job contentment of the members of the considered SOU. There has been a long way from the theoretical debates of job satisfaction to overcome the disadvantages of Taylorism

to the current understanding of best job motivation and of creating lasting organisational commitment. The theory of cognitive dissonance on the one hand and the theory of the “Primat der Aufgabe”, of the primacy of the task, on the other hand are in combination the approaches to be followed on during the course of this paper (Festinger, 1957; Aronson et al., 2008; Ulich, 2001).

2. THEORETICAL BASIS OF SUCCESS CRITERIA IN NEW PRODUCT DEVELOPMENT

In chapter 2 the finding of chapter 1, summarised under paragraph1.6, are further analysed to clarify the expected implications on basic operating units in MDDs, the nucleus of New PD. Therefore a more detailed view into the specific working conditions of MDDs in the environment of fully integrated SW packages (such as 3D CAD) is made and the relevant theories – related to division of labour, team work, modern product development methods and job satisfaction respectively cognitive dissonance - are substantiated by discussions of the outcomes of related investigations, relevant to the presented research. These analyses lead to the formulation of hypothesis / propositions and the design of a causal model which is validated in chapter 3 and 4.

2.1. Analytical and Theoretical Outline of New Product Development Success Criterion Division of Labour

Various occasions have already been used to comment the changes of the working conditions of engineers in many MDDs by the increasing employment of integrated SW packages and the - at least partially - not really satisfied expectations. The MDDs had more or less lost the supporting staff and the development engineer has to fulfil several tasks at the same time: he works in sales, accompanies the manufacture and assembly or the work preparation for problems with new products, is responsible for the ordering of tools and machines and generates nearly the whole product documentation (Ehrlenspiel K., 2007, 277 sqq.). Interruptions and unforeseen tasks are characteristic of the daily routine. This means time for the actual development of new products is drastically restricted by the excessive multi-functionality of engineers in MDDs.

2.1.1. Official Employment Statistics

The trend towards a decreasing availability of auxiliary staff is officially confirmed by a view into the current employment statistics of the Bundesagentur für Arbeit (Federal Employment Agency). Technical draughtspeople, the main actors within the auxiliary staff, declined rapidly. 1999 the product development industry had 143.483 technical draughtspeople under social insurance contribution - 2011 there were only 120.379 left (Berufsordnung 635 Technische Zeichner/innen auch: Bauzeichner, Vermesssungszeichner, Kartographen). The population index declined from 100 in 1999 to 84 in 2011. In the same time frame the population of engineers increased from 637.935 to 708.476 people under social insurance

contribution (Berufsgruppe 60 Ingenieure/innen). The population index increased from 100 in 1999 to 111 in 2011 (IAB, 2011 – Institute for Employment Research - of the Federal Employment Agency). As a consequence the overall ratio between technical draughters and engineers in Germany went from 0,225 in 1999 to 0,170 in 2011 which is a reduction of 24.5 %. In this context an interview of several managers, participating in that research, revealed that the decline in medium sized companies / MDDs was even worse. This short insight into statistics receives an additional weight by the perspectives resulting from a tremendous deficit of qualified employees, which is already now being lamented and which is at least from the view point of practitioners more likely to accelerate (cf. Wittenstein, 2006, p. 61 sqq.; BMBF 2007, 2011) - though it is also discussed controversially. Whether the observed deficits are caused by weak personal politics or by other reasons does not matter in this context (e.g. Handelsblatt, 08.08.2013, Weber, 2010; Weißbrod, 2014). An actual report of BMAS (Bunderministerium für Arbeit und Soziales – Federal Ministry of Labour and Social Affairs), quoted in various daily newspapers addressed 20 professional groups with deficits, of which more than one third are related to technical areas requiring university education (e.g. OVB, 13.03.2014).

Remark: Latest data from the Bundesagentur für Arbeit (Federal Employment Agency) for 2012 is not available due to an intermediate change of data collection grouping; for 2013 the old grouping is maintained again and figures for 2012 can be calculated by interpolation when data for 2013 are communicated.

2.1.2. Characteristics of Main Tasks in New PD

The main task of product development departments is the execution of research and developing projects till market maturity; this contains new products and/or technologies and also the further development of already existing products/solutions.

Every development project is divided into three phases, the preparation phase (1), the creative phase (2) and the executive phase (3). In phases one and two engineers have to be present; the third phase does not crucially require an engineer completely (Hubka, 1976, p. 14).

During the preparation phase (1) specification documents are written, tasks and project definition are determined and plans for deadlines, costs and capacity are drawn up. This phase is tremendously pioneering to the success of the project since foresight, intellectual configuration of systems as well as the indication of later behaviour or rather of the strived for conditions / actions happen there. To achieve this experience and expertise knowledge at the highest possible level is absolutely necessary. The second, the creative phase (2) of a development project contains the search for concepts to solve technical problems. It is the

actual main creative activity of an engineer's work. Here as well as in the first phase, knowledge about certain methods, specialised knowledge and experience are essential for the job of an engineer. In the final executive phase (3) the concepts are worked out to serial production. It contains apart from others the drawing up of product documentations, lists of items, drafts, assembly drawings, detailed drawings and calculations (for further details see table 2.1). This type of work ranges within the restrictions set up in phases one and two and therefore requires a less high qualification (Hubka, 1976, p. 14).

As far as the subject of this paper is concerned there is clear evidence that in various ranges of duty coherent division of labour can operate in MDDs. According to the characterisation of these ranges of duty (table 2.1) there are two directions of DoL identifiable. One direction indicates the DoL with the individual operational disciplines / functions within the company from marketing to production and dispatch to the customer (the basis for team building across functions). The second direction is oriented to DoL within the MDDs especially within the executive phase (3), the dedicated subject of this paper.

Table 2.1: Executive development tasks and DoL-options in phase 3

Tasks in phase 3:	**Required Qualification:**
Draft drawings	AS
Drawings of assemblies	AS
Detailed drawings	AS
Parts protocols	AS
Calculations	E / AS
Selection of standard and repeat parts	AS
Parts lists / Bill of material	AS
Product documentation	AS
Cooperation with suppliers and adaptation of models and drawings	AS / E
Initial sampling of tools and adaptation of tolerances	AS / E
Discussion of tool improvements / changes with supplier	AS / E
Early information, integration of the production departments	E
Integration of the procurement department	AS
Prototype part purchasing	AS / procurement

E = Engineer; AS = Auxiliary Staff

Table 2.1 contd.

Tasks in phase 3:	**Required Qualification:**
Prototype creation and tests	E
Coordination of the start of series production with the production departments	E
Production release (circulation of relevant information to the next downstream working units)	E
Performance review	AS / E

E = Engineer; AS = Auxiliary Staff

Source: own table

Direction one of DoL, referring to the kind of cooperation detailed under sub-chapter 1.3, is a common practise in nearly every commercial organisation, in small companies as well as in large ones. As discussed here, this is not really in dispute and should not be questioned in this paper. However, this paper is concerned more about the second direction of DoL-options which is perceivable in table 2.1 by the allocation of the respective professions to the individual sub-tasks to be executed within the scope of MDDs. Whereas the DoL in direction one is permanently carefully considered by management as well as by SW-developers to simplify the flow of information as much as somehow possible, direction two seems to be disregarded, non-existent or covered respectively solved by the SW in use - without supporting staff. However recalling again those analyses which had shown that roughly one third of the time spent in MDDs for the development of a project can be allocated to auxiliary staff (Wittenstein 2007, p. 166 sqq., p. 189; Ehrlenspiel 2007, p. 245 sqq.), the extent of auxiliary tasks is more than remarkable. Taking the demand for DoL as a fact, the author intends to investigate by surveys of actual projects (elaborated in chapter 3 and 4) as to whether the theoretical findings discussed in chapter 1 on team composition (such as competence diversity, familiarity, leadership etc.), on socio-psychological relationships (cognitive dissonance etc.) and on modern development practices (overlapping etc.) should or must also be applicable with success in the field of direction two of DoL, the core of New PD. The paper analyses the efficiency potential lying within SOUs of MDDs in order to get that area once more into the focus of HRM.

The analysis of several new product performances in respect of the appropriate metrication by

Cohen et al. (2000, p. 348 sq.) showed the dilemma between ambitious time to market, product performance and development cost. An overly ambitious time-to-market target leads to an upward bias in the intensity of resource usage and a downward bias in product performance. Given a target product performance, the analyses show that the coordination between marketing and R&D is easier because the resulting development resource intensity and time-to-market decisions become separable. However, an overly ambitious product performance target leads to an upward bias in the development resource intensity and a delayed product launch that may miss the window of opportunity, the - limited - time horizon for the sale of the new product. Finally, the analyses show that the target development cost approach can lead to a downward bias in product performance and a premature product launch.

In the case of the work presented, there are good chances to improve all of the three commonly used new product performance metrics to a certain extent, the time-to-market, the product performance and the total development costs, if the results of related investigations in respect to DoL, team composition, overlapping of activities, cognitive dissonances etc. are applied adequately. A task and competence based ratio between engineers and auxiliary staff for the development of new products (at least in the executive phase of variant construction projects within a 3D CAD environment in MDDs) should be achievable that increase economic and socio-psychological efficiency significantly.

2.2. Analytical and Theoretical Outline of New Product Development Success Criterion Teamwork

One common statement related to teamwork is: The aim of team composition, of clustering of people, is “to boost diversity as it enhances creativity and social collaboration and to make sure that the various departments of the organisation have a say in the project” and “are equally represented in the team” (www.12manage.com/description_cross_functional_team.html). The extensive survey of Hollenbeck et al. (2004) already referred to under paragraph 1.3.1, however resulted in a variety of team composition guidelines / recommendations of scientists on the basis of their researches analysing the multiple manifestations of teams. This survey, divided in the areas team composition, team training and team task design, illustrates that there are good reasons to rely on researches in the process of implementing and applying teams as opposed to intuitive decision making on team building (Hollenbeck et al., 2004, p. 363). One of the essentials of team composition is the diligent analysis of the individual task, in the case of the presented research, the development of new products.

Haon et al., (2009) developed three hypotheses within their recent investigation of new product development teams, visualised with figure 2.1: Competence diversity improves the performance of the New PD by an increased degree of instrumental use of available information on customers, competitors and technology and, the positive effects are even more, the stronger the familiarity among team members is.

2.2.1. Analyses of Related Surveys

To validate their hypotheses - and to show that the undifferentiated use of diversity and the contempt of familiarity by managers and team leaders are above all responsible for the heterogeneous outcome of the surveys made during the years 1988 and 2005, as described in chapter 1 with details in Annex 4, Haon et al. surveyed new product development teams again by interviewing one respondent from each team who has taken part in a recent development project and can describe that project effectively. For large firms, they interviewed product managers, for small and medium-sized enterprises sales managers; the respondents represent

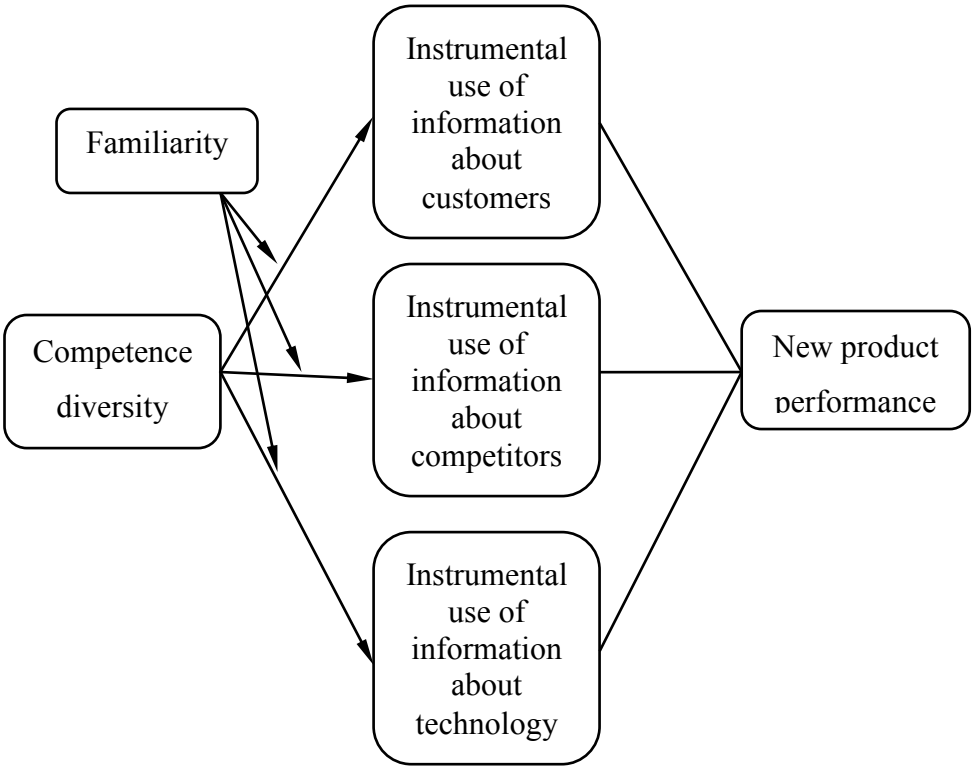


Figure 2.1: Research hypotheses of Haon et al.
Source: Haon et al., 2009, p 79

all 58 French industrial sectors. Special attention was directed to an elaborate reference / discussion of the adequate methods used for the analysis of all collected data in respect of reliability and validity. According to the latest state of the art to examine cause-effect relations

in social sciences (outlined for example by Eberl 2004, Schira 2005 or Weiber & Mühlhaus 2010) formative indicators, index construction, multicollinearity, variance inflation factor, exploratory factor analysis, convergent and discriminant validity, path analysis, confirmatory factor analysis have been considered.

In fact this solid analysis confirmed the hypotheses to a broad extent. What was not validated was the interaction between familiarity and competence diversity in the case of using the information about customers. “This effect could indicate that information about customers is considered central to developing new products and, as a consequence, is used regardless of who the team members are” (Haon et al., 2009, p 82 sq.). Nevertheless there are strong arguments for the importance of familiarity; the moderating effect concerning competence diversity and instrumental use of information about competitors and technology has revealed a high significance. It is just the benefit of the detailed design of the model of Haon et al. that supplemental to importance of competence diversity in contrast to simple functional diversity the crucial characteristic of familiarity is made evident for team members and in particular for team leaders and managers. In general the findings are that the setup of project teams must encourage information sharing, broaden the understanding of the development problem and increase the ability to solve the development problem (Bstieler, 2005, p. 271) and, thus, as envisaged by the presented model and research, improve the efficiency of development teams.

Another notable research addressed a peculiar aspect of team composition made in conjunction with the discussion of DoL, job enrichment and job based specialisation under paragraph 1.2.. To recall, Mayer (1988, p. 159 sqq.) demands a cooperative division of labour with a specialised expert at the centre. In this context Humphrey et al. (2009. pp. 48-61) analysed the impact of core role holders on team performance, core role holders in the sense of team members attributed with a substantial higher level of KSAs (attributes as knowledge, skills and ability) compared with the average of the team members. The review was made in the field of sports, an area commonly known for the employment of core role holders under extraordinary conditions (high investment and salaries), with data from 778 baseball teams over a period of 29 years (1974-2002). Teams equipped with those specialised members had a significantly better performance. A further result is “teams that invest more of their financial resources in these core roles are able to leverage such investments into significantly improved performance” (Humphrey et al. 2009. p. 48). Transferred to the composition of New PD team considerations, the specialist at the centre, as already addressed by Mayer 1988, has a really impressive particular actualisation.

2.2.2. Implications on the Research Question

From a managerial point of view in general - and this includes the viewpoint of MDDs - the summary of the discussion of cross-functional teams and leadership range from a need to change the terminology to personal development aspects, to rules for the composition of teams and teamwork and to some vital traits of team leaders in that specific environment:

- The idea behind cross-functionality is more precisely addressed by competence diversity and therefore cross-functionality is better replaced by competence diversity as only competence diversity can guarantee the variety of information and knowledge required for optimal decision making processes. Mere cross-functionality is not necessarily able to establish that. Talking of competence diversity teams rather than cross-functional teams is more operational in respect to the actions to be taken by managers (HR-managers and others involved) and team leaders composing coherent teams.
- HRM should promote and control interpersonal diversity by hiring and training and thus support the team composition processes.
- When designing a team competence diversity and familiarity aspects must play the key role from the very beginning.
- As competence-diversity-benefits can be leveraged through higher familiarity among team members management and team leader must highly emphasise the development and maintenance of a productive collaboration climate, a shared mental model.
- To obtain the positive effects of competence diversity on New PD performance, management and team leader must actively encourage the team members to make use of the richness of information and knowledge available by competence diversity.

The results of this discussion of competence (cross-functional) diversity and leadership are - as already stated - applicable in general regardless of the size of a company, i. e. for major industrial enterprises as well as for MDDs. This paragraph is understood to contribute to the discussion of measures for the establishment and use of coherent team structures. This proposal intends to demonstrate that management in focusing continuously on the improvement of organisation to enable technology innovation or to cope with the challenges of the world wide finance and economy changes / crises must not lose the view for the SOUs in their companies. For example by analysing the deployment of an all commercial processes integrating software (e. g. 3D CAD) there is easily the danger to lose sight of the everyday work life of any single productive unit - or to actually accept possible collateral damages – and take it as supposedly unavoidable. The author takes the view that to create competence diversity is not only a global organisational task, management must in parallel adequately observe the requirements of successful team composition for single productive units as well in

order to enable efficiency improvements. One of the essentials of team composition in theory as well in scientific researches is the diligent analysis of the individual task in respect of the traits of interest, the nature of the particular challenge, the desired team outcome etc. (Hollenbeck et al., 2004, p. 357). Following that, the analysis made for the tasks in the considered SOU of New PD, as detailed under paragraph 2.1.2, distinctly suggest that a coherent, task and competence based team composition and teamwork by IofAS is advisable.

2.3. Analytical and Theoretical Outline of New Product Development Success Criterion Overlapping Development Activities

The subject of this paper is creative and routine activities in New PD. The idea is to demonstrate that overlapping activities in the execution phase with coherent employment of auxiliary staff is a method to decrease development lead time and hence development costs and finally to increase the economic efficiency of the development department and the company as a whole. Based on an assessment of the pros and cons of concurrent / overlapped engineering it will be shown how overlapping can be processed efficiently from the creative to the execution phase respectively from the task of engineering design to part and assembly documentation of New PD between engineers and auxiliary staff. Convinced of a solvable imbalance in respect of the perceived allocation of personal resources in MDDs the results of the discussion of overlapping development activities in chapter 1 is examined in detail to analyse which combinations in information sharing are suitable and economically efficient between engineers and auxiliary staff in a modern engineering environment.

Since every product development project creates a different number of new components there should be good chances in a redesign construction to transfer the information of (every) single component parallel/overlapped from the engineer to the auxiliary staff to produce part and assembly drawings/documentation which serve worldwide as procurement documents - provided supporting staff has been assigned to engineer adequately. On the one hand, as already stated in chapter 1, the evolution in variant construction normally is fast and major changes are not expected at the end of the engineer's upstream activity, on the other hand the downstream sensitivity is low as the main structure remains, small - and also larger - changes can be easily accommodated / reworked by the auxiliary staff downstream activity.

2.3.1. Relevant Types of Overlapping Activities for the Present Investigation

Krishnan et al. analysed and illustrated their overlapping model discussed under sub-chapter 1.4 with an application of the design process of an automobile door panel and door handle (with the overlapping pair of activity engineering design and prototype development) and

with an application of the development of an electronic pager (with the overlapping pair of activity industrial design and engineering design). The automobile example for instance resulted in a lead time reduction from 18 weeks plus 4 weeks (sequential) to 18 weeks plus 1 day (overlapped), which is a substantial contribution to overall cost of the development of an entire automobile; in the 90s this cost had been calculated to be at least 1 million $ per day (Krishnan et. al. 1997, p. 446).

The author advances the findings on the four extreme situations of overlapping, fast or slow upstream evolution and high or low downstream sensitivity, as discussed in chapter one, with figure 2.2. Figure 2.2 is an advanced form of figure 1.3 (chapter 1.4.3), highlighting the auxiliary staff - overlapping option (see text boxes and additional arrows). The characteristics of the overlapping option 4 (chapter 1.4.3), the Distributive Overlapping, represent to a great extent the basic conditions of the present research question. Whereas the Iterative Overlapping is applicable in a development situation when a completely new product comes into existence, manufactured with known technologies, the Divisive Overlapping or No Overlapping is an option for a development situation with a completely new product and new manufacturing technology. The Preemptive Overlapping, the third case, fits in with a redesign development situation under new manufacturing technology conditions.

The Distributive Overlapping, the preferred case for the discussed model, is characterised by a fast upstream evolution and a low downstream sensitivity which is typically for adjustment and variant construction; this constellation allows downstream activity to start with preliminary information (no need for freezing too early) and continues with the onward progress of the New PD process with in advance finalised upstream information. Large changes in the upstream process happen early and finalised information - before the end of the upstream activity - do not lead to huge quality losses in the upstream process. The low downstream sensitivity means those large changes in the magnitude of the upstream information exchanges do not entail large iteration loops. Both activities, the upstream and the downstream, contribute to an efficient overlapping process, the involvement is distributed. This situation is most favourable for overlapping (Krishnan et. al. 1997, p. 449). Transferred to the activities from the creative to the execution phase of New PD, respectively engineering design to part and assembly documentation, the work sharing between engineers and auxiliary staff, means, that when an individual part and assembly construction / design is widely progressed by the engineer the drawing of documentation, executed through the auxiliary staff can start. This development situation appears when a product redesign with known manufacturing technologies is generated or when an engineer redesigns a part, for example which is manufactured with a defined method. This complies with a variant construction, the

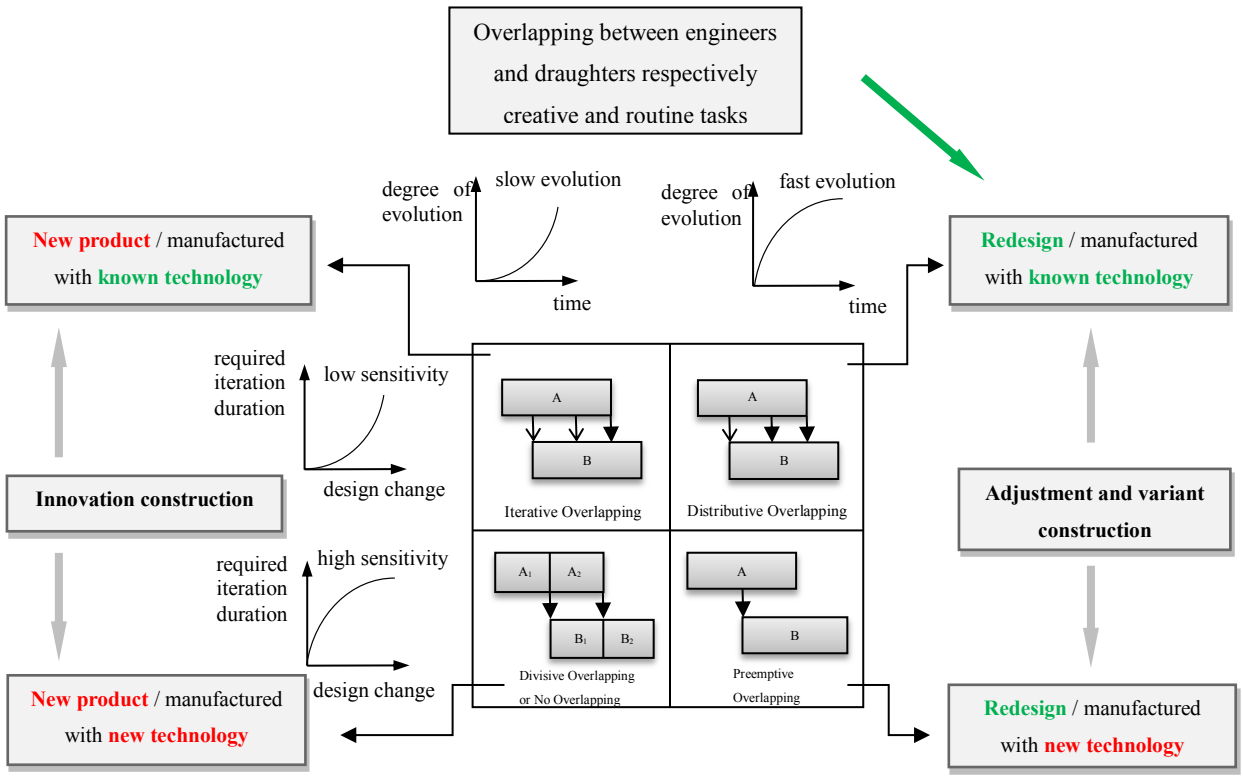


Figure 2.2: Placement of the research topic in the overlapping system
Source: Krishnan et. al. 1997, p. 446, modified by the Author

most frequent construction worldwide and - this complies explicitly with the subject to this dissertation.

2.3.2. Overlapping Activities – and a Missing Link in MDDs

There is no generalisation possible, but if overlapping is approached in a careful and systematic manner, analysing individual traits of a project and acknowledging possible risk impacts on quality and cost, a reduction in lead time seems to occur largest (Bogus , 2011, p. 950 sqq.) because one essential prerequisite of a success promising overlapping the standardisation of the tasks of engineers and auxiliary staff (Bogus, 2011, p. 951) in the executive phase of New PD is, generally speaking, at a significantly high level - and this at least in part is owed to the application of an integrated SW package in MDDs. A few figures may demonstrate the potential - following Annex 1: Our standard project, a variant construction, takes about 12 man/months with a supporting labour portion of about 4 months and 8 months of engineering tasks, of that 3 months creative tasks and 5 months executive tasks (detailed in table 2.1); it is one with about 20 new parts and 200 new drawings which can be disaggregated and processed one after another. The drawing portion is about 75% of all auxiliary activities, say 3 months or 60 working days, which means one part consumes about

3 working days. These figures imply under optimal overlapping conditions the option for a reduced lead time of 8 months for engineering tasks +1 month for additional supporting documentation activities + 3 working days for the last part after the completion of creative activity = 9 months +3 days - vs. 12 months. Considering only the executive portion (phase 3), the subject of that investigation the relevant figures are 6 months +3 days vs. 9 months. Chapter 3 and 4 – research design and research performance and analysis – will examine whether a reduction of at least 24% of the average total time respectively 32% of the executive phase 3 time is actually achievable – disregarding the potential lying in the possible overlapping of the 1 month for additional supporting documentation activities.

The overlapped procedure in general seems more adequate for an inherent iterative development process than a one shot finalised information exchange as it was assumed in project management until recently. In the New PD process preliminary information exchange is useful and profitable and especially the overlapped activities between engineers and auxiliary staff should lead to economic efficiency, measured with hard facts - lead time and costs. However, as far as the current situation of many MDDs is concerned, there is what could be called, referring to the well-known counterpart of the term evolution in the original sense, a missing link.

One tricky outcome of the 3D CAD revolution, with its pretension to automatically integrate all supporting functions in a SW package, was as already outlined the dramatic change of the personal structure in many MDDs demonstrated already under paragraph 2.1 with official statistic data. (There are actual cases of MDDs with one auxiliary staff person “working” for 20 engineers.). The engineers in these companies have more or less lost their “right-hands”, the technical auxiliary staff. The massive drawing documentation work was creeping towards the engineer as the software is not as efficient and not powerful enough to generate automated part and assembly drawings. According to this situation and apart from the advantages and disadvantages of concurrent/overlapped engineering the companies concerned more or less unconsciously lost the option to overlap creative and routine activities between engineers and auxiliary staff. Exactly one of the major results of this analysis is that overlapping is highly recommendable for the examined situation of variant constructions. In this circumstance the auxiliary staff is actually the missing link in the chain to improved efficiency which stops the evolution towards a success related use of professional methods and expertise for New PD in many MDDs. In addition, what makes the prospects even worse; there is no chance to overcome that gap by employing more engineers, what might be seen as an option to get more flexibility in rapid changing markets; but this is actually not an encouraging approach in an economic environment with growing shortage of engineers. Additionally, and not only based

on these for engineers positive perspectives, it is not really the intention of an engaged engineer to lose - on a permanent basis - too much time with supporting activities, valuable time which is required to apply and to improve his personal profession in the preparation and the creative phases of New PD. These thoughts lead again to the relevant areas of socio-psychology with its strong efficiency impacts. It looks as if efficient New PD is actually not possible without the coherent, task and competence based employment of auxiliary staff.

2.4. Analytical and Theoretical Outline of New Product Development Success Criterion Cognitive Dissonance

The review of the relevant literature related to socio-psychological efficiency aspects was carried out with the aim to formulate hypotheses in respect of the availability of qualified and motivated employees according to the requirements of a given situation / task. With this sub-chapter the further refinement in the designed line of argumentation – according to the process of agglomeration of relevant theories and research results, described under sub-chapter 1.1 – is made and the preparation of the theoretical and empirical basis of the proposed model of IofAS and the subsequent analyses continue.

This part of the study revealed a strong dependence/correlation between task content and self-image. Under the described situation - to have the qualified and motivated employees available according to the particular requirements - , it is reasonable for managers and team leaders to note that they are a part of the success related interactions (Stacey, 2010, p. 35 sqq.; Stacey, 2007, p. 292 sqq.) and to consider more seriously how an ambitious, dedicated engineer would deal with the disparity between his professional expectations and his professional reality. His organisational commitment requires special attention, the identification with the values and goals of the organisation, the execution of extra effort on its behalf, the representation of his company, the recruitment of partners for his company, the loyalty to his company or - the readiness for a change.

2.4.1. Success Potential Revealed by Cognitive Dissonance Theory

The insights gained through the review of relevant socio-psychological literature suggest the assumption that employment of auxiliary staff for the generation of technical drawings (product documentation) and the documentation handling till market maturity can increase the economic and socio-psychological efficiency of MDDs. Socio-psychological efficiency is a decision criterion for all areas of human actions, transactions and interactions, interpersonal relationships and leisure and is analysed by evaluable variables, such as satisfaction, acceptance, and others. The intension is to combine the economic terms (cost aspects) with

the evaluable variables of sociological, psychological and socio-psychological provenance and to undertake cost-benefit analyses which enable to deduce recommendations for the design and use in commercial systems (Neuert J., 2009, p. 65 sqq. respectively 551). The execution of standard projects (see Annex 1) at various levels of the selected independent variables will be examined and the collected data will be analysed and interpreted by a causal analysis, the established method for the analysis of various social and economic issues.

This review of theoretical findings in the area of socio-psychological efficiency was triggered by the severe imbalance, perceived from the view point of the development teams concerned, the SOUs, between the organisation of development departments planned and established by the management and the understanding of efficient working conditions by that operating unit (Staita, 2013, pp. 106-117). In detail, the findings are as follows:

- Job enrichment does not necessarily lead to job satisfaction.
- The aim of economic and social-psychological efficiency imposes limitations on job enrichment.
- The relevant socio-psychological criterion seems to be task satisfaction, not job satisfaction.
- Job dissatisfaction factors are not mandatory negative for task satisfaction.
- Striving for harmony and equilibrium means looking for individual solutions with the least resistance.
- The study revealed a strong dependence and correlation between task content and self-image.
- The review of the relevant literature suggests the assumption that a higher conformity of self-image with task content leads to a higher task satisfaction and socio-psychological and economic efficiency.

The design of a task and competence based team structure should be possible in a way that increases the economic and socio-psychological efficiency of the development department and of the company as a whole. Of particular value for the progress of this research are the aspects received from the theory of cognitive dissonance. The research revealed that, if the concerns of the development team are permanently removed from the performance of its actual task, the development of an optimal new product in time, there are strong reasons for the management to analyse carefully the situation. This could on the one hand open good opportunities to increase the efficiency of MDDs; on the other hand, as the situation carries the risk of a continuous divergence from the socio-psychological optimum, all the negative consequences of unsolved dissonances could result.

There is at least one further problem that needs a separate investigation: a low fluctuation rate must not necessarily indicate well balanced working conditions; the question is whether in a -

superficially seen - low fluctuation rate key personnel, core role holders, are over-represented due to their stronger demands for task satisfaction and their higher readiness to change.

2.4.2. Measurement of Job and Task Satisfaction

In the present study development projects with different levels of independent variable team structure (IofAS) will be carried out, which means that engineers / auxiliary staff will create documentation with varying intensity. To measure the socio-psychological effects, psychologists examine how the individual feels in his professional world, bearing in mind that the individual aspiration level changes with experiences (Rosenstiel, 2003, p. 443) and that the individual condition of consciousness has some influence on job satisfaction (Werner, 1974, p. 264 sqq.). In empirical science the particular concept which is under review has to be operationalised i.e. in the present case verifiable indicators for job satisfaction must be defined. Job satisfaction is commonly understood to be multidimensional. Through factor analyses researchers found several diverse job satisfaction dimensions: colleagues, task contents, management and leadership, salary, working conditions, company, career advancement, social benefits, training, recognition and status, performance achievement, responsibility, safety and personal development (Rosenstiel, 2003, p. 429 sq.; Kappagoda, 2012, p. 23). According to Vroom (1964, p. 115 sqq.) general factors for job satisfaction are different personality traits, different response tendencies, different environmental conditions etc. Herzberg et al. divided job satisfaction into two categories, work satisfaction and not dissatisfaction. Empirical hints indicate that work/task satisfaction is strongly established through intrinsic motifs, for example, achievement, recognition, work / task itself, responsibility, advancement and growth. Dissatisfaction can be better diminished through extrinsic motifs, for example, company policy, supervision, relationship with the boss, working conditions, salary and relationship with peers and security (Herzberg et. al., 1959, p. 62 sqq.). Transferred to this paper, two factors from the socio-psychological realm will be subject to a specific investigation. Will the work / task itself and the compliance of education level with the demands of the development task increase the satisfaction and the socio-psychological/economic efficiency in the specific environment? The accent on task satisfaction is justified, because (job) satisfaction is strongest through the work / task itself (Ironson, et al., 1989, p. 193 sqq.; Kappagoda S., 2012, p. 23 sqq.) and therefore that intrinsic aspect seems to be the most important one. In this context Ulich talks of the primacy of the task (Ulich, 2001, p. 197 sqq. “Vom Primat der Aufgabe”).

Many studies conducted to determine the factors that influence job satisfaction in organisations displayed for the most part at least statistical correlation with the task

(Kappagoda, 2012; Rosenstiel, 2003, 1988, 1975; Semmer & Udris, 1995; Weinert 1998). The author's intension is to confirm those results and to identify causality to a certain extent with the presented model.

2.5. New Model of Integration of Auxiliary Staff: Hypothesis and Propositions

The analyses of relevant literature and scientific investigations in context with the described actual working conditions in many MDDs have demonstrated the limits of multi-functional organisation in the development sector. Under certain conditions a model of task and competence based IofAS might have obvious advantages over an application of job enrichment in New PD. Important are the characteristics of the task in preparation and the availability of resources fitting to the respective requirements. Precondition is, as sufficiently indicated, a careful analysis of the starting situation in respect of the task characteristics and the disposable resources and, in addition, the readiness of the management to put the results of that analysis into practice. Following the designed proceeding of this proposal (according to paragraph 1.1), the implications of the review of division of labour, competence diversity, concurrent engineering / overlapping of activities and cognitive dissonances are now combined by the author to formulate hypotheses suitable to process a scientific validation of the proposed model of IofAS within MDD teams dealing with variant constructions. All the preliminary considerations suggest very strongly that there might be a task and competence based team structure, a coherent degree of IofAS, which can sustainably improve the cost-benefit-ratio and the contentment with the job in MDDs. An interesting side effect, a contribution to a noticeable alleviation of the shortage of specialised personnel, should not be precluded, but is outside the design of this analysis.

2.5.1. Temporary Character of Scientific Hypotheses

According to Popper theories are nets that we cast to capture the world, to rationalise it, to explain and control it (Popper, 2005, p. 31). The building blocks of theories are hypotheses and hypotheses are in turn test requiring speculations (Spinner, 1973, p. 1186, cited in Neuert, 2009, p. 136). In order to enable a scientific validation, ideas, assumptions, views, opinions or speculations must be transferred into scientific hypotheses satisfying the criteria of the information content, of the inter-subjective verifiability and the general validity (Wossidlo, 1975, S. 13 sqq.). Hypotheses show information content by asserting states and functional relations of reality that can be falsified in reality. The information content of hypotheses usually formulated in the form of if-then statements increases if the then-component is formulated more precisely holding the if-component constant or if the if-component is

formulated more general, holding the then-component constant. Inter-subjective verifiable are real-theoretical hypotheses if they are formulated in a way able to be confronted with reality. Real-theoretical i.e. empirical scientific research is characterised through the consistent efforts to obtain factual validity. This factual validity is present if the statements (hypotheses) and the real facts correspond (Neuert, 2009, p. 136). As far as a general validity is concerned, i.e. the validity beyond the individual case, it is a common understanding that scientific hypotheses - at least in the behavioural sciences - have only a temporary character; they are used to explain certain phenomena, but with the restriction that they are situational, partial, temporary valid. Results of empirical research are therefore never completed, in the sense that they could not prove to be incorrect at a later date (Dreier, n.d., p. 18). However, there is from the scientific point of view nevertheless a dedicated intention to validate the hypotheses with the empirical reality, to detect the proximity to truth (Dreier, n. d., p. 20) and to accept provisionally approved (not falsified) hypotheses and to reject falsified ones (Neuert, 2009, p.176).

2.5.2. Formulation of Basic Hypothesis and Propositions

Taking all considerations made so far into account, the author transfers his proposal into the following set of hypothesis and propositions, subject to a scientific validation process:

Basic Hypothesis HB:

HB: The higher the degree of task and competence based Integration of Auxiliary Staff, the higher the economic and socio-psychological efficiency of project outcomes.

This overall hypothesis is structured into the area of the determination variable, the degree of Integration of Auxiliary Staff and the area of the effect variables, the economic and socio-psychological efficiency.

The determination variable deals with the question, which - determining, explaining - variables influence the construct of the latent exogenous auxiliary staff integration intensity. The latent, independent variable is in this case observable by the indicators (X_1) contribution of auxiliary staff to the creation of the drawing set and (X_2) additional supporting documentation activities performed by auxiliary staff in the execution phase of variant construction projects within a 3D CAD environment.

The effect variables deal with the question, which - latent endogenous, to be explained – variables, the efficiency dimensions, are influenced by the application of the model Integration of Auxiliary Staff, by the degree of the integration of the auxiliary staff within the

selected development projects. The observable dimensions of the dependent variables are in this case deadlines (Y_1), cost (Y_2), drawing errors (Y_3), engineer's contentment with the task (Y_4), acceptance of the project progress (Y_5) and degree of utilisation of engineer's competences (Y_6).

Following this structure the basic hypothesis can be specified in detail by the following compound propositions (P_1-P_6) pointing at the elements / indicators of the expected project outcome and, in addition, illustrating for each proposition the observable determination indicators (X_1, X_2) causing the observable effect indicators of the expected outcomes (Y_1-Y_6).

P_1: The higher the degree of task and competence based Integration of Auxiliary Staff, the higher the possibility of meeting the project deadlines.

PY_1X_1: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the possibility of meeting the project deadlines.

PY_1X_2: The higher the additional supporting documentation activities, the higher the possibility of meeting the project deadlines.

P_2: The higher the degree of task and competence based Integration of Auxiliary Staff, the higher the possibility of reducing the project costs.

PY_2X_1: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the possibility of reducing the project costs.

PY_2X_2: The higher the additional supporting documentation activities, the higher the possibility of reducing the project costs.

P_3: The higher the degree of task and competence based Integration of Auxiliary Staff, the higher the possibility of reducing the drawing set errors.

PY_3X_1: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the possibility of reducing the drawing set errors.

PY_3X_2: The higher the additional supporting documentation activities, the higher the possibility of reducing the drawing set errors.

P_4: The higher the degree of task and competence based Integration of Auxiliary Staff, the higher the engineer's contentment with the tasks.

PY_4X_1: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the engineer's contentment with the tasks.

PY_4X_2: The higher the additional supporting documentation activities, the higher the

engineer's contentment with the tasks.

P_5: The higher the degree of task and competence based Integration of Auxiliary Staff, the higher the acceptance of engineers and auxiliary staff with the project progression.

PY_5X_1: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the acceptance of engineers and auxiliary staff with the project progression.

PY_5X_2: The higher the additional supporting documentation activities, the higher the acceptance of engineers and auxiliary staff with the project progression.

P_6: The higher the degree of task and competence based Integration of Auxiliary Staff, the higher the possibility of utilisation of engineer's competences.

PY_6X_1: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the possibility of utilisation of engineer's competences.

PY_6X_2: The higher the additional supporting documentation activities, the higher the possibility of utilisation of engineer's competences.

Furthermore, the author creates a causal model in order to visualise the hypothesis / propositions system and to enable a causal analysis, the method generally accepted in social sciences to examine proposed relations and assumed cause effects with empirical data. The actual verification process is the subject of chapters 3 and 4.

2.6. Framework of Causal Model

From the view of social sciences the relations under examination are not deterministic. The occurrence of causes only increases the probability for the occurrence of impacts. Therefore in the practice of social sciences statistical methods that may reflect this, play a large role (Buch, 2007, Geleitwort von Prof. Dr R. Brühl, p. IV).

2.6.1. Causal Analysis: The Established Hypothesis Testing Method

After having outlined under paragraph 2.5 the transfer of the relevant considerations and reflections - theoretical and empirical - into the basic hypothesis, the general efficiency assumption, and further into the collection of supposed cause-effect relations / propositions it is helpful to establish a more transparent view of the potential relationships by developing a structure qualified to test and examine them. Relations between variables of various types - manifest, latent, endogenous, exogenous etc. - play a central role in real sciences i.e. the sciences, dealing with actual phenomena, processes and events (Buch, 2007, p. III, Neuert,

2009, p. 135) and the causal analysis (or covariance structure model) is an established hypothesis testing method applied when cause-effect relations based on empirical data sets need to be examined. In a causal model respectively causal analysis, the postulated influence of the latent exogenous variable on the latent endogenous variable is specified by the aligned hypothesis (Buch, 2007, p. III). Usually the relations between variables in causal models are graphical illustrated by using path diagrams (Weiber & Mühlhaus, 2010, p. 29). Various terms are used in English language publications such as „covariance structure model“ (e.g. Breckler, 1990) or „structural equation models“ (e.g. Jöreskog, 1993; Sobel, 1990). Overall the term „Strukturgleichungsmodelle“ - „structural equation models“ seems to prevail. To avoid ambiguity, Buch refers consistently to the term “causal analysis” (the advancement of the path analysis for latent variables, Buch, 2007, p. 3) to mainly describe the methodical approach, the term “structural equation model” or “model structure” to describe relations between variables primarily in the form of equations and the term “path diagram” for a graphical illustration (Buch, 2007, p. 1).

A path diagram displayed in figure 2.3 shows abbreviated and transparently the fundamental assumption of a research project by addressing causes and effects and connecting them with arrows according to the respective direction of the expected impacts. According to (Buckler, 2001, p. 31) a causal model is basically composed of an independent structural, causal variable X (in our case the IofAS) which has effect on the dependent structural variables Y, Z (in our case the Efficiency dimensions), i.e. - in the simplest way - Y/Z = f(X). The

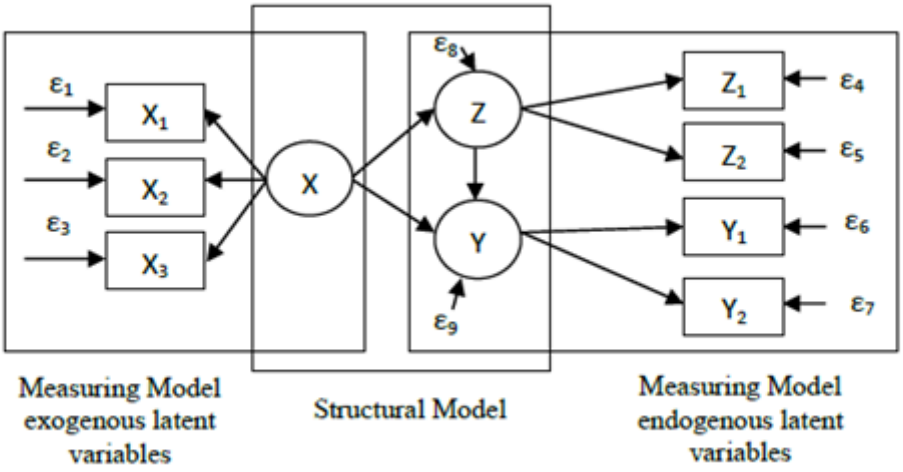


Figure 2.3: Simple path diagram

Source: Buckler, 2001, p. 31

independent structural variable X, the latent exogenous, causal variable is explained by a set of indicators whose values are determined by factors outside the model (measured by x_1- x_n)

and in this connection X is a dependent variable.

The dependent structural variables Y and Z, the latent endogenous - to be explained / effect - variables, are determined by factors within the model i.e. by X and measured by a set of indicators whose values are determined by factors outside the model y_1- y_n and z_1- z_n. The layout of this model always comprises the three sections, left the measurement model of the latent exogenous variable, in the midst the structural model – e.g. Y/Z = f(X) - and right the measurement model of the latent endogenous variables. The process of transferring theoretical, not really observable, and therefore latent terms as IofAS or Efficiency into empirically observable manifest terms is subject to a process of operationalisation i.e. subject to the measurement models. Using this understanding for the object of this paper we receive the explanatory causal model in figure 2.4.

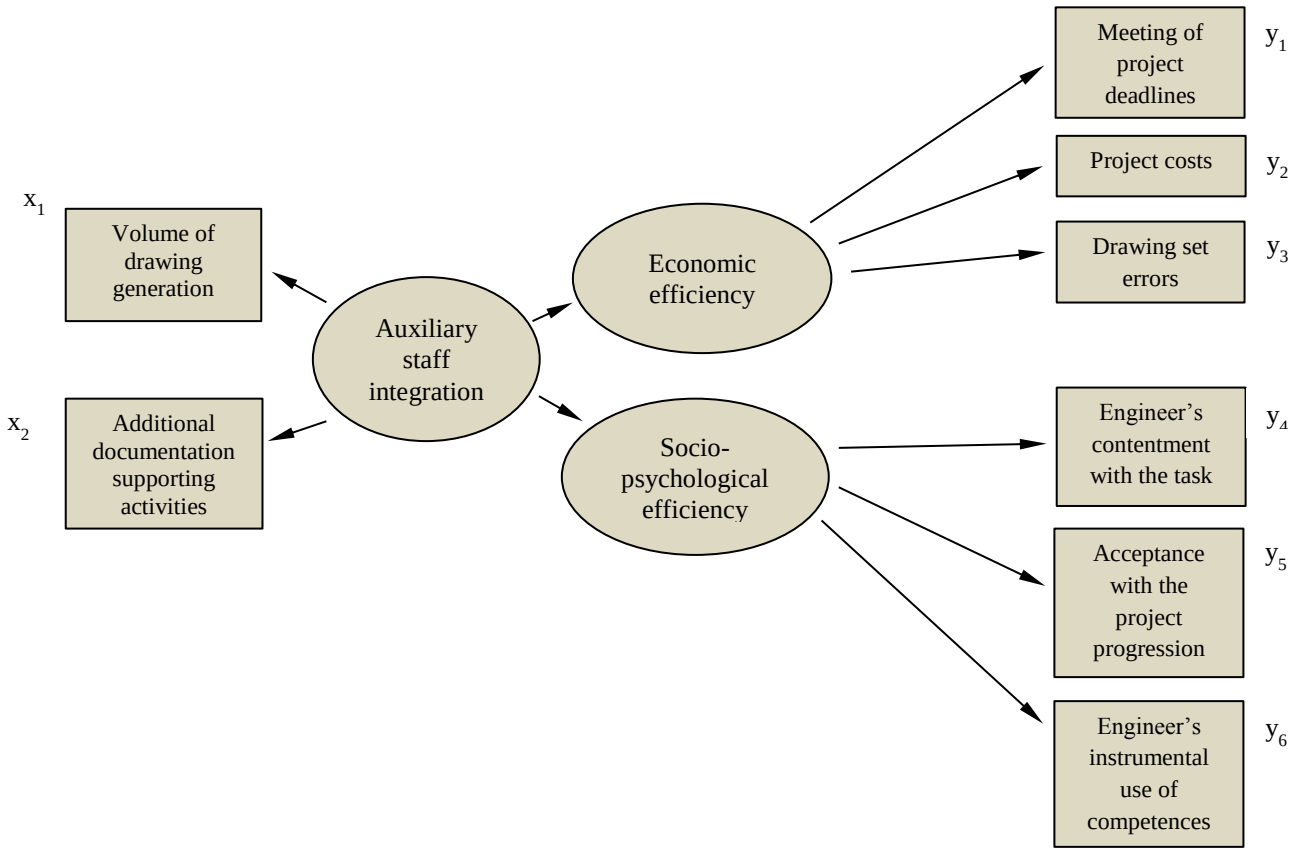


Figure 2.4: Causal Model

Source: own figure

Legend for the causal model:

$x_1 – x_2$ = manifest measurement variable for the latent exogenous variable IofAS

$y_1 – y_3$ = manifest measurement variable for the latent endogenous variable economic efficiency project outcomes

$y_4 – y_6$ = manifest measurement variable for the latent endogenous variable socio-psychological efficiency project outcomes

The causal analysis, the method to review a complex of hypotheses, implies on the one hand the existence of cause-effect statements referring to the dependent variables and independent variables and on the other hand the existence of a collection of data and information related to the defined research question / hypothesis / propositions complex which comply with the quality criteria of scientific research of validity, reliability and representativity (Neuert, 2009, p. 134 sq.). Also Buch explicitly points to this basic prerequisite: “Before the statistical analysis of the data sets can be run, intensive reflections about the relation between the variables are necessary” (Buch, 2007, p. II).

2.6.2. Specification of Constructs – General Measurement Considerations

The presentation of the relationship between latent variables in the causal model corresponds to the regression analysis approach (Backhaus et al., 1994, p. 349). Using regression equations the theoretical relation between latent exogenous and endogenous variables are shown and estimated (Homburg & Hildebrandt, 1998, p. 15 sq.). Prerequisite for performing a regression analysis is that both exogenous and endogenous variables are metrically scaled and there is a clear direction of the relationship between two variables (Buch, 2007, p. 8). To make latent variables such as IofAS or Socio-economic Efficiency measurable and in further consequence utilisable for regression and structural analyses these theoretical terms require a transformation into empirically observable terms, a process of operationalisation, a measurement model (Friedrichs, 1980, p. 77). Measurement models include instructions on how a latent variable or a hypothetical construct can be assigned to an observable fact (= operationalisation) and recorded by numbers (= measurement). The result is a measurable variable that is empirically observable and thus constitutes a manifest variable (Weiber & Mühlhaus, 2010, p. 86). According to Buch the process of operationalisation is characterised by the search for indicators that can capture the construct respectively the latent variable adequately. i.e. by a search for indicator variables which can be accepted as an empirical correlation to the construct respectively the latent variable (Buch, 2007, 5 sq., Backhaus et al., 2003, p. 349 sqq.) and which comply with the quality criteria of scientific researches, validity, reliability and representativity (Neuert, 2009, p. 134 sq.). Appropriate (statistical) methods examine whether the indicators used measure in fact what they should measure ("validity"), and if so, how reliable they are (Andreß, 2001). Exemplary "non-empirical" terms can be socio-economic status, working environment, employee satisfaction, Integration of Auxiliary Staff, etc., as opposed to so-called "empirical" concepts such as velocity, mass, temperature, length, etc. (Moosmüller, 2004, S. 24 sq.). Neuert elaborates, that the range of validity of a

theoretical analysis depends on the quality of operationalisation, i.e. the appropriate choice of indicators and measures of the variables determine their range of validity. The better the transformation of the theoretical terms into empirical terms is, the better the empirical term correspond with the theoretical term, the more valid is the content of the statements of a theory or a hypothesis to be tested (Neuert, 2009, p. 223).

The issue is at one point to work out, which (latent exogenous, i.e. explanatory) variables manipulate the different application levels of the IofAS.

Ideally the degree of a model application is 100% (the equivalence number is “1”), i.e. the auxiliary staff is fully integrated in the PD process. The opposite would be an application level of "0", the engineer is not getting the slightest support.

Depending on the direction of the impact there is a differentiation between reflective and formative models of measurement and different statistical methods are applicable to identify causality between the latent construct and the manifest variables. The respective direction of the impact is graphically indicated by arrows (see paragraph 2.6.1). A commonly used example to make a formative model obvious is the construct of “socio-economic status” introduced by Hauser (1973, S. 268; see also Eberl, 2004, p. 6; Buch, 2007, p. 16). Socio-economic status is established by the indicators education, income and prestige of the job and is dependent – as is typical for a formative model – on every single indicator. In a reflective model the construct, the latent variable, in the present project for example the degree of IofAS, establishes the manifest indicators and in the simplest case the omission of one indicator does not necessarily change the whole construct. Therefore manifest variables in reflective models normally correlate significantly, whereas in formative models this is not mandatory (Buch, 2007, p. 20).

The measurement of indicators is depended on the quality of the hypotheses and the respective assigned facts. Whether the quality challenges are actually achieved by the propositions formulated under paragraph 2.5 will be examined in chapter 3 and 4 - research design and research results and interpretation. Measurable terms are, as elaborated, ideally observable by quantity, velocity, weight, temperature, time etc. For hypothetical constructs the easiest case of measurement is the direct rating of a latent variable by using an intensity scale, e.g. ranging from very high to very low with 5 (or 6) graduations (Neuert, 2009, p. 213; Weiber & Mühlhaus, 2010, p. 34). The difficulty with direct assessments of hypothetical constructs, however, is that respondents combine very different content with a latent term to be evaluated and therefore comparability is not really given (Weiber & Mühlhaus, 2010, p. 35). A measurement model with directly observable variables is in accordance with scientific standards and is in any case preferred. Scaling is, generally speaking, the procedure of

transferring qualitative properties (dimensions) of situations into quantitative ones by allocation numbers (Weiber & Mühlhaus, 2010, p. 95). The relevant empirical science has developed various qualified scales which have already proven their plausibility, validity and reliability (Neuert, 2009, p. 212). Some of the most familiar methods are the Likert -, the Guttmann -, magnitude scaling or the polarisation profile. These ratings are subject to a "standardisierten und vollstrukturierten Erhebungsbogen", a questionnaire with closed questions based on prepared scales and reflecting exactly the basic hypothesis respectively the propositions elaborated in more detail in chapter 3 (Neuert, 2009, p. 133 and p. 211 sq.). However already at this stage Neuert's hint must be adopted; the scalings for questions are to be chosen in a way to provide (relatively) precise measurements that enable ambitious and meaningful statistical analyses (Neuert, 2009, p. 196). The specific research design for the present investigation covering the measurement model - the indicatorisation, the operationalisation, the metrication of latent variables - and the experimental design and the analysis plan are subject to the following chapters 3 and 4.

3. TESTING THE MODEL OF INTEGRATION OF AUXILIARY STAFF

The discussion of the relevant literature, theories as well as related researches, was a continuous narrowing from a vague description of assumptions to a decided formulation of the research questions and the hypothesis / propositions. This line of argumentation is elaborated in detail in sub-chapter 1.1 and with figure 1.1 this process of agglomeration is illustrated. Starting with the relatively imprecise, spacious but nevertheless fundamental theme of division of labour the ongoing proceeding has received a first refinement by the discussion of the topics team composition, teamwork, competence diversity, familiarity and shared mental model. With the subsequent extensive specification and analysis of overlapping of development activities this literature research has concentrated on the central subject of this work. Finally, the ultimate focus is achieved by adding the relevant socio-psychological aspects, especially the theory of cognitive dissonance, giving the importance of behavioural economics in explaining economics (Cammerer et al., 2004, p. 4) an adequate place in the presented work. The various related findings have encouraged the author to propose and discuss a model, which is called a model of IofAS within mechanical development teams. The model of efficiency improvement by task and competence based IofAS, the overarching topic of the present proposal to compose and apply coherent teams in New PD, is approached by the discussion of selected, model relevant efficiency increase measures within New PD processes related to task and competence based team composition and teamwork. All the preliminary basic considerations suggest very strongly that there might be a coherent, task and competence based team structure, a coherent degree of IofAS, which can sustainably improve the economic and socio-psychological efficiency within the carefully restricted area. Empirical evidence together with the theoretical findings resulted in the system of hypothesis / propositions and the causal model elaborated under paragraph 2.5 and 2.6. In chapter 3 the central assumptions and the deduced hypothesis / propositions are transferred into an adequate scientific research design which will be validated in chapter 4.

3.1. Six Steps of a Scientific Research Design

Research design (RD) is the „science (and art) of planning procedures for conducting studies so as to get the most valid findings“ (Vogt, 1993, p.196). The process of developing a research design is focused on a detailed plan which guides the research procedure according to established scientific rules. As a consequence a scientific research study must follow the steps 1 to 6 (Neuert, 2009, S. 557, Neuert, 2010a, p. 2):

1 Identify the central research question

2 Formulate working-hypotheses and developing a cause-effect relation model according to a causal analysis

3 Define precisely the variables involved, the independent and dependent, the exogenous and endogenous and the latent and manifest ones by indicatorisation, operationalisation and metrication

4 Develop, test and conduct a dedicated experimental design / experimental study to validate the cause-effect-catalogue in reality using the defined variables

5 Define the statistical analysis plan

6 Extract supportable or substantiated and negated hypotheses and summarise the results and conclusions.

Steps one and two and the general part of step three of this scientific research study have already been completed and discussed within chapter 2, the detailed part of step three and the steps four to five are subject to this chapter 3, step six will follow under chapter 4 and 5.

3.2. Research Design: Detailed Definition of the Variables Involved

According to our observation of the selected PD process the degree of IofAS is reflected by (X_1) contribution of auxiliary staff to the creation of the drawing set and (X_2) additional supporting documentation activities performed by auxiliary staff in the execution phase of variant construction projects within a 3D CAD environment.

In order to control the number and the intensity of possible influencing variables this research is strictly related to the execution phase of variant construction projects within a 3D CAD environment executed at various levels of the independent variables (IofAS). The standard projects belong to variant constructions; the most frequent development project (about 60 %) identified in general (Ehrlenspiel, 2007, p. 256 sqq.). A distinction of development projects is made based on the level of novelty of the task into: innovations, adjustment constructions and variant constructions. The selection of variant projects has a high external validity because of their worldwide major dissemination. In the Kathrein KG company variant constructions comprise of up to ten changed article codes (up to 20 constructed parts with about 200 drawings - change of cables not included) and contribute about 60% of all end products (all details in Annex 1). Previous researches suggest that project complexity can have significant influence on a team performance (Ancona & Caldwell, 1992, p. 321 sqq.) and speed to market / lead time (Kessler & Chakrabarti, 1999, p. 231 sqq., Slama, 2010, p. 24). Therefore, a standard project as already mentioned is analysed to detect if the different degrees of the independent variables lead to changes in the dependent variables – at least to a great extent. In accordance with Neuert (2009, p. 147) a normal distribution for equivalent performance of the

participants can be taken as a basis for this study to further reduce the complexity.
For the latent exogenous variable of the present project, the IofAS, the following indicators, identified under paragraph 2.5.2, reflecting the degree of the integration, have been quantified and scaled / metricated. (The actual data collection with questionnaires Q – Annex 5 – is as outlined under paragraph 3.3.)
X_1: The contribution of auxiliary staff to the creation of the drawing set in a variant construction project within a 3D CAD environment. The metrication of this manifest variable takes place with indicator question and a suitable scale combination of Likert-, Gutmann- and Polarity-Profile-Scale, using 1 to 5 from very little up to very intensively (Q No.4).

X_2: The additional supporting documentation activities performed by auxiliary staff in a variant construction project. This indicator is split into various subtasks and is subject to an individual assessment of the involvement of each participant; these are the creation of part lists, archive drawings and cooperation with the part list department and carrying out part and assembly drawing changes. The metrication of this independent variable takes place with indicator questions and a suitable scale combination of Likert-, Gutmann- and Polarity-Profile-Scale, using 1 to 5 from very little up to very intensively (Q No. 5).
The question whether the individual assessments of X_1 and X_2 are consistent with a global opinion about the latent construct of IofAS and whether it is legitimate to use these manifest X_1 and X_2 indicators for the statistical analysis of the causal model, the verification of the assumed causality by relating them as usually performed for these kind of analyses to the manifest effect indicators Y_1 to Y_6 is answered with Weiber and Mühlhaus this way:.
Following the understanding already referred to in 2.6.2, to avoid the difficulty with direct assessments of hypothetical constructs such as IofAS with respect to comparability- as respondents combine very different contents with a latent term (Weiber & Mühlhaus, 2010, p. 35 sqq.) - , a measurement model, applying directly observable variables, is preferred in accordance with scientific standards.
In order to perform the efficiency measurements understood as input / output respectively benefit measurements the indicatorisation and scaling of the terms economic and socio-psychological efficiency, the latent endogenous variables follow now, using the respective propositions, already drawn up under paragraph 2.5.2. Preparing this, the basic hypothesis is recalled: The higher the degree of task and competence based Integration of Auxiliary Staff, the higher the economic and socio-psychological efficiency of project outcomes. The economic and socio-psychological evaluation covers the following outstanding elements: The first requirement aims to reduce measurably the labour / work load and cost involved for all

concerned. The second requirement aims to increase the satisfaction level of the participants with their job. As constituted under paragraph 1.1 the economic efficiency dimension subsumes primarily objective (but also created by subjective assessment) cost-benefit ratios while the socio-psychological component of efficiency subsumes all indicators, related to the individual and / or collective satisfaction based on the subjective assessment of all participants (Neuert, 2009, p. 250).

The concept of economic efficiency is a decision criterion, which of several equally effective environmental measures selects the one that is associated with the least economic cost, also called cost efficiency (Pareto, 1897).

Socio-psychological efficiency is a decision criterion for all areas of human actions, transactions and interactions, interpersonal relationships and leisure and is analysed by evaluable variables, such as satisfaction, acceptance, and others. The intension is to combine the economic terms (cost aspects) with the evaluable variables of sociological, psychological and socio-psychological provenance and to undertaking cost-benefit analyses (Neuert, 2009, p. 67).

For the first latent endogenous variable of the present project, the economic efficiency, the following indicators, identified with the propositions under paragraph 2.5.2 have been quantified and scaled / metricated:

Y_1: The application of the model IofAS improves the meeting of project deadlines. Missed deadlines lead to additional project costs plus higher workload for the project participants as well as for those involved downstream (down to production maturity). The metrication of this dependent variable, based on the standard project (Annex 1), takes place with indicator questions and a suitable scale combination of Likert-, Gutmann- and Polarity-Profile-Scale, using 1 to 5 from very low up to very high (Q No. 8). Meeting of project deadlines is strongly related to project duration. Project duration and deadlines belong to the most important measurement for organisation performance (Zhang et al., 2009, p. 3474) and are the key elements of this research. The considerations of proven experts behind the simple assessment of low or high respectively the extent of improvement achieved in PD require further explanations of the ideas behind their evaluations. Deadline and duration indications are in general available from the project records - in days or hours - normally unambiguous and without measurement errors. A really important item lays in the diligent interpretation of the duration time and of the relation between project personnel cost and project duration: nearly equal cost of 2 projects can differ decisively in respect to duration. Duration depends not only on the time used for the genuine development process. One example (of various others) is the

availability of the product requirement document which is a necessary input from upstream activities and outside the responsibility of the development department. Another aspect of project duration is enclosed in the question of sequential or parallel / overlapped development activities. Recent publications have demonstrated the great potential of a coherent selection out of specific modern development methods, depending on the diligent analysis of the respective character of the development task (details under paragraph 1.4 and 2.3). Referring to the variant construction, the development task of this project, the method of overlapping activities can result in a completion of the total development task nearly simultaneously with the engineer's executive part of the project as the auxiliary tasks can be performed more than 90% in the overlapped mode (in addition to paragraph 1.4/2.3 see also Staita, 2012, pp.657 sqq.). This way the duration saving is expected to amount up to more than 32% of complete duration of the executive phase of New PD.

From the project records the starting date of phase 3 (date of final concept definition - d_o) can be read, the project completion date (circulation of relevant information to the next downstream working units, e.g. parts list department - d_1) and the working hours spent for the project by the auxiliary staff and by the engineers for phase 3 of the project. The triggering situation for this evaluation project can be simplified with the statement that the period d_1 - d_o, the phase 3 related portion of the complete development project duration is (nearly) 100% performed by the engineer(s):

$$(d_1 - d_o)_{max} = D_{max} = gE + dT + S$$

with

D_{max} = maximal duration time of phase 3 (no support available)

gE = duration of the genuine Engineer tasks in phase 3

dT = duration of the distributable Task in phase 3 (drawings and others)

S = duration delta related to a skill factor (engineer’s missing experience / skill for auxiliary tasks)

To calculate D_{max} for a project the project records of the working hours actually spent for this project by the engineer(s) in phase 3 (i.e. gE plus the not distributed portion of dT) are taken and the working hours actually spent for this project by the auxiliary staff, the duration portion of the actually distributed task. S, the skill factor related duration portion, should be – for the time being – 10% of the duration of the actually distributed task to the auxiliary staff and is assumed to be a net factor, allowing adequately for distribution efforts. Following this calculation D_{max} is the duration required for phase 3 of the development activities performed

solely by an engineer(s) in sequential mode. As the participants of this study are all proven experts these considerations related to one of the topics of this analysis, the overlapping of activities, are the results of intensive discussions in the starting and pre-test phase. Objective values out of the project records (working hours, duration, cost) are in the context of this investigation transferred into 5-point Likert scale substitutes by the experts following the procedure demonstrated by Neuert; Neuert standardised indicators such as time and cost data according to the 5-point metrication of all other parameters used in the evaluation process. This is done by relating mean values of time and cost to the lowest empirically determined values and the respective highest empirically determined values (Neuert, 2009, p. 490 sq.).

The more the auxiliary staff is integrated in the development activities of phase 3 the more compression of the respective schedules is possible by overlapping activities. If no overlapping is performed the project can benefit only very little from a skill factor. If overlapping is exercised diligently a benefit up to nearly 3 months is possible for variant development projects which are, according to Annex 1, assessed to last at the maximum 9 months (D_{max}). When the engineer in an overlapping mode has released the last, the 20th new part of the standard project, the distributable task up to the 19th part has already been done and there are only 3 further working days left for the last part (with 3 months distributable drawing portion = 60 working days divided by 20 parts = 3 working days per part). At most 3 months minus 3 days can be saved of the total 9 months required at a maximum for the development activities of phase 3; this is roughly 32% of the average phase 3 duration, provided the auxiliary staff is actually available and adequately skilled.

Ceteris paribus market maturity is achievable nearly 3 months earlier by this overlapping process with all the benefits resulting for the company, such as improved competitiveness, additional availability of specialised man power (engineers as well as managers), additional revenues, cash flow and profit etc. (e.g. Kumar & Krob, 2007, p. 279). The aspects of lost sales and lost profit are not further considered in this analysis - the field of opportunity cost - as the definition of suitable, qualified indicators for these effects is subject to other disciplines /professions, e.g. controller etc., which is outside the responsibility of the development department.

Based on the above considerations the metrication of the proposition - that the application of the model of IofAS noticeably facilitates to achieve the project target deadline - is made by comparing the actual ($D_a=D_1-D_2$) with maximum (D_{max}) project duration. The percentage ratio $(D_{max} – D_a) / D_{max}$ x 100 is taken as the indicator to measure this impact.

Y_2: The application of the model IofAS reduces the project cost. With this dimension it is

possible to do an economic productivity calculation with a comparison of input and output, income and expenses and cost benefit relations. This economic profitability and productivity measurements is operationalised through the indicator total personnel costs segregated into cost for engineers and draughters. This indicator primarily based on the project records, normally unambiguous and without measurement errors, is transferred into individual assessments by the interviewed experts. Based on the standard project (Annex 1), the development task of this project, metrication consideration are exclusively made to capture personnel cost, actual figures as well as worst case cost. The maximum personnel cost figures are calculated in a way explicitly outlined for Y_1, the project dead line and duration (maximum cost without any support = engineers and auxiliary staff actual cost and skill factor) in order to calculate only those solid cost differences strictly under control of the development department. This is the reason why total project cost are not taken into account by this review, even if, as already referred to, up to 80 % of the product cost is determined during the development process and the quality of engineering achievements at least tend to result in cost benefits by a coherent relief from auxiliary activities. The metrication of this dependent variable follows the understanding described for Y_1 and takes place with indicator questions and a suitable scale combination of Likert-, Gutmann- and Polarity-Profile-Scale, using a 1 to 5 scale (Q No. 9).

Y_3: The application of the model IofAS reduces the drawing errors. The metrication of this manifest variable, again an indicator referring to quality dimension and duration time (see skill factor), takes place with questions and a suitable scale combination of Likert-, Gutmann- and Polarity-Profile-Scale, using a 1 to 5 scale (Q No. 10).

The second dependent latent endogenous variable the socio-psychological efficiency is a decision criterion for all areas of human actions, transactions and interactions, interpersonal relationships, leisure analysing rateable variables as satisfaction and acceptance. It is dissected in the manifest variables Y_4-Y_6, “engineer’s contentment with the tasks”, “acceptance of engineers and auxiliary staff with the project progression” and “possibility of utilisation of engineer’s competences”. These indicators have to be quantified and scaled / metricated as follows:

Y_4: The application of the model IofAS increases the engineer’s contentment with the task. The metrication of the indicator Y_5 takes place with a question and suitable scale combinations of Likert-, Gutmann- and Polarity-Profile-Scale, using a 1 to 5 scale (Q No. 6). The assessment of this indicator is related to the work load of engineers and the individually

perceived stress level. The individual subjective stress level is a crucial factor, which can have far reaching economic implications for example state of exhaustion, loss of working hours due to illness and therapies etc.(e. g. Akgun et al., 2007, p. 628 sqq.).

Y_5: The application of the model IofAS increases the acceptance of the project progression. The metrication of this manifest variable, again an indicator referring to satisfaction dimensions, takes place with a question and a suitable scale combination of Likert-Gutmann- and Polarity-Profile-Scale, using a 1 to 5 scale (Q No. 7).

Y_6: The application of the model IofAS increases the instrumental use of engineer's competences, measured by the intensity of product related design. The metrication of the indicators Y_6 takes place with a question and suitable scale combinations of Likert-, Gutmann- and Polarity-Profile-Scale, using a 1 to 5 scale Q No. 11).

With Y_6 the detailed transfer of the theoretical construct into empirical measurable indicators of the independent and dependent variables of the model IofAS is completed. The next step of this research design is to discuss the way of data collection and subsequently the analysis of the data by mathematical, statistical methods.

3.3. Outline of Experimental Design

The methods of data collection can basically be divided in observation methods and interview methods, see figure 3.1. These two data collection methods can again be differentiated either in a primary data collection method that generates within an empirical study under the use of certain techniques data originally, providing information on the validity of hypotheses. Or in contrast, there is the secondary data collection method where on the basis of existing studies data are collected/examined, which open the opportunity to answer research questions or to give additional information to support or falsify hypotheses (Bortz & Döring, 2006, p. 370).

The observation methods aim to obtain impressions about behaviour, action, processes and their results by the observation of subjects within natural situations or environments and to draw conclusions out of their behaviour and actions, i.e. to generate answers for research questions (Aronson et al., 2008, p. 30; Neuert, 2009, p. 192). In a scientific context observation methods are mostly used within experiments. While in everyday language, the term "experiment" is associated with the idea "of trying something", the experiment in a scientific meaning is characterised as "repeatable observations under controlled conditions". In this process one (or more) independent variables (n) are varied in a way that a review of the underlying hypothesis (assertion of a causal link) in different situations is given; this process is joined by a measurement of dependencies between the variables with mathematical

functions which describes these dependencies (Zimmermann, 1972, p. 37). Due to this understanding the experiment seems to be the most exact form of scientific research (Friedrichs, 1980, p. 334). Generally, experiments are divided in so called laboratory experiments and field experiments.

Laboratory experiments are characterised by their artificial environment, while in field experiments the subjects, i.e. the observation objects, are more or less preserved in their natural environment.

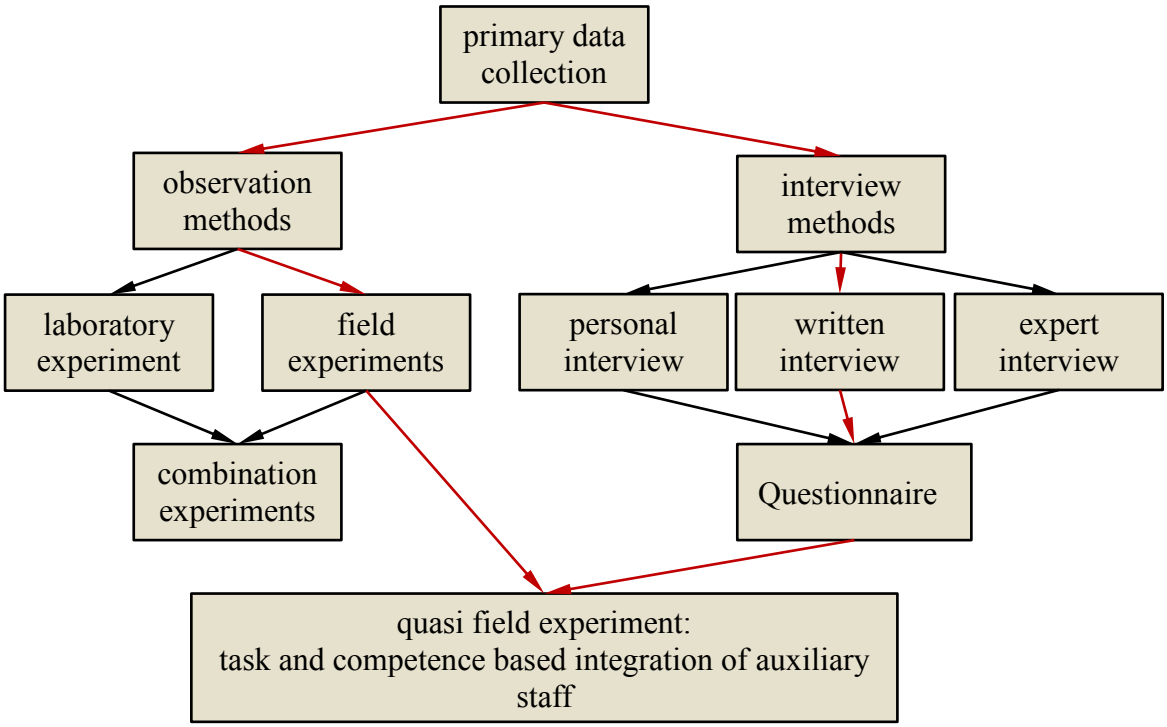


Figure 3.1 Methods of empirical data collection

Source: Neuert, 2009, p. 194

The figure 3.2 below demonstrates a classification of the most important experimental research approaches dependent on the starting situation. The approach is either confirmatory if an idea of independent and dependent variables exist, this is the case in the present research project, or is exploratory if possible dependences are to be explored - (Neuert, 2009, p. 134). Within the present research project there is a clear picture about the independent and the dependent variable. The variation of the independent variable is in the past and outside the researcher's responsibility and interference, the independent variable is chronologically before the dependent variable and the variation of the independent variable is representative. Within the classification of figure 3.2 the present research project can be determined as an ex-post facto design by questionnaires.

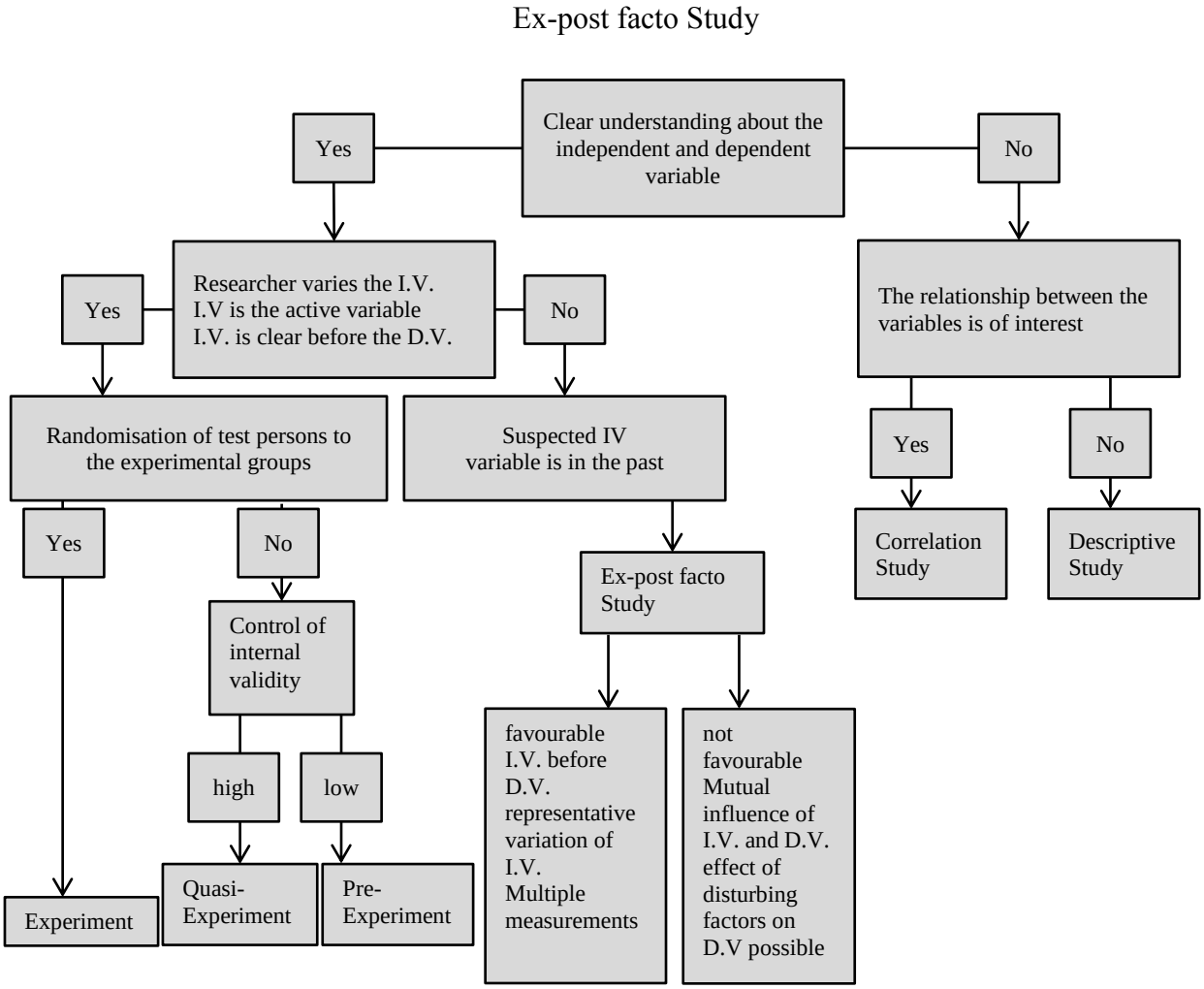


Figure 3.2: Classification of experimental research approaches

Source: Neuert, 2009, p. 134

Legend: I.V. = independent variable, D.V. = dependent variable

In a scientific laboratory experiment the researcher creates the exact desired situation in which the researcher controls some variables and some are varied. A laboratory experiment is conducted in an artificial setting, not the natural setting where participants would normally be found. Tests in artificial environments allow proceedings under controlled conditions and therefore they eliminate or control disturbing factors which could influence the dependent variable (cf. Aronson et al., 2008, p. 38 sqq.)

The laboratory experiment has to have the most possible control of all the independent variables and simultaneously exclude all disturbing influences. Furthermore, the allocation of the participants to different experimental conditions must be achieved precisely (Friedrichs, 1980, p. 339). Usually this setting is literally a laboratory in natural and behavioural sciences,

as in S. Milgram´s experiment (1974) on people´s obedience to authority. Many business and management experiments take place in classrooms, for the convenience of the experimenter and the participants, even though classrooms and students are not necessarily identical to organisations and managers. The laboratory experiment gives the most control over the participants, the experimental treatment and the experimental setting. In areas such as medicine, engineering or psychology, this setting might well be a laboratory, but it can be any other setting where there is a high degree of control. A formal laboratory setting enables to maximise the control over the experimental setting, the experimental treatment and the assignment of the participants to a particular treatment or control group. An extreme example of a laboratory experiment is a computer simulation, where the experimenter can control all aspects of the experiment, and variation in the outcome result from the application of statistical variations and rules for the behaviour out of the system that is being simulated. Even in a laboratory setting, there may be factors that are not tested but which cannot be controlled. These variations might be systemic, recurring in some fashion, or they might be extraneous, non-recurring (Aronson et al., 2008, p. 46; Bortz & Döring, 2006, pp. 57-58; Maylor & Blackmon, 2005, p. 207; Neuert, 1987, pp. 149-150; Witte et al, 1988, p. 166).

The scientific laboratory experiment is executed under artificial conditions with the exclusion of disturbing influences of the reality of life. This happens decidedly with the purpose of eliminating disturbing and distorting effects, so that only the "independent" variables in the course of the experiment effects unambiguously the dependent variables and this is what social scientist call internal validity (e.g. Aronson et. al., 2008, p. 40). Such control is only possible in an artificial environment. Significant examples of scientific laboratory experiments are found mainly in the so-called "Experimental Economics" for the execution of empirical research projects, which simulate decision-making, transaction, negotiation processes etc. in the laboratory (Held et al. 2003).

Laboratory experiments are often criticised as unrepresentative of what actually goes on in organisations. The laboratory setting can be artificial and simplified compared with organisations. The treatment may not closely represent people’s actual tasks in organisational settings. The experimental participants themselves are - unlike in the present project - often undergraduates, or business/management students, rather than representing typical organisational populations. All this means that laboratory settings are most appropriate when you are investigating basic aspects of how people behave independently of settings rather than complex social and organisational phenomena (Maylor & Blackmon, 2005, pp. 207 sq.).

An experiment that takes place in its natural setting is called a field experiment. Natural settings for business and management experiments include the workplace (office, shop,

factory or development department), the classroom, the household and public spaces such as shopping malls or public streets. As field experiments minimise the artificiality of the experimental setting on what you are studying, you generally have less control over your participants, experimental treatment and other factors than in a laboratory experiment (Maylor & Blackmon, 2005, p. 208). Field experiments can be complicated because of a high amount of disturbing variables or intervening variables and the challenge to isolate the independent and the dependent variables from these disturbing effects. On the contrary field experiments have the advantage that the subjects act in their natural environment and therefore display a more situational like behaviour or action instead of being in a rather artificial environment within a laboratory experiment. As field experiments allow subjects to remain in the natural environment they are therefore mostly characterised by high external validity, in contrast to laboratory experiments (Maylor & Blackmon, 2005, p. 207; Aronson et al., 2008, p. 46; Bortz & Döring, 2006, p. 57 sq., Neuert, 1987, p. 149 sq., Witte et al., 1988, p. 166).

Laboratory experiments are high in control but low in realism. In a field experiment, some control is traded off for a more realistic setting. In a field setting a certain degree of control over people, conditions and/or environment (Maylor & Blackmon, 2005, p. 208) can be moderated – and this is intended by concentrating the present project on a variant construction project.

The perfect experiment in social sciences would be a field experiment in a natural environment with a random sample of the population not knowing they are participating in an experiment and the possibility of eliminating or controlling disturbing factors.

This would enable a high external validity as well as a high internal validity. As it is mostly hard to fulfil all these conditions at the same time a compromise has to be made between the internal and the external validity. This is on the one side the choice of allocating a random set of people to the experiment and to gain enough control over the situation so that the results are not affected by disturbing factors and on the other side the effort to allow for a transfer of the results into everyday life. The most controlled situations are within a laboratory experiment but real life can be best captured in a field experiment. The solution to the dilemma of internal versus external validity is not in trying to include everything in one experiment. Most studies in social science decide first on internal validity and start therefore with a laboratory experiment. This allows them to select a random base for their sample of subjects and eliminate or control disturbing factors. This makes it rather easier for them to understand which effect has which cause. In some social studies, researchers try in a second step to maximise the external validity by conducting a field experiment after the laboratory experiment (Aronson et al., 2008, p. 46 sq.).

The present research can be aligned in the above presented methodology as an observation experiment in a real environment. A further classification is made by considerations about a coherent feasibility.

Quite different to the classical approach of generating scientific findings with the researcher as passive observer, particularly in recent anglo-american management theory real-scientific scientists hold the opinion that the researchers should better be actively integrated in actual problem-identification and problem-solving processes. This paper is using this way of generating scientific findings and this way cause-effect statements should be created, theories or hypotheses complexes on this basis formulated, problem-solving approaches developed and validated under real conditions. Lewin defines this approach, called action research, " ... as the application of scientific methods of facts finding and experimentation in practical problems requiring action solutions and involving the collaboration and cooperation of scientists, practitioners and laymen" (Lewin, 1953, p. 48). An essential understanding of this direction is expressed by Heron and Reason: "We believe that ordinary people are quite capable of developing their own ideas and work together in a cooperative inquiry group to see if … these ideas make sense of their world and work in practice" (Heron & Reason, 2001, p. 179).

In practical terms the performance of the analysis of the declared imbalances in MDDs is planned with a tight involvement of selected, experienced team members, proven experts in MD, in iterative processes, in processes w i t h rather than o n people (Heron & Reason, 2001, p. 179). There are detailed discussion of the existing problems, of the aberration of the cooperation in the team, - as the engineer was forced to learn how to organise his job as all-rounder and to look for support only in emergency cases -, and of the methods to be applied for the collection of reliable data and the evaluation. During these processes the model concept of the Integration of Auxiliary Staff was considered as a program to identify a set of measures for perceptible efficiency improvement. This way a methodologically sound questionnaire was developed step-by-step respecting the basic scientific requirements of a structured standardisation. Neuert calls it "standardisierter und vollstrukturierter Fragenkatalog", a questionnaire with questions based on prepared scales for the variables involved as elaborated under paragraph 3.2 (= standardisiert / standardised) and reflecting exactly the (basic hypothesis or) propositions according to paragraph 2.5.2 (=vollstrukturiert / fully structured; Neuert, 2009, p. 133 and p. 211 sq.). Thus one questionnaire is available to compile information about facts, opinions, values, behaviour, problems, solutions etc., see Annex 5. The data collection is performed after the completion of every single variant construction project using the distributed questionnaires and the related explanatory notes, see

Annex 6.

The selected action research method with the ex-post data collection by questionnaires is considered adequate for the present research project as the actual allocation of the available personal in the development department to the respective project is more or less by accident, at least not controlled by the researcher. The researcher is not in the position to influence the outcomes by intervening during the performance. In order to broadly control disturbing factors, only those development projects related to a variant construction are selected and only the executive phase of the total MD process is explicitly considered - as already stated at various stages (Annex 1). The choice of the polled experts was made by project managers without involvement of the researcher. The quality of interviews depends, amongst others, on the careful selection of the respondents in order to meet the criterion of representativity in the design of applied empirical studies. Representativity refers to the context with the given research question and to the involved persons. The analysed situation completely coincide with reality, with actual New PD projects. In addition, there is the question to what extent the applied behaviour and assessments of the probands correspond with those of people in the real world. This criterion is absolutely satisfied by the fact that the survey is related not only to real New PD projects but also to persons actually involved in reality. Therefore the representativity of this empirical study with regard to the condition structures - the environment and involved people - is given to a high degree (Neuert, 2009, p. 206 sq.). In a process of selecting respondents / experts the target of a study is to be aligned to suitable persons. The criteria are the quantity of respondents and their profession, experience, expertise etc. (Häder, 2000, p. 1, / p.3). The respondents of the presented research are selected as proven experts, able to provide general assessments of procedures, processes and organisations related to new PD and to provide professional evaluations of selected new PD projects performed with their substantial contribution. The criteria for the engineers to be selected are absolved study of engineering, professional experience over years in a mechanical development department and the ability to validate the complexity of a variant construction. For auxiliary staff the criteria are identical, apart from the education level.

3.4. Definition of the Statistical Analysis Plan

This paragraph discusses the statistical analysis plan comprising the examination of the selected indicators using statistical procedures, the combination of the answers received via questionnaires to compound values, the review of correlations between the variables, the application of the variables in the causal model, the extraction of the supportable or substantiated and negated hypotheses / propositions and the summarising of the results.

The measurement models developed under paragraph 3.2 for the latent exogenous (explanatory) variables and the latent endogenous (to be explained) variables must be tested in a mathematical causal analysis based on the collection of data received via the above described inquiry activities and others sources, e.g. development project records. The suitability of the structural equation model in terms of an empirical statistical verification of the efficiency dimensions is backed up by scientifically plausible standards (Neuert, 2009, p. 271, Weiber & Mühlhaus, 2010, p. 66).

A scientific statistical analysis plan comprises of

the calculation of distribution and position parameters and

the testing of null hypotheses,

the determination of expected functional relationships and

the examination of expected cause-effect relationships.

Statistical methods are used to quantify, to describe and to assess larger quantities of data, to draw conclusions and to make meaningful explanations possible, i.e. the methods are either of a descriptive or of an inductive, inferential nature (Neuert, 2009, p. 279). A probate measure for professional data analyses in social sciences is the software package SPSS (Weiber & Mühlhaus, 2010, p. XVIII, Neuert, 2009, p. 222), which is also used to verify this project.

Demographical basics such as the exact name of the project, exact name of the used 3D CAD program, exact name of the degree of the involved engineer(s) and auxiliary staff, age, gender, duration of employment in one or more Mechanical Development Departments up to the present, nature of the described project etc. are recorded in order to get general information of the characteristics of the project and the assessors and eventually hints or explanations for possible major deviations in specific situations.

The statistical analysis comprises the set of the (subjective) assessments of the exogenous manifest variables X_1 and X_2 and the set of the (subjective) assessments of endogenous manifest variables $Y_1 – Y_6$ of this research project by the project participants.

The underlying assumptions / working hypotheses related to the variables X_1 and X_2 are: the degree of the IofAS (draughters etc.) is subject to (X_1) the contribution of auxiliary staff to the creation of the drawing set and (X_2) the additional supporting documentation activities performed by auxiliary staff in the execution phase of variant construction projects within a 3D CAD environment.

The underlying assumptions / propositions related to the variables $Y_1 – Y_6$ deal with the question, which latent endogenous (to be explained) variables, the efficiency dimensions, are influenced by the application of the model IofAS, by the degree of integration of the auxiliary staff in the selected development projects, i.e. by the exogenous manifest variables X_1 and X_2.

The observable dimensions of the dependent variables are in this case deadlines (Y_1), cost (Y_2), drawing errors (Y_3), engineer's contentment with the task (Y_4), acceptance of the project progress (Y_5) and degree of utilisation of engineer's competences (Y_6).

In combination the two manifest exogenous variables X_1 and X_2 and the six manifest endogenous variables Y_1 – Y_6 result in a matrix of 12 individual manifestations to be examined in detail.

The proper statistical analysis starts with a homogeneity or heterogeneity review of the - subjective - assessments of the exogenous manifest variables X_1 and X_2 and the endogenous manifest variables Y_1 – Y_6 of this research project by the project participants. The ratings of "homogeneity" respective "heterogeneity" are based on the hypothetical assumption that our empirical survey is more valid and reliable, if a high density of the estimates is substantiated - and vice versa, i.e. do the indicators used measure reliable what they should measure (for validity and reliability - see paragraph 2.5.1 and 2.6.2; Voß, 2000, p. 219 sq.). The applied statistical tools for this homogeneity check are absolute and relative frequency, mean and standard deviation (Neuert, 2009, p. 288). Possible inconsistencies, which seriously challenge the validity and reliability of the empirical survey, are traced and necessary adjustment of the questionnaires is made after a preliminary analysis of the data received via a pre-test. This procedure is legitimate without losing the character of hypothesis testing provided the main review is made with new, independent data (Buch, 2007, p. 36).

The calculation of compound, total effects is made by additions of the single ratings, e.g. for X_1/X_2. This is according to Orth well targeted if a hypothesis exists concerning the interaction of a multi-dimensional property, a well arranged relation is observable and producible and the components in principle are feasible independent of one another (Orth, 1985, S. 60). These conditions are fulfilled in the present project.

In order to test to what extent the hypothesis / propositions are acceptable or must be rejected, the corresponding statistical-empirical analyses are carried out in the next step to detect any functional relationships between the indicators under review, between the manifest exogenous variables X_1 and X_2 and the manifest endogenous variables Y_1 – Y_6. The appropriate tools to get support for a presumed functional causal relationship - or not - are correlation analyses according to Bravais-Pearson or Spearman (Neuert, 2009, p. 309; Brinks, 2002, p. 41 sq.; Weiber & Mühlhaus, 2010, p. 9 sqq.). By correlation analyses the statistical relations between two sets of quantitative statistical values are analysed. The conjecture is that a change of one value can cause a change of the other observed value, e.g. ideally: value 1 (x) plus 10% results in a 10% increase or decrease of value 2 (y) and - as both variables are considered equitable - vice versa. The effect in a case like this example is very strong, 1:1, with a positive

or a negative direction. These correlations are expressed by correlation coefficients ranging from -1 to +1. A +1 coefficient stands for an absolute positive correlation, a -1 coefficient for an absolute negative correlation, a 0 coefficient for no correlation. Normally the calculation of the correlation coefficient (r) is made with statistically edited data of covariances based on standard deviations (σ – sigma) - according to Bravais-Pearson:

$$r = \sigma_{xy} / \sigma_x * \sigma_y$$

with

r = correlation coefficient

σ_x = standard deviation of x

σ_y = standard deviation of y

σ_{xy} = covariance of x and y

respectively transferred according to Spearman (Anderson, 1965, 186 sqq.; Lohninger, 2012):

$$r = 1 - 6 \sum D^2 / n(n^2-1) \qquad (= \text{Spearman's rho})$$

with

D = delta rank of pairs of items

n = number of pairs of items.

The author expects positive correlation results, knowing that positive results can not necessarily prove causality. Weber and Mühlhaus assemble the main prerequisites to be fulfilled if causality can be implied: Provided there is theoretical and/or empirical evidence, a chronological sequence and stable statistical dependences (stable statistical conjunctions also in case of controlling other variables) the assumption of causality can be supported by strong correlation coefficients (Weiber & Mühlhaus, 2010, p. 13 sq. Quatember, 2005, S. 58 sqq.; see also paragraph 2.5./2.6. - Hypotheses and Causal Model). As the available data are realisations of random variables it is impossible to call a hypothesis true or not - with absolute certainty. Therefore scientists try to control the probabilities of wrong decisions by defining minimum requirements, significance levels, to be fulfilled by a statistical data analysis. Differences between measured variables or statistical variables are considered significant (reliable) if the probability that they would come into existence by chance, that they are not based on the independent variables under review, does not exceed a certain level, normally 5% (Aronson, 2008, p. 41). In order to further improve the quality of the results of a study,

calculations of the coefficients of determination (CD) r^2, the squares of the correlation coefficient, and multiple regression analyses (MRA) are undertaken. The coefficient of determination indicates to what relative extent (weight, strength) the explanatory (i.e. independent) variable(s) exert(s) influence on the to-be-explained (i.e. dependent) variable(s) (Neuert, 2009, p.381; Weiber & Mühlhaus, 2010, p. 11, p. 181) The method of MRA is used in the empirical-statistical analysis to take account of the fact that in reality variations in the dependent variable are to be explained by several independent variables (predictors), in this study at least by the contribution of auxiliary staff to the creation of the drawing set (X_1) and

the additional supporting documentation activities performed by auxiliary staff (X_2) or possibly by even some more variables (Neuert 2009, p. 526; Weiber & Mühlhaus, 2010, p. 21) Whether the hypothesis / propositions of this research project have proven successfully or not is the subject to chapter 4.

4. RESEARCH RESULTS AND INTERPRETATION

In the first chapter the theoretical foundations were discussed. In the second chapter the analyses of existing experience was reflected and the hypothesis/propositions were formulated. These hypothesis / propositions were structured in a causal model and a coherent operationalisation was elaborated. These were the first and essential steps to verify the efficiency of the auxiliary staff integration model / theory. The scientific predicate can only be awarded if the hypotheses of an investigation have been reviewed (Wossidlo, 1970, p.68) with respect to scientific standards. The scientific standards demand for the verification of the hypotheses to confront them with empirical field data (Neuert, 2009, p. 277). According to Popper a final verification is at least impossible, but a refutation respectively a tentative substantiation of these hypotheses is possible (Popper, 2005, p.8). With a statistical support of the presented hypothesis / proposition system, based on theoretical and empirical evidence, an advantage of auxiliary staff integration - at least - in the execution phase of variant construction projects within a 3D CAD environment could be assumed; and if so, an extension of the recommended application of the model, leaving the restrictions of the field research, is to be considered.

The evaluation and interpretation of the data follows after the data collection. The interpretation and evaluation is done through statistical-mathematical methods and procedures. The field of statistics provides principles and methodologies for collecting, summarising, analysing, interpreting data in a scientific manner (Schira, 2005, p. 13). Statistical methods are used to quantify, present and assess mass phenomena. Furthermore conclusions are drawn and explanations are prepared (Voß, 2000, p. 7). In this context a distinction in descriptive statistics and inductive statistics takes place. Descriptive statistics records and presents the collected data whereas inductive statistics, applied in this dissertation, includes conclusions and evaluations of the collected data (Quatember, 2005, p.12).

Statistical methods furthermore represent uni-, bi- und multi-variant procedures. If there is only one variable to study uni-variant procedures are used to describe the mean value, standard deviation etc.. Bi-variant procedures are used to analyse two study variables for example the contentment of engineers with the task depending on the auxiliary staff integration intensity. Bi-variant procedures use a correlation analysis to define a relationship between these two variables. If more than two variables are considered multi-variant procedures are used.

For the analysis of the empirical data the following procedures are applied:

- Descriptive statistical methods to determine the location parameter and distributions like the mean value and standard deviation etc. supported by graphical and table methods.

- Correlation and significance level analyses in order to prove dependences between model parameters/variables (correlation coefficients CC-r, coefficients of determination CD-r^2, multiple regression analyses MRA etc.).

The following provides a detailed presentment of the evaluation results.

4.1. Characteristics of Interviewed Experts and Analysed Projects

A total of 130 proven experts, 65 engineers and 65 auxiliary employees, were asked to evaluate recent product development projects in the carefully restricted area with the described questionnaire - Annex 5. 130 questionnaires were evaluated in a statistical analytic procedure. The design of the study started in 2011, completion was in May 2014. 5 different industrial sectors of Mechanical Departments within different companies participated in this empirical field study. The industry sectors were automotive, satellite reception, frequency filter, mobile communication and measurement technology equipment industries. Table 4.1 summarises the characteristics of the experts and the projects. The average age of the participated engineers was 40.2 years with a proportion of 100% male. The average time of employment before being involved in this study amounted to 12 years. The engineers are seen as very experienced within their profession. The choice of the polled engineers was made by project managers - without involvement of the researcher. - taking note of the relevant criteria as the quantity of respondents, their profession, experience, expertise etc. (Häder, 2000, p. 1, / p.3). The respondents of the presented research are selected as proven experts, able to provide general assessments of procedures, processes and organisations related to new PD and to provide professional evaluations of selected new PD projects performed with their substantial contribution. By the application of this procedure a basic condition of the scientific researches, the representativity, is fully met: the selected projects are real cases and the probands, the engineers as well as the auxiliary staff, are - in reality - actually involved in these projects (for details see p. 81 / p. 97).

The average age of the participated auxiliary staff was 38.3 years with a proportion of 60% male and 40% female. The average time of employment before being involved in this study

amounted to 12.9 years. The auxiliary employees are seen as very experienced within their profession, selected under the same criteria applied for the selection of engineers.

All projects were executed using 3D CAD software systems. The dominant software was Pro Engineer, but also Solid Works and Solid Edge were applied. The nature of the described project - variant construction - was marked correct for all questionnaires. The variant construction is according to Ehrlenspiel 2007 the easiest development project and this was also confirmed by the participants upon the question describing the complexity of the project: ”How would you rate the difficulty of the project in the execution phase?” The average value for engineers was 2.45 in the execution phase within a scale of 1 to 5 describing the project complexity from very easy to very hard. The average value for auxiliary staff was 2.75 in the execution phase within a scale of 1 to 5 describing the project complexity from very easy to very hard. The auxiliary staff described the execution phase of the project as slightly more complex than the engineers. Both considered participating groups, engineers and auxiliary staff, were aware that the project complexity of the variant construction projects was low; this gave a further hint to the reliance of the probands. The delimited area was described perfectly.

Table 4.1: Demographic and project data

	Engineers	**Standard deviation of engineers**	**Auxiliary staff**	**Standard deviation of auxiliary staff**
Average age	40,2	8,54	38,3	11
Gender distribution	100% male		60% male / 40% female	
Professional experience	12,0 years	9,4	12,9 years	11
Assessment of project complexity	2,45 execution phase	0,98	2,75 execution phase	0,92

Source: own table

The probands described projects with human support for engineers in the execution phase of

variant construction projects within a 3D CAD environment.

4.2. Testing of the Hypotheses Concerning the Impact of IofAS on Economic and Socio-Psychological Efficiency Outcomes of the Projects - in the Execution Phase of Variant Construction Projects within a 3D CAD Environment -

The basic hypothesis is specified in detail by the following compound propositions (P1-P6) illustrating the observable effects on the expected outcomes (Y_1-Y_6) for each of these 6 propositions caused by the observable determination indicators (X_1, X_2). Based on the theoretical and empirical insights a cause effect relationship between the independent variable auxiliary staff integration - in the execution phase of variant construction projects within a 3D CAD environment - and economic and socio-psychological efficiency outcomes of these projects is assumed. This assumption is tested by taking auxiliary staff integration as the independent variable and economic respectively socio-psychological efficiency outcomes of these projects as the dependent variables. The procedure of hypothesis / proposition – testing starts with an analysis of the independent variables X_1/X_2, the components of the latent exogenous variable IofAS, followed by verification of each of the 6 propositions P_1 –P_6 of this research, the expected individual outcomes of the application of the proposed model of a task and competence based IofAS.

4.2.1. Statistical Data Analysis of the Determination Variables

Volume of Drawing Generation X1 and Additional Supporting Documentation Activities X2

In the proposed theory, the author states, that there is a cause effect relationship between the contribution intensity of auxiliary staff to the creation of the drawing set (X_1) respectively the additional supporting documentation activities such as creation of part lists, archiving of drawings and cooperation with the part list department and carrying out part and assembly drawing changes (X_2) and economic and socio-psychological efficiency outcomes. In a first step of the statistical test procedure the results of the determination variables are presented.

a) Determination variable X_1: Statistical Data as Frequency, Mean etc.

Figure 4.1 shows the relative answer frequency to the question related to X_1.

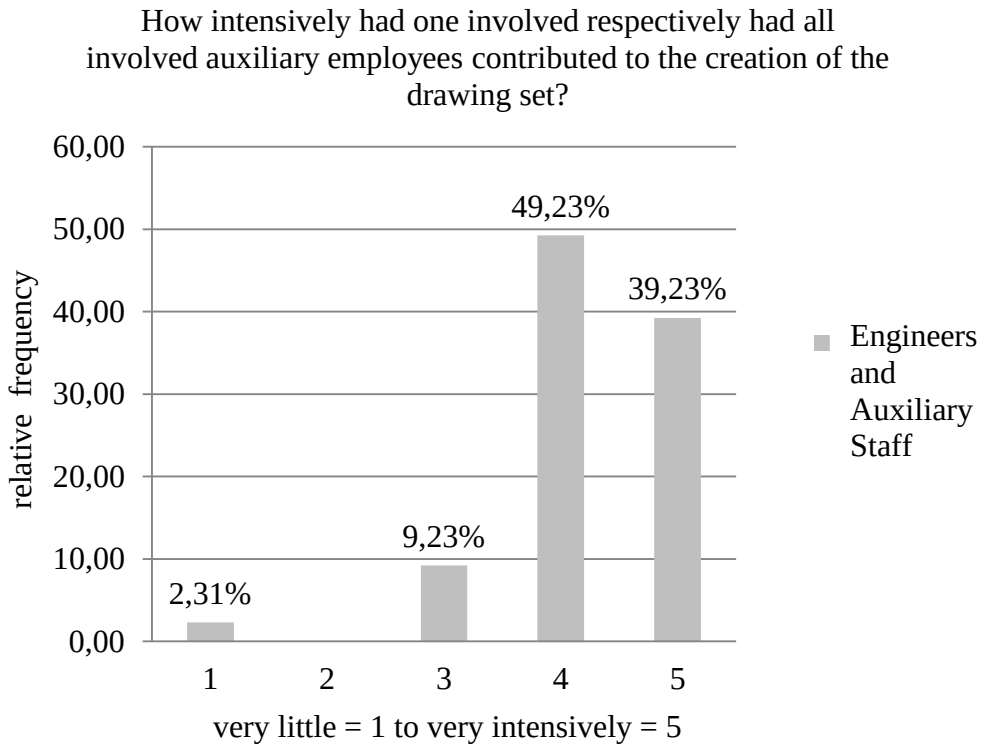


Figure 4.1: Relative answer frequencies to variable X_1

Source: own figure

The diagram shows that 2,31% of the experts responded with 1, 0% responded with 2, 9,23% responded with 3, 49,23 % responded with 4 and 39,23% responded with 5. Table 4.2 summarises these results.

Table 4.2: Frequency, percent, valid percent and cumulative percent of variable X_1

X_1	Frequency	Percent	Valid Percent	Cumulative Percent
very little	3	2,3	2,3	2,3
neutral	12	9,2	9,2	11,5
intensively	64	49,2	49,2	60,7
Very intensively	51	39,2	39,2	100,0
Total	130	100,0	100,0	

Source: own table

The mean value, the median and the standard deviation of X1 are shown in table 4.3.

Table 4.3: Mean value, median and standard deviation of variable X_1

X_1		X_1: How intensively had one involved respectively had all involved auxiliary employees contributed to the creation of the drawing set?
N	Valid	130
	Missing	0
Mean		4,2308
Median		4,0000
Std. Deviation		,80250

Source: own table

b) Determination variable X_2: Statistical Data as Frequency, Mean etc.

Figure 4.2 shows the relative answer frequencies for the first of 3 sub-responses related to the additional supporting activities X_2 (Creation of part lists, archiving of drawings and cooperation with the part list department, carrying out part and assembly drawing changes):

- Response 1 (R_1): Creation of part lists

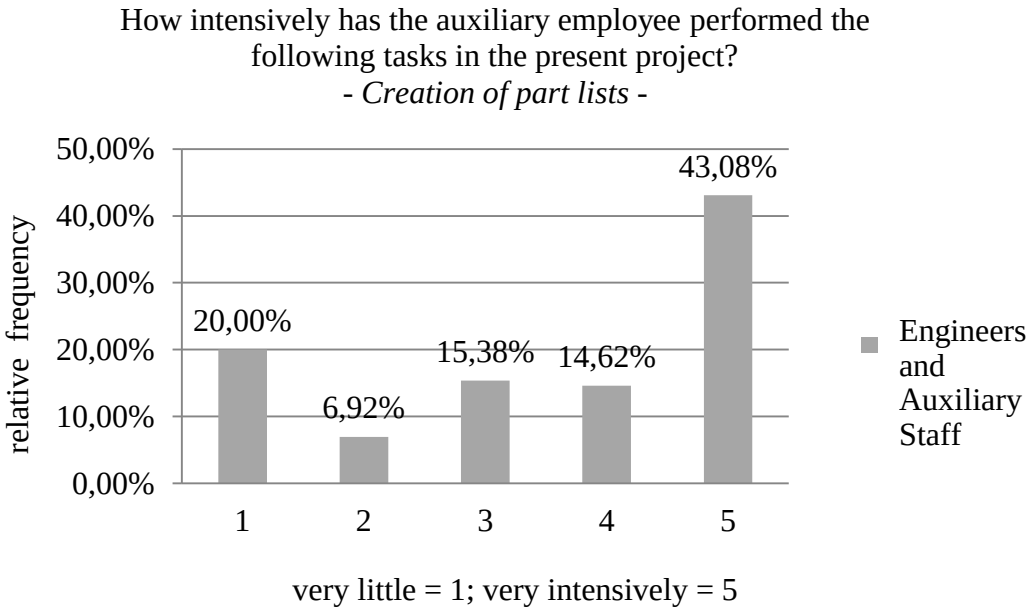


Figure 4.2: Relative answer frequencies to variable X_2/R_1

Source: own figure

The diagram shows that 20,00% of the experts responded with 1, 6,92% responded with 2, 15,38% responded with 3, 14,62% responded with 4 and 43,08% responded with 5.

Table 4.4 summarises these results.

Table 4.4: Frequency, percent, valid percent and cumulative percent of variable X_2/R_1

X_2/R_1	Frequency	Percent	Valid Percent	Cumulative Percent
very little	26	20,0	20,0	20,0
little	9	6,9	6,9	26,9
neutral	20	15,4	15,4	42,3
intensively	19	14,6	14,6	56,9
very intensively	56	43,1	43,1	100,0
Total	130	100,0	100,0	

Source: own table

The mean value and the standard deviation to X_2/R_1 (response 1) are shown in table 4.5.

Table 4.5: Mean value, median and standard deviation of variable X_2/R_1

X_2/R_1		X_2/R_1: How intensively had the auxiliary employees performed the following tasks in the present project? *- Creation of part lists -*
N	Valid	130
	Missing	0
Mean		3,5403
Median		3,0000
Std. Deviation		1,5402

Source: own table

- Response 2 (R2): Archiving of drawings and cooperation with the part list department

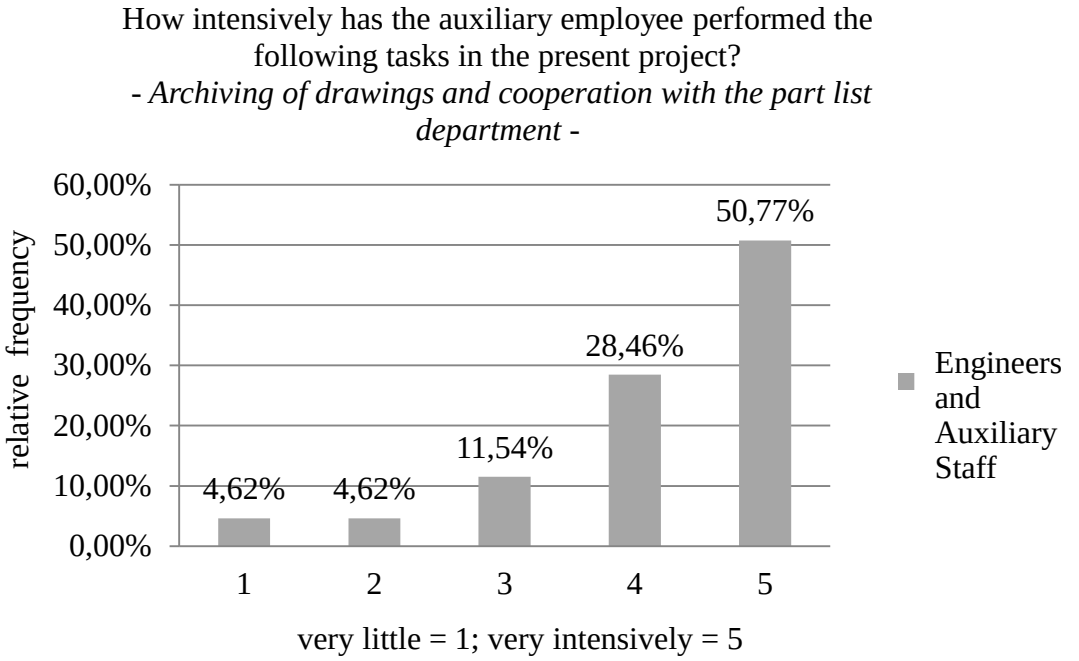


Figure 4.3: Relative answer frequencies to variable X_2/R_2
Source: own figure

The diagram shows that 4,62% of the experts responded with 1, 4,62% responded with 2, 11,54% responded with 3, 28,46% responded with 4 and 50,77% responded with 5.
The next table summarises these results.

Table 4.6: Frequency, percent, valid percent and cumulative percent of variable X_2/R_2

X_2/R_2	Frequency	Percent	Valid Percent	Cumulative Percent
very little	6	4,6	4,6	4,6
little	6	4,6	4,6	9,2
neutral	15	11,5	11,5	20,7
intensively	37	28,5	28,5	49,2
very intensively	66	50,8	50,8	100,0
Total	130	100,0	100,0	

Source: own table

The mean value, the median and the standard deviation to X_2/R_2 are shown in the next table.

Table 4.7: Mean value, median and standard deviation of variable X_2/R_2

X_2/R_2		X_2/R_2: How intensively had the auxiliary employees performed the following tasks in the present project? *- Archiving of drawings and cooperation with the part list department -*
N	Valid	130
	Missing	0
Mean		4,1603
Median		4,0000
Std. Deviation		1,1020

Source: own table

- Response 3 (R3): Carrying out part and assembly drawing changes

The diagram 4.4 shows that 3,85% of the experts responded with 1, 6,15% responded with 2, 21,54% responded with 3, 16,15% responded with 4 and 52,31% responded with 5.

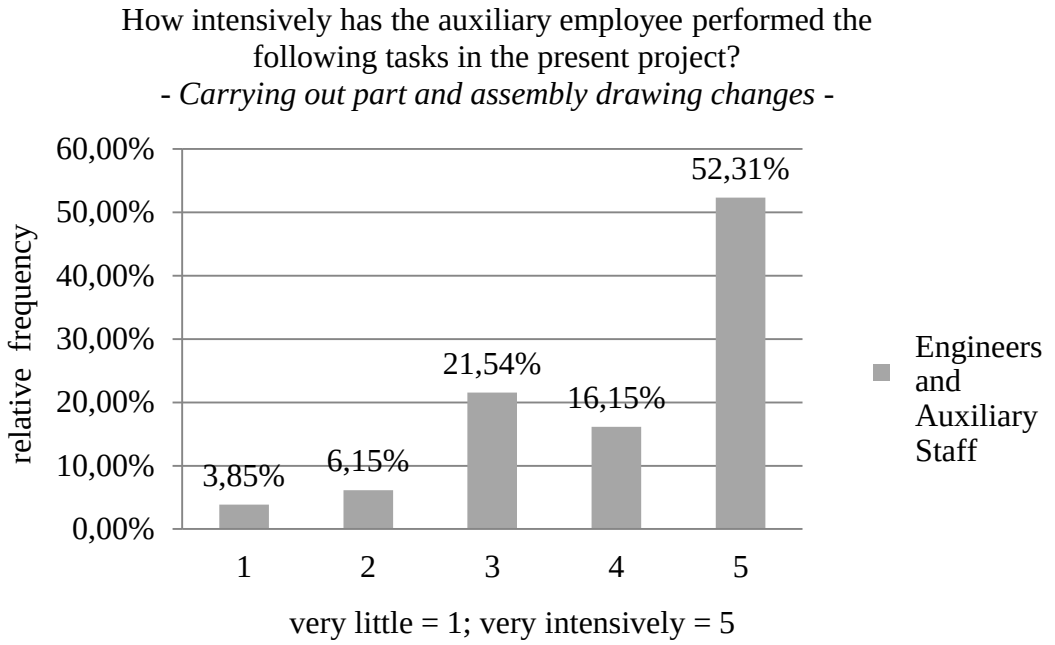


Figure 4.4: Relative answer frequencies to variable X_2/R_3

Source: own figure

The next table summarises these results.

Table 4.8: Frequency, percent, valid percent and cumulative percent of variable X_2/R_3

X_2/R_3		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	very little	5	3,9	3,9	3,9
	little	8	6,2	6,2	10,1
	neutral	28	21,5	21,5	31,6
	intensively	21	16,1	16,1	47,7
	very intensively	68	52,3	52,3	100,0
	Total	130	100,0	100,0	

Source: own table

The mean value and the standard deviation to X_2/R_3 are shown in the table 4.9.

Table 4.9: Mean value, median and standard deviation of variable X_2/R_3

X_2/R_3		X_2/R_3: How intensively had the auxiliary employees performed the following tasks in the present project? *- Carrying out part and assembly drawing changes -*
N	Valid	130
	Missing	0
Mean		4,070
Median		4,0000
Std. Deviation		1,1054

Source: own table

The next table shows the compound mean value X_2 ($(X_2/R_1 + X_2/R_2 + X_2/R_3)/3$).

Table 4.10: Compound mean value, median and standard deviation of variable X_2

X_2		X_2: How intensively had the auxiliary employees performed the following tasks in the present project? *- Creation of part lists (R_1)* *- Archiving of drawings and cooperation with the part list department (R_2)* *- Carrying out part and assembly drawing changes (R_3)*
N	Valid	130
	Missing	0
Mean		3,93
Median		3,0000
Std. Deviation		1,0701

Source: own table

To conclude this section it can be stated that the calculation of the inter-correlation of X_1 and X_2 results in a highly significant coefficient of correlation (CC)-r value of 0,46.

4.2.2. Testing Proposition 1

These analyses comprise the calculations of Mean Value, Median and Standard Deviation and the correlations of the independent variables X_1/X_2 with the individual dependent variable Y_1. The aligned proposition 1 to be verified with this research is according to paragraph 2.5.2:

P_1: The higher the degree of task and competence based IofAS, the higher the possibility of meeting the project deadlines, with

PY_1X_1: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the possibility of meeting the project deadlines and

PY_1X_2: The higher the additional supporting documentation activities, the higher the possibility of meeting the project deadlines.

a) Dependent Variable Y_1: Statistical Data as Frequency, Mean etc.

In this step the relevant results of the observable variables are presented.

Figure 4.5 shows the relative answer frequency to the question related to Y_1.

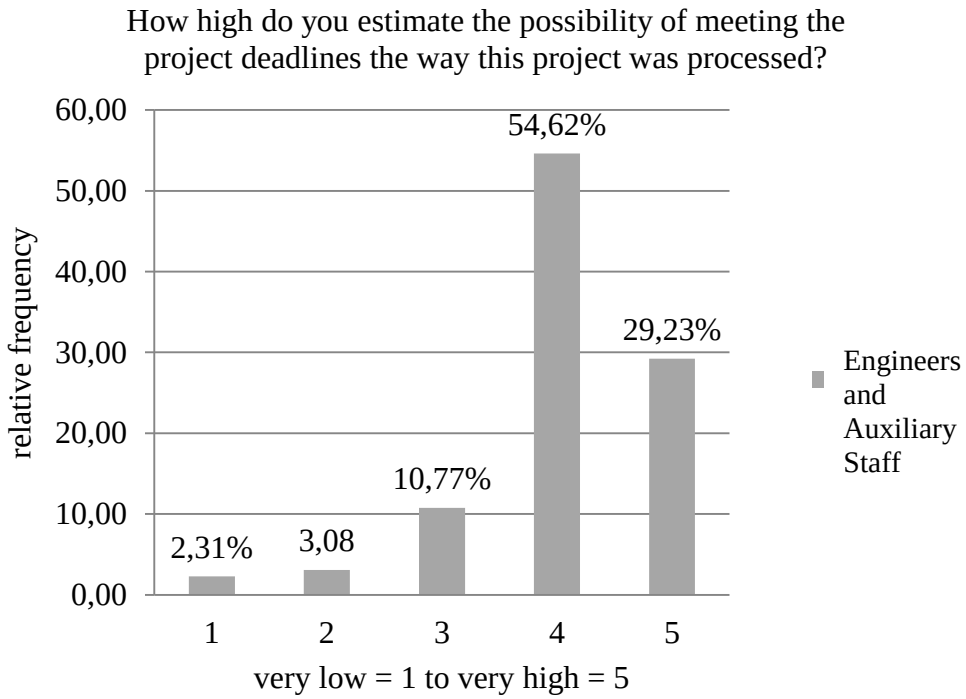


Figure 4.5: Relative answer frequencies to variable Y_1

Source: own figure

The diagram shows that 2,31% of the experts responded with 1, 3,08% responded with 2, 10,77% responded with 3, 54,62% responded with 4 and 29,23% responded with 5.

The next table summarises these results.

Table 4.11: Frequency, percent, valid percent and cumulative percent of variable Y_1

Y_1	Frequency	Percent	Valid Percent	Cumulative Percent
very low	3	2,3	2,3	2,3
low	4	3,1	3,1	5,4
neutral	14	10,8	10,8	16,2
high	71	54,6	54,6	70,8
very high	38	29,2	29,2	100,0
Total	130	100,0	100,0	

Source: own table

The mean value, the median and the standard deviation to Y_1 are shown in the next table.

Table 4.12: Mean value, median and standard deviation of variable Y_1

Y_1		Y_1 How high do you estimate the possibility of meeting the project deadlines the way this project was processed?
N	Valid	130
	Missing	0
Mean		4,0538
Median		4,0000
Std. Deviation		,85645

Source: own table

b) Correlation analyses between X_1/X_2 and Y_1

In this step the results of the correlation analysis according to Spearman between X_1/X_2 and Y_1 are presented. The next table shows the correlation coefficient (r) between X_1 and Y_1.

Table 4.13: Correlation coefficient (r) according to Spearman between X_1 and Y_1

X_1 / Y_1			X_1: How intensively had one involved respectively had all involved auxiliary employees contributed to the creation of the drawing set?	Y_1: How high do you estimate the possibility of meeting the project deadlines the way this project was processed?
Spearman's rho	X_1: How intensively had one involved respectively had all involved auxiliary employees contributed to the creation of the drawing set?	Correlation Coefficient	1,000	0,225**
		Sig. (2-tailed)	-	0,010
		N	130	130
	Y_1: How high do you estimate the possibility of meeting the project deadlines the way this project was processed?	Correlation Coefficient	0,225**	1,000
		Sig. (2-tailed)	0,010	-
		N	130	130

**. Correlation is significant at the 0.01 level (2-tailed)

Source own table

The r value of 0,225 means that the contribution intensity of auxiliary staff to the creation of the drawing set and the possibility of meeting the project deadlines correlate positively, this means that a positive correlation/relationship exists.

In this case, the proposition PY_1X_1 can tentatively be substantiated. In other words: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the possibility of meeting the project deadlines.

It must be noted that on the basis of the identified CC-r, the coefficient of determination (CD)

r^2 of $0{,}225^2 = 0{,}051$ indicates a relative weak strength of the independent variable X_1 on the dependent variable Y_1.

The next table shows the correlation coefficient (r) according to Spearman between X_2 and Y_1.

Table 4.14: Correlation coefficient (r) according to Spearman between X_2 and Y_1

X_2 / Y_1			X_2: How intensively has the auxiliary employee performed the following tasks in the present project? *- Creation of part lists - - Archive drawings and cooperate with the part list department - - Carry out part and assembly drawing changes -*	Y_1: How high do you estimate the possibility of meeting the project deadlines the way this project was processed?
Spearman's rho	X_2: How intensively has the auxiliary employee performed the following tasks in the present project?	Correlation Coefficient	1,000	0,158
		Sig. (2-tailed)	.	0,073
		N	130	130
	Y_1: How high do you estimate the possibility of meeting the project deadlines the way this project was processed?	Correlation Coefficient	0,158	1,000
		Sig. (2-tailed)	0,073	.
		N	130	130

Source: own table

The r value of 0,158 means that the additional supporting documentation activities in the execution phase of a variant construction project within a 3D CAD environment performed by auxiliary staff (*namely creation of part lists, archiving of drawings and cooperation with the*

part list department and carrying out part and assembly drawing changes) and the possibility of meeting the project deadlines do not correlate meaningful and as well as not significant. Moreover it must be noted that on the basis of the identified CC-r, the CD r^2 of $0{,}158^2$ = 0,025 indicates a relative weak strength of the independent variable X_2 on the dependent variable Y_1.

The Proposition P_1 which contains X_1 as well as X_2 must therefore be tentatively rejected.

This assessment is supported by the result received of the pertinent MRA summarised in table 4.36: $Y_1 = 2{,}562 + 0{,}377X_1 - 0{,}027X_2$ - The constant and X_1 are highly significant, but X_2 is not significant.

Result for P_1 – partially substantiated:

PY_1X_1: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the possibility of meeting the project deadlines. .

In general it can be stated that especially X_1 has a non-negligible impact on Y_1. In addition the inter-correlation of X_1 and X_2 shows a highly significant r value (0,46). This indicates that at least to a certain extent both independent variables influence the independent variable "project deadline"

4.2.3. Testing Proposition 2

These analyses comprise the calculations of Mean Value, Median and Standard Deviation and the correlations of the independent variables X_1/X_2 with the individual dependent variable Y_2.

The aligned proposition 2 is to be verified with this research in according to paragraph 2.5.2:

P_2: The higher the degree of task and competence based IofAS, the higher the possibility of reducing the project costs, with

PY_2X_1: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the possibility of reducing the project costs and

PY_2X_2: The higher the additional supporting documentation activities, the higher the possibility of reducing the project costs.

a) Dependent Variable Y_2: Statistical Data as Frequency, Mean etc.

In this step the relevant results of the observable variables are presented.

Figure 4.6 shows the relative answer frequency to the question related to Y_2.

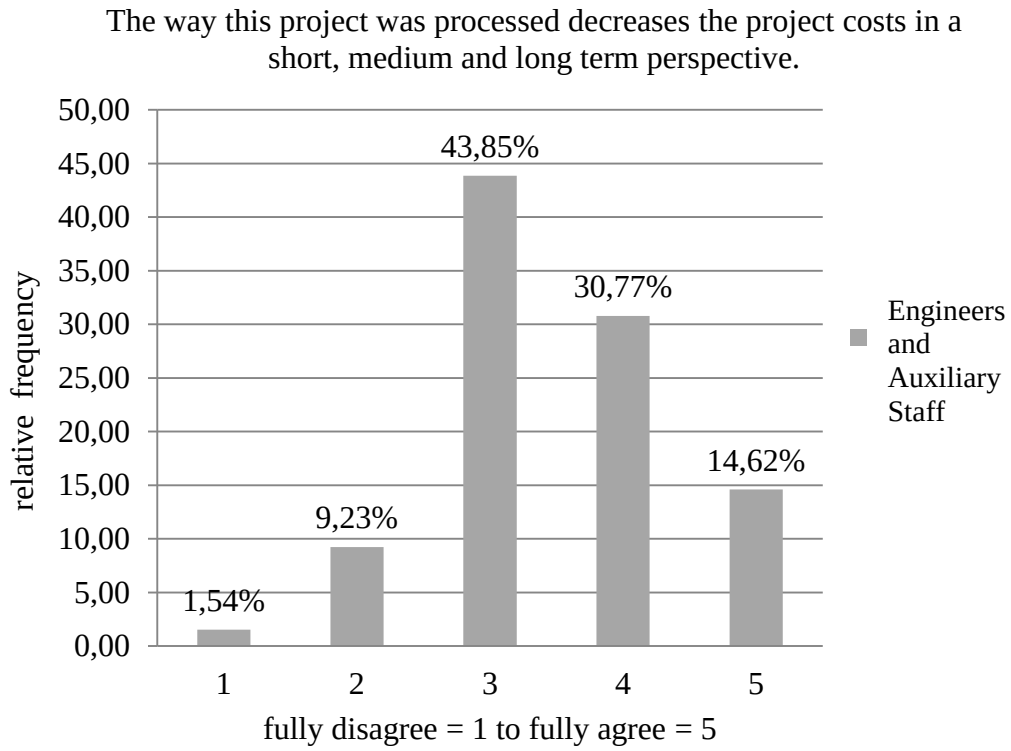


Figure 4.6: Relative answer frequencies to variable Y_2

Source: own figure

The diagram shows that 1,54% of the experts responded with 1, 9,23% responded with 2, 43,85% responded with 3, 30,77% responded with 4 and 14,62% responded with 5. The next table summarises these results.

Table 4.15: Frequency, percent, valid percent and cumulative percent of variable Y_2

Y_2	Frequency	Percent	Valid Percent	Cumulative Percent
fully disagree	2	1,5	1,5	1,5
disagree	12	9,2	9,2	10,7
neutral	57	43,9	43,9	54,6
agree	40	30,8	30,8	85,4
fully agree	19	14,6	14,6	100,0
Total	130	100,0	100,0	

Source: own table

The mean value, the median and the standard deviation to Y_2 are shown in the next table.

Table 4.16: Mean value, median and standard deviation of variable Y_2

Y_2		Y_2: The way this project was processed decreases the project costs in a short, medium and long-term perspective.
N	Valid	130
	Missing	0
Mean		3,4769
Median		3,0000
Std. Deviation		,90832

Source: own table

b) Correlation analyses between X_1/X_2 and Y_2

In this step the results of the correlation analysis according to Spearman between X_1/X_2 and Y_2 are presented. The table 4.17 shows the correlation coefficient (r) between X_1 and Y_2.

Table 4.17: Correlation coefficient (r) according to Spearman between X_1 and Y_2

X_1 / Y_2			X_1: How intensively had one involved respectively had all involved auxiliary employees contributed to the creation of the drawing set?	Y_2: The way this project was processed decreases the project costs in a short, medium and long-term perspective.
Spearman's rho	X_1: How intensively had one involved respectively had all involved auxiliary employees contributed to the creation of the drawing set?	Correlation Coefficient	1,000	0,172*
		Sig. (2-tailed)	.	0,050
		N	130	130
	Y_2: The way this project was processed decreases the project costs in a short, medium and long-term perspective.	Correlation Coefficient	0,172*	1,000
		Sig. (2-tailed)	0,050	.
		N	130	130

*. Correlation is significant at the 0.05 level (2-tailed)

Source: own table

The r value of 0,172 means that the intensity of the contribution of auxiliary staff to the creation of the drawing set and the extension to the decrease of the project costs in the way this project was processed in a short, medium and long term perspective correlate only limited positively, this means that a very slight positive correlation/relationship exists; Y_2X_1 do not correlate meaningfully but significantly. It must be noted that on the basis of the identified CC-r, the coefficient of determination (CD) r^2 of $0{,}172^2 = 0{,}030$ indicates a relative weak strength of the independent variable X_1 on the dependent variable Y_2.

The next table shows the correlation coefficient (r) according to Spearman between X_2 and Y_2.

Table 4.18: Correlation coefficient (r) according to Spearman between X_2 and Y_2

X_2 /Y_2			X_2: How intensively has the auxiliary employee performed the following tasks in the present project? - *Creation of part lists* - - *archiving of drawings and cooperation with the part list department* - - *carrying out part and assembly drawing changes* -	Y_2: The way this project was processed decreases the project costs in a short, medium and long-term perspective.
Spearman's rho	X_2: How intensively has the auxiliary employee performed the additional supporting tasks in the present project?	Correlation Coefficient	1,000	0,151
		Sig. (2-tailed)	.	0,086
		N	130	130
	Y_2: The way this project was processed decreases the project costs in a short, medium and long-term perspective.	Correlation Coefficient	0,151	1,000
		Sig. (2-tailed)	0,086	.
		N	130	130

Source: own table

The r value of 0,151 means that the additional supporting documentation activities in the execution phase of a variant construction project within a 3D CAD environment performed by auxiliary staff (*namely creation of part lists, archiving of drawings and cooperation with the part list department and carrying out part and assembly drawing changes*) and the decrease of the project costs in the way this project was processed in a short, medium and long term perspective do not correlate meaningfully as well as not significantly. It must be noted that on the basis of the identified CC-r, the CD r^2 of $0,151^2 = 0,023$ indicates a relative weak strength of the independent variable X_2 on the dependent variable Y_2.

Result for P_2 – tentatively rejected:

The Proposition P_2 which contains X_1 as well as X_2 must be tentatively rejected.

This assessment is supported by the result received of the pertinent MRA summarised in table 4.36: $Y_2 = 2,276 + 0,241X_1 + 0,046X_2$ - The constant is highly significant, X_1 is significant, but X_2 is not significant.

In general it can be stated that especially X_1 has a non-negligible impact on Y_2. In addition the inter-correlation of X_1 and X_2 shows a highly significant r value (0,46). This indicates that at least to a certain extent both independent variables influence the independent variable "project cost".

4.2.4. Testing Proposition 3

These analyses comprise the calculations of Mean Value, Median and Standard Deviation and the correlations of the independent variables X_1/X_2 with the individual dependent variable Y_3.

The aligned proposition 3 to be verified with this research is according to paragraph 2.5.2:

P_3: The higher the degree of task and competence based IofAS, the higher the possibility of reducing the drawing set errors, with

PY_3X_1: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the possibility of reducing the drawing set errors and

PY_3X_2: The higher the additional supporting documentation activities, the higher the possibility of reducing the drawing set errors.

a) Dependent Variable Y_3: Statistical Data as Frequency, Mean etc.

In this step the relevant results of the observable variables are presented.

Figure 4.7 shows the relative answer frequency to the question related to Y_3.

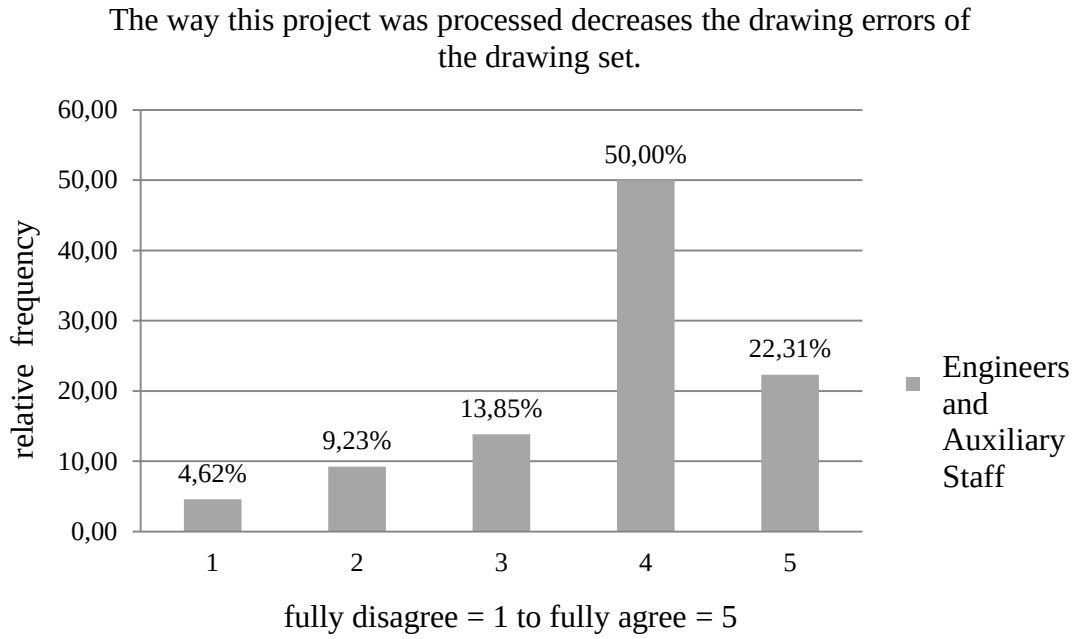


Figure 4.7: Relative answer frequencies to variable Y_3

Source: own figure

The diagram shows that 4,62% of the experts responded with 1, 9,23% responded with 2, 13,85% responded with 3, 50,00% responded with 4 and 22,31% responded with 5. The next table summarises these results.

Table 4.19: Frequency, percent, valid percent and cumulative percent of variable Y_3

Y_3		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	fully disagree	6	4,6	4,6	4,6
	disagree	12	9,2	9,2	13,8
	neutral	18	13,9	13,9	27,7
	agree	65	50,0	50,0	77,7
	fully agree	29	22,3	22,3	100,0
	Total	130	100,0	100,0	

Source: own table

The mean value, the median and the standard deviation to Y_3 are shown in the next table.

Table 4.20: Mean value, median and standard deviation of variable Y_3

Y_3		Y_3: The way this project was processed decreases the drawing errors of the drawing set
N	Valid	130
	Missing	0
Mean		3,7615
Median		4,0000
Std. Deviation		1,04773

Source: own table

b) Correlation analyses between X_1/X_2 and Y_3

Table 4.21: Correlation coefficient (r) according to Spearman between X_1 and Y_3

X_1 /Y_3			X_1: How intensively had one involved respectively had all involved auxiliary employees contributed to the crea-tion of the drawing set?	Y_3: The way this project was processed decreases the drawing errors of the drawing set
Spearman's rho	X_1: How intensively had one involved respectively had all involved auxiliary employees contributed to the creation of the drawing set?	Correlation Coefficient	1,000	0,360**
		Sig. (2-tailed)	.	0,000
		N	130	130
	Y_3: The way this project was processed decreases the drawing errors of the drawing set.	Correlation Coefficient	0,360**	1,000
		Sig. (2-tailed)	0,000	.
		N	130	130

**. Correlation is significant at the 0.01 level (2-tailed).

Source: own table

In this step the results of the correlation analysis according to Spearman between X_1/X_2 and

Y_3 are presented. Table 4.21 shows the correlation coefficient (r) between X_1 and Y_3.The r value of 0,360 means that the contribution intensity of auxiliary staff to the creation of the drawing set and the extension of the decrease of drawing errors in the drawing set the way this project was processed correlate positively, this means that a positive correlation/relationship exists. In this case the proposition PY_3X_1 can tentatively be substantiated. In other words:

PY_3X_1: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the possibility of reducing the drawing set errors. It can be noted that on the basis of the identified CC-r, the coefficient of determination (CD) r^2 of $0{,}360^2 = 0{,}130$ indicates a relative clear strength of the independent variable X_1 on the dependent variable Y_3.

The next table shows the correlation coefficient (r) according to Spearman between X_2 and Y_3.

Table 4.22: Correlation coefficient (r) according to Spearman between X_2 and Y_3

X_2 /Y_3			X_2: How intensively has the auxiliary employee performed the additional supporting tasks in the present project?	Y_3: The way this project was processed decreases the drawing errors of the drawing set.
Spearman's rho	X_2: How intensively has the auxiliary employee performed the additional supporting tasks in the present project?	Correlation Coefficient	1,000	0,170
		Sig. (2-tailed)	.	0,053
		N	130	130
	Y_3: The way this project was processed decreases the drawing errors of the drawing set	Correlation Coefficient	0,170	1,000
		Sig. (2-tailed)	0,053	.
		N	130	130

Source: own table

The r value of 0,170 means that the additional supporting documentation activities in the

execution phase of a variant construction project within a 3D CAD environment performed by auxiliary staff (*namely creation of part lists, archiving of drawings and cooperation with the part list department and carrying out part and assembly drawing changes*) and the decrease of drawing errors in the drawing set in the way this project was processed do not correlate meaningfully as well as not significantly.

The Proposition P_3 which contains X_1 as well as X_2 is only in part, for X_1, tentatively substantiated. This assessment is supported by the result received of the pertinent MRA summarised in table 4.36: $Y_3 = 2{,}029 + 0{,}458X_1 - 0{,}052X_2$ - The constant and X_1 are highly significant, but X_2 is not significant.

Result for P_3 – partially substantiated:

PY_3X_1: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the possibility of reducing the drawing set errors.

In general it can be stated that especially X_1 has a non-negligible impact on Y_3. In addition the inter-correlation of X_1 and X_2 shows a highly significant r value (0,46). This indicates that at least to a certain extent both independent variables influence the independent variable "drawing set errors". It must be noted that on the basis of the identified CC-r, the CD r^2 of $0{,}170^2 = 0{,}029$ indicates a relative weak strength of the independent variable X_2 on the dependent variable Y_3.

4.2.5. Testing Proposition 4

These analyses comprise the calculations of Mean Value, Median and Standard Deviation and the correlations of the independent variables X_1/X_2 with the individual dependent variable Y_4. The aligned proposition P_4 to be verified with this research is according to paragraph 2.5.2:

P_4: The higher the degree of task and competence based IofAS, the higher the engineer's contentment with the tasks, with

PY_4X_1: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the engineer's contentment with the tasks and

PY_4X_2: The higher the additional supporting documentation activities, the higher the engineer's contentment with the tasks.

a) Dependent Variable Y_4: Statistical Data as Frequency, Mean etc.

In this step the relevant results of the observable variables are presented.

Figure 4.8 shows the relative answer frequency to the question related to Y_4.

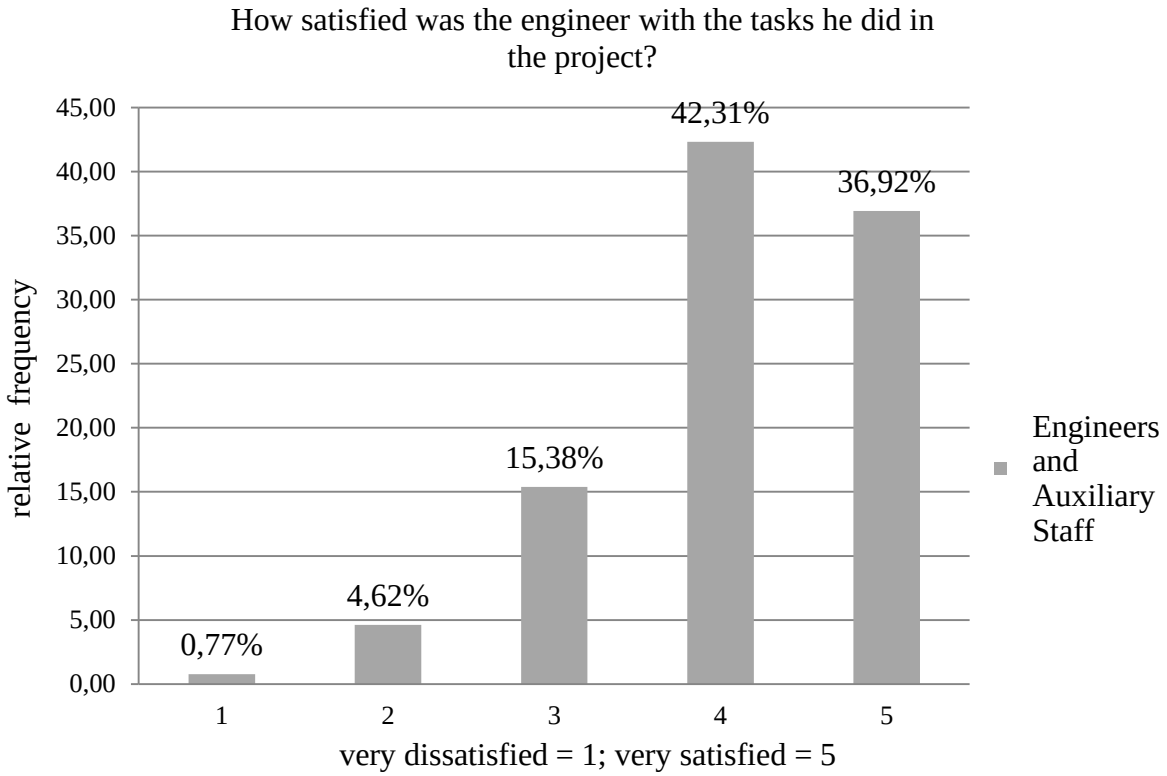


Figure 4.8: Relative answer frequencies to variable Y_4

Source: own figure

The diagram shows that 0,77% of the experts responded with 1, 4,62% responded with 2, 15,38% responded with 3, 42,31% responded with 4 and 36,92% responded with 5. The next table summarises these results.

Table 4.23: Frequency, percent, valid percent and cumulative percent of variable Y_4

Y_4	Frequency	Percent	Valid Percent	Cumulative Percent
very dissatisfied	1	0,8	0,8	0,8
dissatisfied	6	4,6	4,6	5,4
neutral	20	15,4	15,4	20,8
satisfied	55	42,3	42,3	63,1
very satisfied	48	36,9	36,9	100,0
Total	130	100,0	100,0	

Source: own table

The mean value, the median and the standard deviation to Y_4 are shown in the next table.

Table 4.24: Mean value, median and standard deviation of variable Y_4

Y_4		Y_4: How satisfied was the engineer with the tasks he did in the project?
N	Valid	130
	Missing	0
Mean		4,1000
Median		4,0000
Std. Deviation		0,87913

Source: own table

b) Correlation analyses between X_1/X_2 and Y_4

In this step the results of the correlation analysis according to Spearman between X_1/X_2 and Y_4 are presented. The next table shows the correlation coefficient (r) between X_1 and Y_4.

Table 4.25: Correlation coefficient (r) according to Spearman between X_1 and Y_4

X_1/ Y_4			X_1: How intensively had one involved respectively had all involved auxiliary employees contributed to the creation of the drawing set?	Y_4: How satisfied was the engineer with the tasks he did in the project?
Spearman's rho	X_1: How intensively had one involved respectively had all involved auxiliary employees contributed to the creation of the drawing set?	Correlation Coefficient	1,000	0,326**
		Sig. (2-tailed)	.	0,000
		N	130	130
	Y_4: How satisfied was the engineer with the tasks he did in the project?	Correlation Coefficient	0,326**	1,000
		Sig. (2-tailed)	0,000	.
		N	130	130

** Correlation is significant at the 0.01 level (2-tailed)

Source: own table

The r value of 0,326 means that the contribution intensity of auxiliary staff to the creation of the drawing set and the engineer's contentment with his tasks correlates positively, this means

that positive correlation/relationship exists. In this case, the proposition PY_4X_1 can tentatively be substantiated. In other words:

PY_4X_1: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the engineer's contentment with the tasks. It can be noted that on the basis of the identified CC-r, the coefficient of determination (CD) r^2 of $0{,}326^2 = 0{,}106$ indicates a relative clear strength of the independent variable X_1 on the dependent variable Y_4.

The next table shows the correlation coefficient (r) according to Spearman between X_2 and Y_4.

Table 4.26: Correlation coefficient (r) according to Spearman between X_2 and Y_4

X_2 / Y_4			X_2: How intensively has the auxiliary employee performed the additional supporting tasks in the present project?	Y_4: How satisfied was the engineer with the tasks he did in the project?
Spearman's rho	X_2: How intensively has the auxiliary employee performed the additional supporting tasks in the present project?	Correlation Coefficient	1,000	0,349**
		Sig. (2-tailed)	.	0,000
		N	130	130
	Y_4: How satisfied was the engineer with the tasks he did in the project?	Correlation Coefficient	0,349**	1,000
		Sig. (2-tailed)	0,000	.
		N	130	130

Source: own table

The r value of 0,349 means that the additional supporting documentation activities in the execution phase of a variant construction project within a 3D CAD environment performed by auxiliary staff (*namely creation of part lists, archiving of drawings and cooperation with the part list department and carrying out part and assembly drawing changes*) and the engineer's contentment with his tasks correlates positively; this means that a positive correlation/relationship exists. It can be noted that on the basis of the identified CC-r, the CD r^2 of $0{,}349^2 = 0{,}122$ indicates a relative clear strength of the independent variable X_2 on the dependent variable Y_4. In this case, the proposition PY_4X_2 can tentatively be substantiated.

The Proposition P_4 which contains X_1 as well as X_2 is tentatively substantiated. This assessment is supported by the result received of the pertinent MRA summarised in table

4.36: $Y_4 = 2{,}165 + 0{,}322X_1 + 0{,}146X_2$ - The constant and X_1 are highly significant, X_2 only limited.

Result for P_4 – tentatively substantiated:

P_4: The higher the degree of task and competence based IofAS, the higher the engineer's contentment with the tasks, with

PY_4X_1: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the engineer's contentment with the tasks and

PY_4X_2: The higher the additional supporting documentation activities, the higher the engineer's contentment with the tasks.

In general it can be stated that X_1 and X_2 have non-negligible impact on Y_4. In addition the inter-correlation of X_1 and X_2 shows a highly significant r value (0,46). This indicates that to a clear extent both independent variables influence the independent variable "engineer's contentment with the task".

4.2.6. Testing Proposition 5

These analyses comprise the calculations of Mean Value, Median and Standard Deviation and the correlations of the independent variables X_1/X_2 with the individual dependent variable Y_5. The aligned proposition 5 to be verified with this research is according to paragraph 2.5.2:

P_5: The higher the degree of task and competence based IofAS, the higher the acceptance of engineers and auxiliary staff with the project progression, with

PY_5X_1: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the acceptance of engineers and auxiliary staff with the project progression and

PY_5X_2: The higher the additional supporting documentation activities, the higher the acceptance of engineers and auxiliary staff with the project progression.

a) Dependent Variable Y_5: Statistical Data as Frequency, Mean etc.

In this step the relevant results of the observable variables are presented.

The next diagram shows the relative answer frequency to the question related to Y_5.

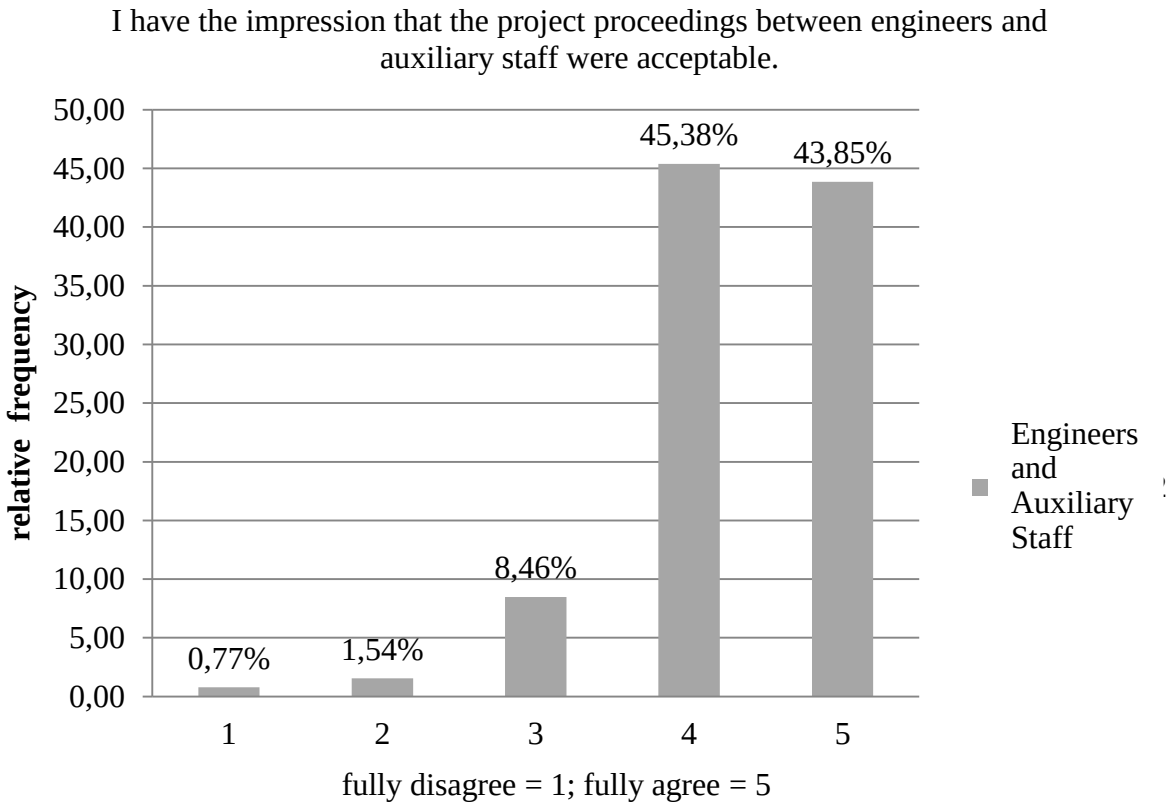


Figure 4.9: Relative answer frequencies to variable Y_5

Source: own figure

The diagram shows that 0,77% of the experts responded with 1, 1,54% responded with 2, 8,46% responded with 3, 45,38% responded with 4 and 43,85% responded with 5. The next table summarises these results.

Table 4.27: Frequency, percent, valid percent and cumulative percent of variable Y_5

Y_5	Frequency	Percent	Valid Percent	Cumulative Percent
fully disagree	1	0,8	0,8	0,8
disagree	2	1,5	1,5	2,3
neutral	11	8,5	8,5	10,8
agree	59	45,4	45,4	56,2
fully agree	57	43,8	43,8	100,0
Total	130	100,0	100,0	

Source: own table

The mean value, the median and the standard deviation to Y_5 are shown in the next table.

Table 4.28: Mean value, median and standard deviation of variable Y_5

Y_5		Y_5: I have the impression that the project proceedings between engineers and auxiliary staff were acceptable.
N	Valid	130
	Missing	0
Mean		4,3000
Median		4,0000
Std. Deviation		0,75380

Source: own table

b) Correlation analyses between X_1/X_2 and Y_5

In this step the results of the correlation analysis according to Spearman between X1/X2 and Y_5 are presented. The next table shows the correlation coefficient (r) between X_1 and Y_5.

Table 4.29: Correlation coefficient (r) according to Spearman between X_1 and Y_5

X_1 / Y_5			X_1: How intensively had one involved respectively had all involved auxiliary employees contributed to the creation of the drawing set?	Y_5: I have the impression that the project proceedings between engineers and auxiliary staff were acceptable
Spearman's rho	X_1: How intensively had one involved respectively had all involved auxiliary employees contributed to the creation of the drawing set?	Correlation Coefficient	1,000	0,128
		Sig. (2-tailed)	.	0,146
		N	130	130
	Y_5 I have the impression that the project proceedings between engineers and auxiliary staff were acceptable	Correlation Coefficient	0,128	1,000
		Sig. (2-tailed)	0,146	.
		N	130	130

Source: own table

The r value of 0,128 means that the contribution intensity of auxiliary staff to the creation of the drawing set and the acceptance to the project proceeding between engineers and auxiliary staff do not correlate meaningfully as well as not significantly. It must be noted that on the basis of the identified CC-r, the coefficient of determination (CD) r^2 of $0{,}128^2 = 0{,}016$ indicates a relative weak strength of the independent variable X_1 on the dependent variable Y_5.

The next table shows the correlation coefficient (r) according to Spearman between X_2 and Y_5.

Table 4.30: Correlation coefficient (r) according to Spearman between X_2 and Y_5

X_2 / Y_5			X_2: How intensively has the auxiliary employee performed the additional supporting tasks in the present project?	Y_5: I have the impression that the project proceedings between engineers and auxiliary staff were acceptable.
Spearman's rho	X_2: How intensively has the auxiliary employee performed the additional supporting tasks in the present project?	Correlation Coefficient	1,000	0,131
		Sig. (2-tailed)	.	0,138
		N	130	130
	Y_6: I have the impression that the project proceedings between engineers and auxiliary staff were acceptable	Correlation Coefficient	0,131	1,000
		Sig. (2-tailed)	0,138	.
		N	130	130

Source: own table

The r value of 0,131 means that the additional supporting documentation activities in the execution phase of a variant construction project within a 3D CAD environment performed by auxiliary staff (*namely creation of part lists, archiving of drawings and cooperation with the part list department and carrying out part and assembly drawing changes*) and the acceptance to the project proceeding between engineers and auxiliary staff do not correlate meaningfully as well as not significantly. This assessment is supported by the result received of the pertinent MRA summarised in table 4.36: $Y_5 = 3{,}118 + 0{,}297X_1 - 0{,}019X_2$ - The constant and

X_1 are highly significant, but X_2 is not significant. It must be noted that on the basis of the identified CC-r, the CD r^2 of $0{,}131^2 = 0{,}017$ indicates a relative weak strength of the independent variable X_2 on the dependent variable Y_5.

Result for P_5 – tentatively rejected:

The Proposition P_5 which contains X_1 as well as X_2 must tentatively be rejected.

4.2.7. Testing Proposition 6

These analyses comprise the calculations of Mean Value, Median and Standard Deviation and the correlations of the independent variables X_1/X_2 with the individual dependent variable Y_6. The aligned proposition 6 to be verified with this research is according to paragraph 2.5.2:

P_6: The higher the degree of task and competence based IofAS, the higher the possibility of utilisation of engineer's competences, with

PY_6X_1: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the possibility of utilisation of engineer's competences and

PY_6X_2: The higher the additional supporting documentation activities, the higher the possibility of utilisation of engineer's competences.

a) Dependent Variable Y_6: Statistical Data as Frequency, Mean etc.

In this step the relevant results of the observable variables are presented.

Figure 4.10 shows the relative answer frequency to the question related to Y_6.

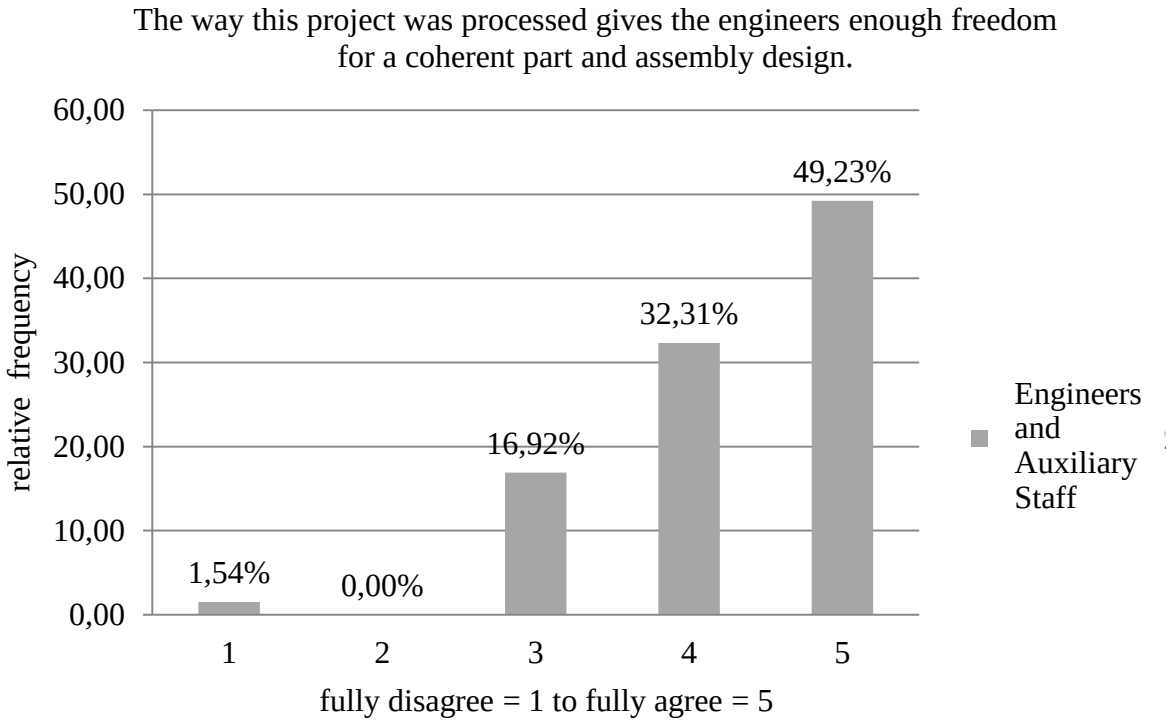


Figure 4.10: Relative answer frequencies to variable Y_6

Source: own figure

The diagram shows that 1,54% of the experts responded with 1, 0,00% responded with 2, 16,92% responded with 3, 32,31% responded with 4 and 49,23% responded with 5.

The next table summarises these results.

Table 4.31: Frequency, percent, valid percent and cumulative percent of variable Y_6

Y_6		Frequency	Percent	Valid Percent	Cumulative Percent
	fully disagree	2	1,6	1,6	1,6
	Neutral	22	16,9	16,9	18,5
	agree	42	32,3	32,3	50,8
	fully agree	64	49,2	49,2	100,0
	Total	130	100,0	100,0	

Source: own table

The mean value, the median and the standard deviation to Y_6 are shown in the next table.

Table 4.32: Mean value, median and standard deviation of variable Y_6

Y_6		Y_6: The way this project was processed gives the engineers enough freedom for a coherent part and assembly design
N	Valid	130
	Missing	0
Mean		4,2769
Median		4,0000
Std. Deviation		0,85377

Source: own table

b) Correlation analyses between X_1/X_2 and Y_6

In this step the results of the correlation analysis according to Spearman between X_1/X_2 and Y_6 are presented.

The next table shows the correlation coefficient (r) between X_1 and Y_6.

Table 4.33: Correlation coefficient (r) according to Spearman between X_1 and Y_6

X_1 / Y_6			X_1: How intensively had one involved respectively had all involved auxiliary employees contributed to the creation of the drawing set?	Y_6: The way this project was processed gives the engineers enough freedom for a coherent part and assembly design.
Spearman's rho	X_1 How intensively had one involved respectively had all involved auxiliary employees contributed to the creation of the drawing set?	Correlation Coefficient	1,000	0,357**
		Sig. (2-tailed)	.	0,000
		N	130	130
	Y_6 The way this project was processed gives the engineers enough freedom for a coherent part and assembly design	Correlation Coefficient	0,357**	1,000
		Sig. (2-tailed)	0,000	.
		N	130	130

**. Correlation is significant at the 0.01 level (2-tailed).

Source: own table

The r value of 0,357 means that the contribution intensity of auxiliary staff to the creation of the drawing set and the engineer's freedom for a coherent part and assembly design correlates positively, this means that positive correlation/relationship exists. It can be noted that on the basis of the identified CC-r, the coefficient of determination (CD) r^2 of $0,357^2 = 0,127$ indicates a clear strength of the independent variable X_1 on the dependent variable Y_6. In this

case, the proposition PY_6X_1 can tentatively be substantiated. In other words:

PY_6X_1: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the engineer´s freedom for a coherent part and assembly design.

The next table shows the correlation coefficient (r) according to Spearman between X_2 and Y_6

Table 4.34: Correlation coefficient (r) according to Spearman between X_2 and Y_6

X_2 / Y_6			X_2: How intensively has the auxiliary employee performed the additional supporting tasks in the present project?	Y_6: The was this project was processed gives the engineers enough freedom for a coherent part and assembly design
Spearman's rho	X_2 How intensively has the auxiliary employee performed the additional supporting tasks in the present project?	Correlation Coefficient	1,000	0,143
		Sig. (2-tailed)	.	0,105
		N	130	130
	Y_6 The way this project was processed gives the engineers enough freedom for a coherent part and assembly design	Correlation Coefficient	0,143	1,000
		Sig. (2-tailed)	0,105	.
		N	130	130

Source: own table

The r value of 0,143 means that the additional supporting documentation activities in the execution phase of a variant construction project within a 3D CAD environment performed by auxiliary staff (*namely creation of part lists, archiving of drawings and cooperation with the part list department and carrying out part and assembly drawing changes*) and the engineer´s freedom for a coherent part and assembly design do not correlate meaningfully as well as not significantly. It must be noted that on the basis of the identified CC-r, the CD r^2 of $0{,}143^2$ = 0,020 indicates a relative weak strength of the independent variable X_2 on the dependent variable Y_6.

The Proposition P_6 which contains X_1 as well as X_2 is only in part, for X_1, tentatively

substantiated. This assessment is supported by the result received of the pertinent MRA summarised in table 4.36: $Y_6 = 2{,}356 + 0{,}499X_1 - 0{,}048X_2$ - The constant and X_1 are highly significant, but X_2 is not significant.

Result for P_6 – partially substantiated:

PY_6X_1: The higher the contribution of auxiliary staff to the creation of the drawing set, the higher the freedom for engineers for a coherent part and assembly design.

In general it can be stated that especially X_1 has a non-negligible impact on Y_6. In addition the inter-correlation of X_1 and X_2 shows a highly significant r value (0,46). This indicates that at least to a certain extent both independent variables influence the independent variable "instrumental use of engineer's competences".

4.3. Main Findings

The basic hypothesis is specified in detail by the compound propositions (P_1-P_6) illustrating the observable effects of the expected project outcomes (Y_1-Y_6) for each of these 6 propositions caused by the observable determination indicators (X_1, X_2). Based on the theoretical and empirical insights a cause-effect relationship between the independent variable AS integration - in the execution phase of variant construction projects within a 3D CAD environment - and economic and socio-psychological efficiency outcomes of these projects is assumed. Table 4.35 summarises the results of the correlation coefficients (CC, CD) respectively the significance levels (Sig.) between $X_{1/2}$ and $Y_{1\,-\,6}$ (P_1-P_6), followed by table 4.36 representing the results of the multiple regression analyses (MRA) indicating the respective constants, the regression coefficients (RC) and the significance levels.

Table 4.35: Correlation coefficient(CC r) and coefficient of determination (CD r^2)

			X_1	X_2	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6
Spearman-Rho	X_1	CC- r	1,000	0,460**	0,225**	0,172*	0,360**	0,326**	0,128	0,357**
		CD – r^2			0,050		0,130	0,106		0,127
		Sig. (two-tailed)		-	0,010	0,050	0,000	0,000	0,146	0,000
		N	130	-	130	130	130	130	130	130
	X_2	CC- r	0,460**	1,000	0,158	0,151	0,170	0,349**	0,131	0,143
		CD – r^2						0,122		
		Sig. (two-tailed)	-		0,073	0,086	0,053	0,000	0,138	0,105
		N	-	130	130	130	130	130	130	130

** The correlation is at the 0,01 level significant (two tailed)
* The correlation is at the 0,05 level significant (two tailed)
Source: own table

Table 4.36: Multiple regression analyses (MRA)

Value	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6
Constant (Intercept)	2,562	2,276	2,029	2,165	3,118	2,356
Sig.	0,000	0,000	0,000	0,000	0,000	0,000
RC - X_1	0,377	0,241	0,458	0,322	0,297	0,499
Sig.	0,000	0,021	0,000	0,001	0,001	0,000
RC - X_2	-0,027	0,046	-0,052	0,146	-0,019	-0,048
Sig.	0,698	0,543	0,537	0,036	0,756	0,460

Example to read: $Y_1 = 2,562+0,377X_1-0,027X_2$
Source: own table

Based on correlation analysis according to Spearman and a significance level test of the manifest measurement of the latent exogenous variable volume of drawing generation (X_1), the indicator for the independent variable IofAS and the manifest measurement of the latent endogenous variables meeting of **project deadlines** (Y_1) and **drawing set errors** (Y_3), the

indicators for the dependent variable economic efficiency

the empirical data do provide essential results to tentatively substantiate the propositions PY_1X_1 and PY_3X_1.

The empirical results of Krishnan et al. (1997- see paragraph 2.3) support these propositions. Time and errors can be reduced by coherent project proceedings taking the characteristics of the overlapped tasks into account. The overlapping pairs of activities in the author's study are coherent part and assembly design in a variant construction project and part and assembly documentation, meaning, upstream tasks with fast evolution characteristics and downstream tasks with low sensitivity characteristics. According to the study of Krishnan this situation is most favourable for successful overlapping activities. This case of overlapping, the Distributive Overlapping, discussed under paragraph 1.4./2.3..and characterised by a fast upstream evolution and a low downstream sensitivity is typically for adjustment and variant construction; this constellation allows for a start of downstream activity with preliminary information (no need for freezing too early) and continue with the onward progress of the New PD process with in advance finalised upstream information, because large changes in the upstream process happen early and finalised information - before the end of the upstream activity - do not lead to huge quality losses in the upstream process. The low sensitivity means, that large changes in the magnitude of the upstream information exchange do not entail large iteration loops. This constellation is according to the study of Krishnan et al. most favourable for successful overlapping activities. Both activities, the upstream and the downstream, contribute to a time and quality efficient overlapping process, the involvement is distributive.

Based on the correlation analysis according to Spearman and a significance level test of the manifest measurement of the latent exogenous variable volume of drawing generation (X_1) respectively the additional supporting documentation activities (X_2), namely creation of part lists, archiving of drawings and cooperation with the part list department and carrying out part and assembly drawing changes, the indicators for the independent variable IofAS and the manifest measurement of the latent endogenous variable reduction of **project costs** (Y_2), the indicator for the dependent variable economic efficiency

the empirical data do not provide essential results to substantiate the proposition P_2.

Contradictive to the theory of Weltz & Bollinger who call for a task and job based specialisation, contradictive to Kühn who noted a rising integration of tasks by specialised

experts, of tasks, which could easily been done by people with a lower level of expertise and contradictive to Mayer who already demands in the year 1988 a cooperative division of labour with a specialised expert at the centre. Vertical division of labour proves itself as coherent as it does not lead to uneconomic cost inefficient use of (high) qualifications. Wittenstein (2007, p. 98) substantiates this demand with what she calls “Sinnvoll verteilbare Arbeitseinheit”, practically distributable task unit”. One of the essential influencing variables for a practicable distribution, one of the k.o.-criteria, is the ratio of effort of time for distribution of a work unit vs. the temporal scope of effort, of the work unit to be distributed; the smaller the ratio is, the better is the suitability for distribution (Wittenstein, 2007, p. 136). This empirical study is focused on the impact of auxiliary staff integration basically for documentation purposes on economic and socio-psychological efficiency of the execution phase of variant construction projects within a 3D CAD environment; however, by no means the author queries that other factors have an impact on economic efficiency of variant construction projects (e.g. training and education of auxiliary staff, communication skills of engineers etc.). Recalling the evidence as well as the experiences triggering this research, the fact, that time is the dominate challenge of New PD processes, deadlines and quality are obviously overruling the cost considerations of the participants in the nucleus of New PD. As the cost effects seem to be remarkable from the commercial point of view, the author is of the opinion that a more comprehensive investigation of the indicator “reduction of project costs” requires an extension of the circle of respondents for example to the controller and management level.

In respect of the socio-psychological efficiency in the execution phase of variant construction projects the correlation analysis according to Spearman and a significance level test of the manifest measurement of the latent exogenous variable volume of drawing generation (X_1) respectively the additional supporting documentation activities (X_2), namely creation of part lists, archiving of drawings and cooperation with the part list department and carrying out part and assembly drawing changes, the indicators for the independent variable IofAS and the manifest measurement of the latent endogenous variables **engineer´s contentment with the task** (Y_4), the indicator for the dependent variable socio-economic efficiency

the empirical data do provide essential results to tentatively substantiate the complete proposition P_4. Empirical hints indicate that work / task satisfaction is stronger established through intrinsic motifs, for example, achievement, recognition, work / task itself, responsibility, advancement and growth. The accent on task satisfaction is justified and confirmed, because (job) satisfaction is strongest through the work / task itself (Ironson et al., 1989, p. 193 sqq.; Kappagoda, 2012, p. 23 sqq.) and therefore this intrinsic aspect seems to be the most important one. These empirical results support the proposition P_4. In this context

Ulich talks of the primacy of the task (Ulich, 2001, p. 197 sqq. “Vom Primat der Aufgabe”).

Based on correlation analysis according to Spearman and a significance level test of the manifest measurement of the latent exogenous variable volume of drawing generation ($X_{1)}$, the indicator for independent variable IofAS and the manifest measurement latent endogenous variable **instrumental use of engineer’s competences** (Y_6), the indicator for the dependent variables socio-psychological efficiency

> the empirical data do provide essential results to tentatively substantiate the proposition PY_6X_1.

The theory of Weltz & Bollinger (1987) who call for a task and job based specialisation, the cognition of Kühn et al. (2006) who noted a rising integration of tasks by specialised experts, of tasks, which could easily been done by people with a lower level of expertise and the theory of Mayer who already demands in the year 1988 a cooperative division of labour with a specialised expert in the centre support strongly this result. Vertical division of labour proves itself so long as coherent as it does not lead to uneconomic use of (high) qualification (Mayer, 1988, p. 80 sqq.) and this situation is reflected in the old model of software driven job enrichment by transferring documentation tasks back into the task portfolio of engineers. With the new model of task and competence based IofAS the engineer is in the position to focus on his most crucial task and this is the design of new components and products in time.
The denoted coefficients of determination (r^2) in paragraph 4.2 indicate the weight, the strength of the independent variables influencing the dependent variables; they range from 5% for X_1Y_1 to 13% for X_1Y_3 respectively from 11 to 12% for $X_{1/2}Y_4$. These results suggest that a strong influence on the dependent variables is achieved by additional impact factors so far not represented in the model. However the results are highly significant. This is also identifiable from the results of the multiple regression analyses summarised in table 4.36. For example within the function $Y_1 = 2{,}562+0{,}377X_1-0{,}027X_2$ the constant and X_1 are highly significant, but X_2 is not significant.and it can be stated that especially X_1 has a non-negligible impact on Y_1, the dependent variable “project deadline”. In addition the inter-correlation of X_1 and X_2 shows a highly significant CC-r value of 0,46. This indicates that at least to a certain extent both independent variables influence the dependent variables.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusion

The results of the empirical and theoretical findings combined with the research results and theoretical interpretations lead to the following conclusions in respect of the basic hypothesis and the related propositions:

Overall, the basic hypothesis, the higher the degree of task and competence based IofAS, the higher the economic and socio-psychological efficiency of project outcomes, is tentatively supported, particular as far as the dominant criteria time (Y_1) and quality of New PD (Y_3) and, in consequence, engineers' contentment (Y_4) plus the instrumental use of engineers' competences (Y_6) are concerned. In detail the related propositions resulted in:

1. There are significant correlations between the contribution intensity of AS to the creation of the drawing set and the meeting of project deadlines (Correlation Coefficient CC X_1/Y_1=0,225) and the reduction of drawing set errors (CC X_1/Y_3=0,360), the economic efficiency dimensions in the carefully restricted area. This indicates that there is a function between AS integration measured by the contribution to the creation of the drawing set and the economic efficiency project outcomes in the demarcated area; this was analogously also confirmed by Krishnan et al. (1997), Bogus, (2004), Dahlin et al. (2005), Wittenstein (2007), Haon et al. (2009) and Marujo (2009). However, the coefficients of determination (r^2) indicate that the variation of the dependent variables "project deadline" and "reduction of drawing set errors" have been influenced by the independent variable "degree of contribution of AS to the creation of the drawing set" with a relative weight of about 5% and about 13%. This indicates that a strong influence on the dependent variables is achieved by additional impact factors so far not represented in our model. However the results are highly significant.

2. There are significant correlations between the contribution intensity of AS to the creation of the drawing set and the engineer's contentment with the task (CC X_1/Y_4=0,326) and the utilisation of engineers´ competences (CC X_1/Y_6=0,357), the socio-psychological efficiency dimensions in the carefully restricted area. This indicates that there is a function between AS integration, measured by the contribution to the creation of the drawing set and the socio-psychological efficiency project outcomes in the demarcated area; this was analogously also confirmed by Semmer & Udris (1995), Weinert (1998) Ulich (2001), Rosenstiel (2003), Dahlin et al. (2005),

Aronson et al. (2008), Haon et al. (2009) and Kappagoda (2012). Also, the coefficients of determination (r^2) for the impact of the independent variable "contribution intensity of AS to the creation of the drawing set" show an impact weight of about close to 11% and 13 % on the dependent variables engineer's contentment with the task and the instrumental use of engineer's competences. Again, this is a non–negligible volume, even though again additional impact factors have to be admitted. However the results are highly significant.

3. Between the additional supporting documentation activities done through AS and the socio-psychological efficiency variable "engineer's contentment with the task" a significant relationship can be stated (CC X_2/Y_4=0,349); this is analogously also confirmed by Semmer & Udris (1995), Weinert (1998), Ulich (2001), Rosenstiel (2003), Dahlin et al. (2005), Aronson et al. (2008), Haon et al. (2009) and Kappagoda, (2012). Also the coefficient of determination (r^2) adds up to more than 12% impact weight on the dependent variable engineer's contentment with the task, again highly significantly. Though, as mentioned above additional impact factors have to be presumed.

Overall, the empirical survey has by and large supported the underlying hypotheses of our causal model. However, taking the results of the CD (r^2) analyses and of the MRA into account, it has to be considered that various additional independent variables do have an impact on the set of dependent variables related to the project success in New PD processes. This insight leads to additional theoretical considerations, concerning other influencing variables on the project success in economic and socio psychological terms.

Again utilising the formal multiple regression approach, the following function can be formulated:

$Y(_{1....6}) = a+bX_1+cX_2+dX_3+eX_4+fX_5+gX_6+\varepsilon$

This regression function presumes a number of additional independent variables (X_3, X_4, X_5, X_6) and an unknown residual (ε) which determine the dependent variables (Y_{1-6}).

Referring to the theoretical considerations of Cooper & Kleinschmidt (1995) the following potential independent variables should be taken into a hypothetical account:

High quality and rigorous product development processes (X_3); pertinent new product strategy (X_4); sufficient and pertinent resources (people and money) (X_5) and the use of cross functional teams (X_6).

This particular set of additional factors suggested by Cooper & Kleinschmidt (1995, p. 53)

can save as an extended theoretical framework which may have to be tested by a further theoretical and empirical research. This approach, also discussed in various articles (cf. Zwikael & Globerson, 2006, containing a summary of critical success factors and processes in project management analysed by various scientists, Cooper & Kleinschmidt and various others, in the years 1988 to 2001) implies an extension of the specifically defined restrictions in the present study (execution phase of variant construction projects within a 3D CAD environment).

5.2. Suggestions

Based on the results of this scientific study the author suggests the following:

1. Management is in the position to bring the essential tasks of the engineer, the design of new components and products in time, back into the focus by applying the model of IofAS.

2. Management must take care of a motivating task content/environment on the basis of a diligent analysis of the requirements of the individual subtasks to be performed, as job satisfaction is strongly related to the task content.

3. Management must - based on the diligent analysis of the requirements of the individual subtasks - compose New PD teams by taking competence diversity adequately into account in order to improve the quality of the development project outcomes.

4. Management must compose New PD teams (AS and engineers) by taking the task content adequately into account in order to relieve engineers from side tasks and to increase their restricted time for the development of new products.

5. Management must commit to the theory of coherent task and competence based division of labour, not just in the context of international co-operations, within different functional units of a company, but also within mechanical development departments, the nucleus of New PD.

6. Management must implement the model of IofAS as engineers' software driven job enrichment threatens the use of modern development techniques such as overlapping of task/activities, a proven method to improve the efficiency by compressing schedules.

7. Management must be aware that in limited specialist manpower environments vertical integration of tasks by specialists leads to avoidable additional shortage of these specialists if task and competence related IofAS is not adapted adequately.

8. Management should query integrated software packages, such as 3D CAD, promising the replacement of AS in general. Using the example of 3D CAD shows that the potential of the SW can only be exploited adequately with AS integrated coherently in a New PD process.

9. Engineers must actively call for the implementation of the model of IofAS by arguing according to the findings of this research.

10. Engineers must improve their partially lost delegation competence, lost via a software driven job enrichment, by transferring increasingly documentation tasks back into the task portfolio of AS.

11. Engineers must be prepared to overcome their tentatively "well-developed" introversion (based on individual personality and forced by the working conditions) by training activities to improve teamwork KSA (Knowledge, Skills and Abilities) in order to make extensive use of the AS offered by management.

5.3. Discussion

More research to identify additional factors, e.g. the intensity and quality of permanent training and education programs, which characterise the degree of AS integration in the execution phase of variant construction projects within a 3D CAD environment, is recommended.

This research project is restricted to the execution phase of a variant construction project within a 3D CAD environment in MDDs. However further investigations into the application of the model of IofAS in all phases of a development process, in adjustment development and innovation development projects and in the electrical or SW development disciplines are recommended as comparable positive outcomes are expected.

REFERENCES

Abolhassan, F. (2003). Das Real-Time Enterprise – Eine Einordnung. In Scheer/Abolhassan/Bosch, A.-W. Scheer, F. Abolhassan, & W. Bosch (Eds.), *Real-Time Enterprise: Mit beschleunigten Managementprozessen Zeit und Kosten sparen* (pp. 1-8). Berlin etc: Springer.

Absar, M. M., Azim, M. T., Balasundaram, N., & Akhter, S. (2010). Impact of Human Resources Practices on Job Satisfaction: Evidence from Manufacturing Firms in Banglades. (P. G. Ploiesti, Ed.) *Economic Sciences Series, Bulletin LXII*(2/2010), 31-42.

Akgun, A., Byrne, J., Lynn, G., & Keskin, H. (2007). Team stressors, management support, and project and process outcomes in new product development projects. *Technovation 27(10)*, 628-639.

Anagnost, A. (2005). Imperatives for Innovation. Breakthrough in 3D usabiliy. *Tech. Watch*, 13-22.

Ancona, D. G., & Caldwell, D. (1992). Demography and design: predictions of new product team performance. *Organisation Science, 3*, 321-341.

Anderson, O. (1965). *Probleme der statistischen Methodenlehre in den Sozialwissenschaften.* Würzburg: Physica Verlag.

Andreß, H.-J. (2001). *Glossar zur Datenerhebung und statistischen Analyse*. Retrieved 04 02, 2014, from http://eswf.uni-koeln.de/glossar/node30.html#402

Aronson, E. (1968). Dissonance theory: Progress and problems. In R. Abelson, E. Aronson, E. McGuire, T. Newcomb, M. Rosenberg, & P. Tannenbaum (Eds.), *Theory of cognitive consistency: A sourcebook* (pp. 5-27). Chicago: Rand McNally.

Aronson, E. (1969). The theory of cognitive dissonance: A current perspective. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 4, pp. 1-34). New York: Academic Press.

Aronson, E., Wilson, T., & Akert, R. (2008). *Sozialpsychologie. 4. Aufl.* . München: Pearson.

Backhaus, K., Erichson, B., Plinke, W., & Weiber, R. (1994). *Multivariate Analysemethoden* (10 ed.). Berlin, Heidelberg, New York: Springer.

Beckert, B. (2000). Do You Speak 3D? Mechanical milleium report. *Computer Aided Engineering*, 419-425.

Beingpoint. (2013). *The Ability To Learn Faster Than Your Competitors May Be The Only Sustainable Advantage.* Retrieved Dec. 12, 2013, from http://www.beingpoint.com/the-ability-to-learn-faster-than-your-competitors-may-be-

the-only-sustainable-advantage/

Bernard, A. (2005). Virtual engineering: methods and tools. In: Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture 219 (5). 413-421.

Bieber, K. (2001). *Effizientes Office- Management mit Kaizen.* Landsberg/Lech: Verlag Moderne Industrie.

BMBF. (2007). *Rede der Bundesministerin für Bildung und Forschung,.* Retrieved Dec. 7, 2013, from http://www.bmbf.de/pubRD/mr_20070620.pdf

BMBF. (2011). *Bundesregierung setzt konsequent auf Bildung und Forschung - 06.07.2011 [Pressemitteilung 095/2011]*. Retrieved Dec. 8, 2013, from http://www.bmbf.de/press/3121.php

Boehe, D. M. (2008). In-house off-shoring of product development by MNCs. *BAR, Braz. Adm. Rev., 5*(1), 1-18.

Bögel, R., & Rosenstiel, L. v. (1993). Das Bild von Menschen in den Köpfen der Macher. In B. Srtümpel, & M. Dierkes (Eds.), *Innovationen und Beharrung in der Arbeitspolitik* (pp. 243-276). Stuttgart: Poeschel.

Bogus, S. M. (2004). *Concurrent engineering strategies for reducing design delivery time.* Colorado: Univ. of Colorado, Boulder, CO.

Bogus, S. M., Molenaar, K. R., & Diekmann, J. E. (2006). Strategies for overlapping dependent design activities. *Construction Management and Economics, 24*(8), 829-837.

Bogus, S., Diekmann, J., Molenaar, K., Harper, C., Patil, S., & Lee, J. (2011). Simulation of Overlapping Design Activities. *Concurrent Engineering* (9), 950-957.

Bortz, J., & Döring, N. (2006). *Forschungsmethoden und Evaluation für Human-und Sozialwissenschaftler* (4 ed.). Berlin, Heidelberg, New York: Springer.

Breckler, S. (1990). Applications of Covariance Structure Modeling in Psychology: Cause for Concern? *Psychological Bulletin, 107*(2), 260-273.

Brehm, J., & Cohen, A. (1962). *Explorations in cognitive dissonance.* New York: Wiley.

Brinks, M. (2002). *Sozialwissenschaftliche Datenverarbeitung - Datenanalyse mittels SPSS.* Linz: Univesität-Linz.

Brophy, A. (1959). Self, role, and satisfaction. *Genetic Psychological Monographs, 59*, 263-308.

Bstieler, L. (2005). The moderating effect of environmental uncertainty on new product development and time efficiency. *Journal Product Innovation Management*, 267-284.

Buch, S. (2007). *Strukturgleichungsmodelle - Ein einführender Überblick*. ESCP-EAP

Working Paper 29.

Buckler, F. (2001). *Neusrel: neuer Kausalanalyse Einsatz auf Basis Neuraler Netze als Instrument der Marketingforschung.* Göttingen: Cuvillier Verlag.

Busson, A. (2005). 3D Software - Streamlines more than design. One company´s prespective on using integrated 3D CAD software to make its product development cycle time more efficient. In: Market place 2005. 49-56.

Cammerer, C. F., Loewenstein, G., & Rabin, M. (2004). Advances in Behavioral Economics. *Princton University Press*, 3-53.

Carbonell, P., & Rodriguez, A. (2006). Designing teams for speedy product development: The moderating effect of technological complexity. *Journal of Business Research, 59*(2), 225-232.

Clark, K., & Fujimoto, T. (1989). Reducing the time to Market: The Case of the World Auto Industry. *Design Management Journal*(1), 49-57.

Cohen, M., Eliashberg, J., & Ho, T. (2000). An Analysis of Several New Product Performance Metrics. In:. *Manufacturing & Service Operations Management, 2*(4), 337-349.

Cooper, R. G., & Kleinschmidt, E. J. (1995). New Product Performance: Keys to Success, Profitability & Cycle Time Reduction. *Journal of Marketing Management, 11*, 315-337.

Dahlin, K. B., Weingart, L. R., & Hinds, P. J. (2005). Team diversity and information use. *Academy of Management Journal, 48*(6), 1107–1123.

Dreier, V. (n.d.). *Grundlagen und Methoden der empirischen Sozialforschung, Empirische (Sozial)forschung: Eine (mögliche!) Begriffsbestimmung.* Retrieved Nov. 11, 2013, from http://www.unikoeln.de/kzfss/seminare/0607Methoden/sitzung_woche01_einfuehrung. pdf

Drucker, P. (1993). *The Effective Executive.* New York: HarperCollins Publishers.

Eberl, M. (2004). *Formative und reflektive Indikatoren im Forschungsprozess: Entscheidungsregeln und die Dominanz des reflektiven Modells* (19 ed.). München: EFOplan.

Ehrenspiel, K. (1995). *Integrierte Produktentwicklung. Methoden für Prozessorganisation, Produkterstellung und Konstruktion.* München Wien: Carl Hauser Verlag.

Ehrenspiel, K. (2007). *Integrierte Produktentwicklung: Denkabläufe, Methodeneinsatz, Zusammenarbeit.* München/Wien: Hanser.

Feldmayer, J., & Seidenschwarz, W. (2005). *Marktorientiertes Prozessmanagement: wie Process Mass Customization Kundenorientierung und Prozessstandardisierung*

integriert. München: Vahlen.

Festinger, L. (1957). *A theory of cognitive dissonance.* Evanston: Row and Peters.

Festinger, L., & Aronson, E. (1960). The arousal and reduction of dissonance in social contexts. In D. Cartwright, & A. Zander (Eds.), *Group dynamics* (pp. 214-231). Evanston: Row & Peterson.

Fischer, F. (2008). MBA Management und Leadership - Wertschöpfungsmanagement Teil 1. 1-32. Unpublished Presentation. Rosenheim: FH.

Frey, J. P. (1920). *Die wissenschaftliche Betriebsführung und die Arbeiterschaft. Eine öffentliche Untersuchung der Betriebe mit Taylorsystem in den Vereinigten Staaten von Nordamerika* (2 ed.). Leipzig: Lindner.

Friedrichs, J. (1980). *Methoden empirischer Sozialforschung* (9 ed.). Opladen: Westdeutscher Verlag.

Gerk, J. E., & Qassim, R. Y. (2008). Project Acceleration via Activity Crashing, Overlapping and Substitution. *Engineering Management, IEEE Transaction, 55*(4), 590-601.

Goldratt, E. M. (1990). *What is this thing called Theory of Constraints and how should it be implemented.* Croton-on-Hudson, NY: North River Press.

Goldratt, E. M. (2001). *Critical Chain: A Business Novel.* Great Barrington: North River Press.

Grubb, L. (1998). Using total cycle time for quick response manufacturing. *Assembly Automation 18*(1), 20-24.

Gutenberg, E. (1966). *Grundlagen der Betriebswirtschaftslehre. Erster Band: Die Produktion.* Berlin etc.: Springer.

Hacker, W. (1998). *Allgemeine Arbeitspsychologie.* Bern: Huber.

Häder, M. (2000). *Die Expertenauswahl bei Delphi-Befragungen.* Mannheim: Zentrum für Umfragen, Methoden und Analysen.

Handelsblatt. (08.08.2013). Fachkräftemangel - Mittelstand lässt Milliardenumsätze liegen. *Handelsblatt*.

Haon, C., Gotteland, D., & Fornerino, M. (2009). Familiarity and competence diversity in new product development teams: Effects on new product performance. *Market Lett, 20*, 75-89.

Hauser, R. (1973). Disaggregating a Social-Psychological Model of Educational Attainment. In A. S. Goldberger, & O. D. Duncan (Eds.), *Structural Equation Models in the Social Sciences* (pp. 255-284). New York etc.

Heinen, E. (1974). *Industriebetriebslehre* (3. ed.). Wiesbaden: Gabler.

Held, M., Kubon-Gilke, G., & Sturn, R. (2003). *Normative und institutionelle Grundfragen*

der Ökonomik. Vol. 2: Experimente in der Ökonomik. Marburg: Metropolis Verlag.

Henard, D. H., & Szymanski, D. M. (2001). Why some new products are more successful than others. *Journal of Marketing Research, 38*(3), 362-375.

Heron, J., & Reason, P. (2001). The practice of co-operative inquiry: Research with rather than on people. In P. Reason, & H. Bradbury (Eds.), *Handbook of Action Research: Participative Inquiry and Practice* (pp. 179-188). London: Sage London.

Herzberg, F., Mausner, B., & Snyderman, B. (1959). *The motivation to work.* New York: Wiley.

Hinds, P., Carley, K., & Krackhardt, D. (2000). Choosing Work Group Members: Balancing Similarity, Competence and Familiarity. *Organisation Behaviour and Human Decision Processes, 81*(2), 226-251.

Hirzel, M. (1992). Mit Geschwindigkeit im dynamischen Markt reüssieren. In Hirzel/Leder/Partner, *(Eds.), Speed-Management: Geschwindigkeit zum Wettbewerbsvorteil machen* (pp. 19-26). Wiesbaden: Gabler.

Hollenbeck, J. R., DeRue, D. S., & Rick, G. (2004). Bridging the gap between I/O research and HR practice: Improving team composition, team training and team task design. *Human Resource Management, Vol. 43, Issue 4*, 353-366.

Homburg, C., & Hildebrandt, L. (1998). Die Kausalanalyse: Bestandsaufnahme, Entwicklungsrichtungen, Problemfelder. In L. Hildebrandt, & C. Homburg (Eds.), *Die Kausalanalyse. Instrument der betriebswirtschaftlichen Forschung* (pp. 15-43). Stuttgart: Schäffer-Poeschel.

Horx, M. (2001). *Smart Capitalism. Das Ende der Ausbeutung.* Frankfurt a. M.: Eichborn Verlag.

Hubka, V. (1976). *Theorie der Konstruktionsprozesse: Analyse der Konstruktionstätigkeit.* Berlin etc.: Springer.

Humphrey, S. E., Morgeson, F. P., & Mannor, M. J. (2009, Jan). Developing a theory of the strategic core of teams: A role composition model of team performance. . *Journal of Applied Psychology*, 48-61.

IAB. (2011). *Berufe im Spiegel der Statisitk.* (I. f. Arbeit, Ed.) Retrieved Nov. 29, 2013, from http://bisds.infosys.iab.de/bisds/result?region=19&beruf=BG60&qualifikation=2

Imai, K., Nonaka, I., & Takeuchi, H. (1985). Managing the New Product Development Process. How the Japanese Companies Learn and Unlearn. *Harvard Business School Press*, 337-376.

Ironson, G. H., Smith, P. C., Brannick, M. T., Gibson, W. M., & Paul, K. B. (1989). Construction of a job in general scale. A comparison of global composite and spezific

measures. *Journal of Applied Psychology, 74*, 193-200.

Janssen, J., Erkens, G., Kirschner, P. A., & Kanselaar, G. (2009). Influence of group member familiarity on online collaborative learning. *Computers in Human Behaviour, 25, 161-170*.

Javidan, M. (1998). Core competence: what does it mean in practice. *Long Range Planning, 31*, 60-71.

Jetter, W. (2006). Performance Management entwickeln und einführen. *Personalmanager, 2006*(1), 12-14.

Jonker, C. M., van Riemsdijk, B. M., & Vermeulen, B. (2010). *Shared Mental Models: A Conceptual Analysis.* Retrieved March 7, 2014 from http://mmi.tudelft.nl/~catholijn/cve/Prelim_versions/COIN2010_shared.pdf.

Jöreskog, K. G. (1993). Testing Structural Equation Models. In K. A. Bollen, & J. S. Long (Eds.), *Testing structural equation models* (pp. 294-316). Thousand Oaks, CA.: Sage Publications.

Kappagoda, S. (2012). The Impact of Work Related Attitudes on Task and Contextual Performance: A Comparative Study in Public and Private Banks in Sri Lanka. *International Journal of Research in Commerce, Economics and Management, 2*(9), 23-26.

Kessler, E., & Chakrabarti, A. K. (1999). Speeding up the pace of new product development. *Journal of Product Innovation Management, 16*, 231-247.

Kieser, A., & Walgenbach, P. (2003). *Organisation* (4. ed.). Stuttgart: Schäffer-Poeschel.

Kirchler, E., Meier-Pesti, K., & Hofmann, E. (2004). *Menschenbilder in Organisationen.* Wien: Facultus Verlags u. Buchhandlungs AG.

Kliesch-Eberl, M., & Eberl, P. (2009). An extended perspective on innovation: Bridging organizational creativity to dynamic capabilities. *EGOS Colloquium, Barcelona 2009* (pp. 1-6). Barcelona: EGOS Colloquium.

Kornhauser, A. (1965). *Mental health of the industrial worker: A Detroit study.* New York: Wiley.

Kotelnikov, V. (n.d.). *Cross-functional Management (CFM) - Building a Better Synergistic System for Quality, Cost and Delivery and Innovation (Toyota).* Retrieved Dec. 10, 2013, from http://www.1000ventures.com/business_guide/mgmt_cross-functional.html

Krishnan, V., Eppinger, S. D., & Whitney, D. E. (1997). A Model-Based Framework to Overlap Product Development Activities. *Management Science, 43*(4), 437-451.

Kühn, F., Pleuger, G., & Kreitel-Suciu, A. (2006). Ressourcenmanagement -

Schlüsselkompetenz für ein erfolgreiches Projektportfolio. In M. Hirzel (Ed.), *Projektportfolio-Management: strategisches und operatives Multi-Projektmanagement in der Praxis* (pp. 143-166). Wiesbaden: Gabler.

Kumar, S., & Krob, W. (2007). Phase reviews versus fast product development: a business case. *Journal of Engineering Design, 18*(3), 279-291.

Larson, E. W., & Gobeli, D. H. (1988). Organizing for product development projects. *Product Innovation Management, 5*(3), 180-190.

Legge, K. (2005). *Human Resource Management: Rhetorics and Realities.* Basingstoke: 10th anniversary edition, Palgrave Macmilla.

Lewin, K. (1953). *Die Lösung sozialer Konflikte.* Bad Nauheim: Christian-Verl.

Locke, E. (1976). The nature and causes of job satisfaction. In M. Dunnette (Ed.), *Handbook of industrial and organisational psychology* (pp. 1297-1349). Chicago: Rand McNally.

Lohninger, H. (2012). *Rangkorrelation nach Spearman.* Retrieved March 25, 2014, from http://www.statistics4u.com/fundstat_germ/cc_corr_spearman.html

Marujo, L. (2009). , Rework Impacts Evaluation through System Dynamics Approach in Overlapped Product Development Schedule. *Journal of Technology Management & Innovation, 4*(2), 90-101.

Mayer, D. (1988). *Arbeits- und Organisationsgestaltung im technischen Büro.* Stuttgart: Univ. Diss.

Maylor, H., & Blackmon, K. L. (2005). *Researching business and management.* Houndmills, Basingstoke, Hampshire: Palgrave Macmillan.

McDonough, E. F. (2000). Investigation of factors contributing to the success of cross-functional teams. *Journal of Product Innovation Management, 17*(3), 221-235.

Mello, A. S., & Ruckes, M. E. (2006). Team Composition. *Journal of Business, Vol. 79, Issue 3*, 1019-1039.

Meyer, D. (2005). Multitasking senkt Produktivität - Einfacher arbeiten - besser leben! *Simplify, Selbstmanagement*(E-Mail Newsletter 08.12.2005).

Meyer, D. (2012). Stop multitasking! *Senior Market Adviso, 13*(7), 28-28, 1/3p.

Milgram, S. (1974). *Obedience to Authority: An Experimental View.* New York: Harper and Row.

Mobius, M., & Schoenle, R. (2006). *The Evolution of Work.* Cambridge, Mass: National Bureau of Economic Research NBER Working Papers 12694.

Moosmüller, G. (2004). *Methoden der empirischen Wirtschaftsforschung.* München: Pearson Studium.

Müller, A. M. (2004). *Konzepte der Standardisierung betrieblicher Anwendungssysteme:*

Entwicklung eines neuen Bezugsrahmens für die Wirtschaftsinformatik. Retrieved Dec 7, 2013, from http://www.wim.bwl.uni-muenchen.de/download/epub/ab_2004_02. pdf

Münsterberg, H. (1912). *Psychologie und Wirtschaftsleben. Ein Beitrag zur Angewandten Experimentalpsychologie.* Leipzig: Barth.

Neuert, J. O. (1987). *Planungsgrade. Eine experiementelle Untersuchung zum Zusammenhang zwischen Planungsverhalten und Planungserfolg.* Spardorf: René F. Wilfer.

Neuert, J. O. (2009). Sozio-ökonomische Analyse der "Integrierten Mediation" als Konfliktregelungskonzept. Realtheorie, Modelkonstrukt und empirische Befunde, Wissenschafliches Evaluationsgutachten. Kufstein: FH Kufstein.

Neuert, J. O. (2010a). Philosophy of Research, Scientific Theory and Comprehensive Research Issues, Part 3. Research Design and Research Frameworks, Doctorial Program Modul. 1-12. Kufstein: FH Kufstein.

Neuert, J. O. (2010b). Philosophy of Research, Scientific Theory and Comprehensive Research Issues, Part 4. Dissertation writing: goals, criteria, steps, citation, qualityassurance, Doctorial Program Modul. 1-12. Kufstein: FH Kufstein.

Nippa, M. (1988). *Gestaltungsgrundsätze für die Büroorganisation: Konzepte für eine informations-orientierte Unternehmungsentwicklung unter Berücksichtigung neuer Bürokommunikationstechniken.* Berlin: Schmidt.

Nippa, M. (1996). Anforderungen an das Management prozessdefinierter Unternehmen. In M. Nippa, & A. Picot (Eds.), *Prozessmanagement und Reengineering: die Praxis im deutschsprachigen Raum [das Erfolgsrezept von Hammer/Champy auf dem Prüfstand]* (pp. 39-58). Frankfurt/Main etc.: Campus-Verl.

Nippa, M., & Reichwald, R. (1990). Theoretische Grundüberlegungen zur Verkürzung der Durchlaufzeit in der industriellen Entwicklung. In R. Reichwald, & H. J. Schmelzer (Eds.), *Durchlaufzeiten in der Entwicklung: Praxis des industriellen F&E-Managements* (pp. 65-114). München etc.: Oldenbourg.

Onwubiko, C. (2000). *Introduction to engineering design optimization.* Prentice Hall, NY: Upper Saddle River.

Orth, B. (1985). Einführung in die Theorie des Messens - Ethikrichtlinien für Mediator/-innen. Österreichisches Netzwerk Mediation: Kohlhammer W.

OVB. (2012). FCB Basketball-Section. *OVB - Oberbayerisches Volksblatt*. 09.0.2012.

OVB. (2014). Fachkräfte: Engpässe in 20 Berufsgruppen - dpa. *OVB - Oberbayerisches Volksblatt*. 13.03.2014.

Pareto, V. F. (1897). *Cours d´économie politique.*

Pelled, L. H. (1996). Demographic Diversity, Conflict, and Work Group Outcomes: An Intervening Process Theory. *Organisation Science, Vol. 7, Issue 6*, 615-631.

Pena-Mora, F., & Li, M. (2001). Dynamic planning and control methodology for design/build fast-track construction projects. *Journal of Constr. Eng. Management, 127*(1), 1-1.

Popper, K. (2005). *Logik der Forschung* (H. Keuth ed.). Tübingen: Mohr-Siebeck.

Pottier, C. (2007). Offshore Production of Multinationals in Emerging Countries: Impact on the International Division of Labor; . *Economies et Societes, 41*(2), 299-317.

PTC, P. S. (2013). *Multi-CAD-Umgebungen optimieren.* Retrieved Dec. 8, 2013, from http://www.ptc.com/solutions/multi-cad-design/

Quatember, A. (2005). *Statistik ohne Angst vor Formeln. Ein Lehrbuch für Wirtschafts- und Sozialwissenschaftler.* München: PEARSON Studium.

Robbins, S. P. (2003). *Organizational behaviour, Concepts, controversies, applications.* New Delhi: Prentice Hall of India.

Roemer, T. A., Ahmadi, R., & Wang, R. (2000). Time-cost trade-offs in overlapped product development. *Operations Research, 48*(6), 858-865.

Roh, M., & Lee, K. (2007). Generation of the 3D CAD model of the hull structure at the initial ship design stage and its application. *Computers in Industry* 58 (6). 539-557.

Rohracher, H. (1988). *Einführung in die Psychologie.* München: Psychologie Verlags Union.

Romberg, A., & Haas, M. (2005). *Der Anlaufmanager: Effizient arbeiten mit Führungssystem und Workflow; von der Produktidee bis zur Serie.* Stuttgart: LOG X.

Rosenstiel, L. v. (1975). Arbeitsleistung und Arbeitszufriedenheit. *Zeitschrift für Arbeitswissenschaft, 29*, 72-79.

Rosenstiel, L. v. (1988). Motivationsmanagement. In M. Hofmann, L. v. Rosenstiel, (Eds.), *Funktionale Managementlehre* (pp. 214-264). Berlin: Springer.

Rosenstiel, L. v. (2003). *Grundlagen der Organisationspsychologie.* Stuttgart: 5. Aufl., Schäffer-Poeschel.

Rubinstein, J., Meyer, D., & Evans, J. (2001). Executive Control of Cognitive Processes in Task Switching. *Journal of experimental psychology, 4*, 763-797.

Scheer, A.-W. (2003). *Real-Time Enterprise: mit beschleunigten Managementprozessen Zeit und Kosten sparen.* Berlin: Springer.

Schein, E. H. (1965). *Organizational psychology,* . New York: Prentice Hall.

Schira, J. (2005). *Statistische Methoden der VWL und BWL, Theorie und Praxis.* München: Pearson.

Scholz, R. (1995). *Geschäftsprozessoptimierung: crossfunktionale Rationalisierung oder strukturelle Reorganisation* (2. ed.). Bergisch Gladbach etc.: J. Eul.

Schroeder, R. G., Anderson, J. C., & Scudder, G. D. (1985). Measurement of White Collar Productivity. *International Journal of Operations & Production Management, 5*(2), 25-34.

Semmer, N., & Udris. (1995). Bedeutung und Wirkung von Arbeit. In H. Schuler (Ed.), *Lehrbuch Organisationspsychologie.* Bern: Hans Huber.

Shams-ur, R. (1998). Theory of constraints: A review of the philosophy and its applications. *International Journal of Operations & Production Management, 18*(4), 336-355.

Slama, A. (2010). *Ein Verfahren zur Verkürzung des Entwicklungsprozesses.* Stuttgart: Diss. IAT Universität Stuttgart.

Smith, A. (1776). *An Inquiry into the Nature and Causes of the Wealth of Nations.* Reprint Chicago 1977: University of Chicago Press.

Sobel, M. (1990). Effect analysis and causation in linear structural equation models. *Psychometrika, 55*(3), 495-515.

SolidEdge/Siemens. (2000). *Umstieg von 2D nach 3D CAD, Vorteile durch Produktivitätssteigerung.* Retrieved Dec. 9, 2013, from http://solidedge.cad.de/download/dokumente/Von_2D_nach_3D.pdf

Songer, A. D., Diekmann, J. E., & Karet, D. (2001). Animation-based construction schedule review. *Construction Innovation* 2001. 181-190.

Stacey, R. (2010). *Complexity and Organizational Reality: Uncertainty and the need to rethink management after the collapse of investment capitalism.* Routledge, London.

Stacey, R. D. (2007). The challenge of human interdependence: Consequences for thinking about the day to day practice of management in organizations. *European Business Review 19 (4)*, 292-302.

Staita, C. (2012). Coherent Team Structure in a Three Dimensional CAD New Product Development (New PD) Environment. (pp. 657-667). Riga: University of Lativa, Faculty of Economics and Management.

Staita, C. (2013). Job Enrichment, Task Satisfaction and socio-economic Efficiency: A Research in socio-psychological Theories related to Dissonances in Development Departments of medium-sized Companies. *Journal of Economics and Management Reserch, 2*, 106-117.

Staita Christoph (2014). Integration of Auxiliary Staff in New Product Development (New PD) processes. In: *ISSWOV International Society for the Study of Work & Organisational Values*, Riga, Latvia, 280-287

Stalk, G. J. (2006). Hardball Innovation. Disciplined management is essential to successful product development - it´s what hardball innovators do. *Industrial Research Institute,*

Inc, 21-28.

Steffens, P., Terjesen, S., & Davidson, P. (2012). Birds of a Feather get lost together: New Venture Team Composition and Performance. *Small Business Economics, Vol. 39, Issue 3*, 727-743.

Strategy & Marketing Institute, G. (2005). *Innovationstrends in Deutschland: Expertenpanel von "Technology Review" und der Initiative "Partner für Innovation."* Hannover.

Taylor, F. W. (1911). *The principles of scientific management. New York: Cosimo, 2006.* London: Reprint of Harper & Brothers 1911.

Techt, U. (2004). Schieflage ins Lot bringen: Critical-Chain Projekt: Potenziale in Konstruktion und Abwicklung freilegen. *KEM Konstruktion, Elemente, Methoden*(9), 12-23.

Thomas, P. R. (1991). *Getting competitive: middle managers and the cycle time ethic.* New York etc.: McGraw-Hill.

Thompson, J. (1997). *The Lean Office: How to Use Just-in-Time Techniques to Streamline your Office.* Toronto: Productive Publications.

Thompson, J. (2000). *Lean Production for the Office: Common Sense Ideas to help your Office Continuously Improve.* Toronto: Productive Publications.

Udris, I. (1982). Soziale Unterstützung: Hilfe gegen Streß? *Psychosozial, 5*, 78-91.

Ulich, E. (2001). *Arbeitspsychologie.* Zürich-Stuttgart: ETH und Schäffer-Poesche.

Vogt, W. P. (1993). *Dictionary of statistics and methodology.* Newbury Park, CA: Sage.

Voß, W. (2000). *Praktische Statistik mit SPSS.* .München: Carl Hanser Verlag.

Vroom, V. H. (1964). *Work and motivation.* New York: Wiley.

Weber, S. (2010). Fachkräftemangel - Der Charme der Provinz. *Süddeutsche Zeitung*. 17.05.2010.

Weiber, R., & Mühlhaus, D. (2010). *Strukturgleichungsmodellierung.* Berlin Heidelberg: Springer-Verlag.

Weinert, A. B. (1998). *Lehrbuch der Organisationspsychologie.* München: 4. Auflage, Psychologie Verlags Union.

Weißbrod, B. (2014). Technik - Bosch will in diesem Jahr 800 Hochschulabsolventen einstellen. *Focus online 23.03.2014*.

Weltz, F., & Bollinger, H. (1987). Dezentralisierung und Integration: Zauberformel der Büroarbeit. In: Office Management. *3*, 52-56.

Werner, R. (1974). Zur Problematik subjektiver Indikatoren. In R. Werner, & W. Zapf (Ed.), *Soziale Indikatoren* (Vol. 2, pp. 264-275). Frankfurt/M: Herder & Herder.

Wildemann, H. (2003). *Lean Management: Leitfaden zur Einführung schlanker*

Unternehmensstrukturen und Geschäftsprozesse. München: TCW Transfer-Centrum GmbH.

Witte, E., Hauschild, J., & Grün, O. (1988). *Innovative Entscheidungsprozesse. Die Ergebnisse des Projektes "Columbus".* Tübingen: J. C. B. Mohr (Paul Siebeck).

Wittenstein, A.-M. (2007). Bedarfssynchrone Leistungsverfügbarkeit in der kundenspezifischen Produktentwicklung. *IPA-IAO Forschung und Praxis*. Heimsheim: Jost Jetter Verlag.

Wittenstein, A.-M. (2006). Forschung und regionale Produktionsnetzwerke - eine lebenswichtige Symbiose. In J. Geißinger (Ed.), *Forschung stärken - Produktion sichern* (pp. 61-72). Berlin etc.: Springer.

Wossidlo, P. (1975). *Pluralitätskonzeption und axiomatisierte Theorie - Grundfragen der betriebswirtschaftlichen Forschung.* München: Springer.

Zhang, H., & Qiu, W. (2006). An approach to measuring coupled tasks strength and sequencing of coupled tasks in New Product Development. *Concurrent Engineering, 14*(4), 305-311.

Zhang, X., Luo, L., Yang, Y., Li, Y., Schlick, C., & Grandt, M. (2009). A simulation approach for evaluation and improvement of organisational planning in collaborative product development projects. *International Journal of Production Research, 47*(13), 3471-3501.

Zimmermann, E. (1972). *Das Experiment in den Sozialwissenschaften.* Stuttgart: Teubner,

Zwikael, O., & Globerson, S. (2006). From Critical Success Factors to Critical Success Proccesses. *International Journal of Production Research, 44*(17), 3433-3449.

12manage. (2013). Description of Cross-Functional Team. Explanation. Retrieved Dec. 15, 2013, from http://www.12manage.com/images/picture_ cross_functional

ANNEX

Annex 1: Standard Development Project Data

1. Object of investigation

1.1 Average variant construction

1.2 Executive development phase (phase 3)

2. Average basic data

2.1 Quantity of new parts: 20

(with 200 drawings for the 20 new parts and various aligned elements)

2.1 Project duration 12 man/months

2.2 Duration of planning and creative phase (phase1 and 2): 3 man/months

3. Duration of executive phase (phase 3) 9 man/month

(Starting date of phase 3: Date of final concept definition.

Completion date of phase 3: Date of circulation of relevant information to the next downstream working units, e.g. part list department)

3.1 Duration of genuine engineer tasks in phase 3: 5 man/months

3.2 Duration of distributable tasks in phase 3: 4 man/months

3.2.1 Duration of distributable drawing activities: 3 man/months (i.e. 60 days/20 new parts = 3 days/new part)

3.2.2 Duration of distributable related tasks 1 man/month

4. Personnel cost of auxiliary staff is 2 thirds of the engineer's cost

(for the engineer's cost is 13.000 EURO/month used as an evaluation base)

Annex 2: Bild 4 1-22 Mental walls obstruct the flow of information between departments and result in expensive products (Ehrlenspiel, 1995, p.148)

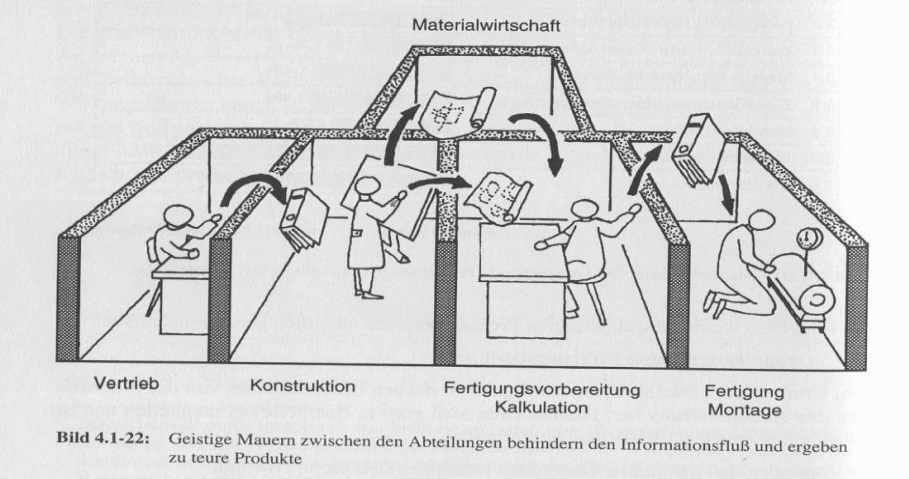


Bild 4.1-22: Geistige Mauern zwischen den Abteilungen behindern den Informationsfluß und ergeben zu teure Produkte

Annex 3: Bild 4.2-4 The product life cycle with information loops respectively feedback controlled loops (Ehrlenspiel 1995, p. 156)

Ehrlenspiel's Bild 4.2-4

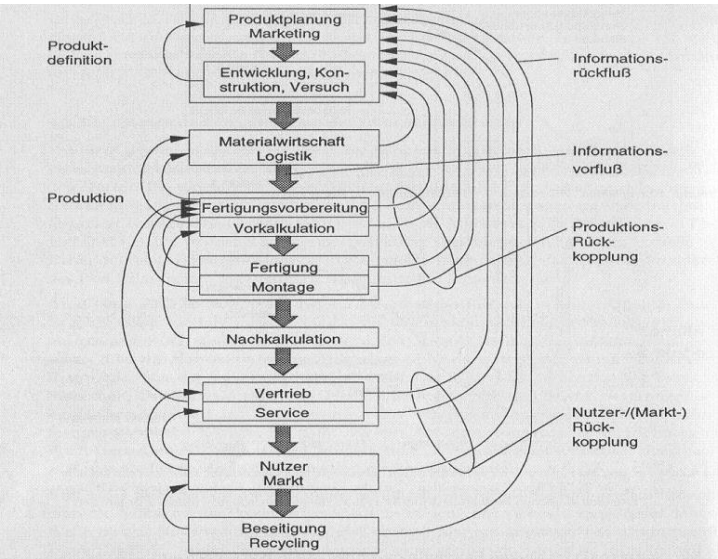


Bild 4.2-4: Der Produktlebenslauf mit Informationsrückflüssen bzw. Regelkreisen

Annex 4: Effects of functional diversity on performance in New PD (McDonough, 2000)

Reference	Sample	Main results
Larson and Gobeli (1988)	540 development projects	Projects developed by cross-functional teams have a higher success rate than those from a single company function
Ancona and Caldwell (1992)	47 development teams	Diversity has a direct negative effect on the performance perceived by members of the team itself and on product innovation
Kahn and McDonough (1997)	514 managers working in the R&D, manufacturing, and marketing departments	Collaboration has a positive significant effect on product development performance and product management performance
Song et al. (1997)	291 questionnaires from R&D managers, 122 questionnaires from manufacturing managers, and 185 questionnaires from marketing managers	Interfunctional cooperation has a positive significant effect on product performance (product quality, NPD cycle time, NPD objective met and NPD program success)
Song et al. (1998)	236 managers working in the R&D, manufacturing, and marketing departments	New product success may be more likely when a firm employs function-specific and stage-specific patterns of cross-functional integration than when the firm attempts to integrate all functions during all NPD stages
Souder et al. (1998)	101 NPD projects	R&D/marketing integration has a positive significant effect on NPD effectiveness
McDonough (2000)	112 development teams	Cross-functionality is associated with a higher success rate of new products
Sethi (2000)	141 cross-functional development team managers	Functional diversity has no effect on the quality of a new product
Lovelace et al. (2001)	43 cross-functional development teams	No significant correlation between functional diversity and new product innovativeness
McDonough et al. (2001)	103 firms (54 had used or were using global teams)	Cultural diversity has a positive significant effect team meeting expectations (time to market, commercial success, product quality, meeting customer needs, overall performance)
Sethi et al. (2001)	141 cross-functional development teams	Functional diversity has no effect on the innovativeness of a product
Bunderson and Sutcliffe (2002)	45 teams	Dominant function diversity has a negative and intrapersonal functional diversity a positive effect on information sharing and unit performance
Gerwin and Barrowman (2002)	5 surveys compiling 317 observations (meta-analysis)	Diversity does not significantly reduce the risk of not reaching set objectives
Sherman, Berkowitz, and Souder (2005)	466 NPD projects	Cross-functional integration has a global positive significant effect on product performance (process, product launch, design change frequency, performance competencies, NPD cycle time)

Annex 5: Questionnaire Participating Engineer(s) / Auxiliary Staff

Teilnehmender Ingenieur / Teilnehmende Hilfskraft

Questionnaire for the Management Project Auxiliary Staff Integration / Erhebungsbogen zum Managementprojekt Integration von Hilfskräften

Amount of handed over questionnaire pages /
Anzahl der ausgehändigten Fragebogenseiten: _____

Exact name of the project (article or product description)
Genaue Projektbezeichnung (Artikel- oder Produktbezeichnung): _____

Exact name of the used 3D CAD program /
Genauer Name des eingesetzten 3D CAD Programms: _____

1. Please answer the following questions about your personal details (please fill out for each new project) /
Bitte beantworten Sie uns die folgenden Fragen zu Ihrer Person (bitte für jedes Projekt erneut ausfüllen):

Your age / Ihr Alter:_____

Your gender / Ihr Geschlecht: *female* ☐ weiblich
male ☐ männlich

What is the exact title of your degree (Engineer)? / Welchen Studienabschluss haben Sie (Ingenieur)?

_____

What is the exact title of your professional qualification (Auxiliary Staff)? / Wie ist die genaue Bezeichnung Ihres Berufsabschlusses (Hilfskraft)?

_____

How long have you been employed in one or more mechanical development departments before you were involved in this project? /
Wie lange waren sie bereits in einer oder mehreren mechanischen Entwicklungsabteilung(en) beschäftigt, als sie an diesem Projekt beteiligt waren?

_____ year(s) / Jahr(e)

2. *Please mark the nature of the described* project /
Um welche Art handelt es sich beim vorliegenden Projekt (Bitte ankreuzen)**?**

Innovation project ☐ Innovationsprojekt

Adjustment construction ☐ Änderungs/Anpassungskonstruktion

Variant construction ☐ Variantenkonstruktion

3. *How would you rate the difficulty in the execution phase of the project?* /
Wie schätzen Sie den Schwierigkeitsgrad des vorliegenden Projekts in der Ausführungsphase ein?

very easy / sehr einfach | 1 | 2 | 3 | 4 | 5 | *very hard* / sehr schwierig

4. *How intensively had one involved, respectively, had all involved auxiliary employees in the execution phase of this project contributed to the creation of the drawing set?*
Wie intensiv hat eine beteiligte Hilfskraft bzw. haben alle beteiligten Hilfskräft in der ausführenden Phase des Projekts zur Erstellung des Zeichnungssatzes beigetragen?

very little / sehr gering | 1 | 2 | 3 | 4 | 5 | *very intensively* / sehr intensiv

5. *How intensively have you performed the following tasks in the execution phase of the present project*? / Wie intensiv haben Sie an den folgenden Aufgaben in der ausführenden Phase des vorliegenden Projekts gearbeitet?

Creation of part lists / Erstellung von Stücklistenlisten

very little / sehr gering | 1 | 2 | 3 | 4 | 5 | *very intensively* / sehr intensiv

Archiving of drawings and cooperation with the part list department /
Archivieren von Zeichnungen und Zusammenarbeit mit der Stücklistenabteilung

very little / sehr gering | 1 | 2 | 3 | 4 | 5 | *very intensively* / sehr intensiv

Carrying out part and assembly drawing changes /
Ändern von Teile- und Baugruppenzeichnungen

very little / sehr gering | 1 | 2 | 3 | 4 | 5 | *very intensively* / sehr intensiv

6. *How satisfied was the engineer with the tasks he did in the execution phase of the* project /
Wie zufrieden war der Ingenieur mit den Aufgaben, die er in der ausführenden Phase des Projekts ausführte?

very dissatisfied / sehr unzufrieden | 1 | 2 | 3 | 4 | 5 | *very satisfied* / sehr zufrieden

7. *I have the impression that the project proceedings between engineers and auxiliary employees in the execution phase were acceptable* /
Ich habe den Eindruck, dass die Projektabwicklung zwischen Ingenieuren und Hilfskräften in der ausführenden Phase des Projekts akzeptabel war.

fully disagree / lehne stark ab | 1 | 2 | 3 | 4 | 5 | *fully agree* / stimme stark zu

8. ***How high do you estimate the possibility of meeting the project deadlines in the execution phase the way this project was processed?*** **/**
Wie hoch ist nach Ihrer Einschätzung die Möglichkeit, mit dieser Art der Projektabwicklung die Termine in der ausführenden Phase des Projekts einzuhalten?

very low / sehr niedrig | 1 | 2 | 3 | 4 | 5 | *very high* / sehr hoch

9. ***The way this project was processed decreases the project costs in the execution phase?*** **/**
Die Art, wie dieses Projekt abgewickelt wurde, reduziert in der ausführenden Phase die Projektkosten.

fully disagree / lehne stark ab | 1 | 2 | 3 | 4 | 5 | *fully agree* / stimme stark zu

10. ***The way this project was processed in the execution phase decreases the drawing errors in the drawing set. /***
Die Art, wie dieses Projekt in der ausführenden Phase abgewickelt wurde reduziert Zeichnungsfehler im Zeichnungssatz.

fully disagree / lehne stark ab | 1 | 2 | 3 | 4 | 5 | *fully agree* / stimme stark zu

11. ***The way this project was processed in the execution phase gives freedom for an optimal part and assembly design. /***
Die Art, wie dieses Projekt in der ausführenden Phase abgewickelt wurde, gibt Freiraum zur optimalen Bauteil- und Baugruppenauslegung.

fully disagree / lehne stark ab | 1 | 2 | 3 | 4 | 5 | *fully agree* / stimme stark zu

Annex 6: Management Project Auxiliary Staff Integration - Guidelines

Guidelines for the execution of the questionnaire survey

1. The questionnaires were handed over to the participating engineer and the participating technical draughtsman / product designer. The engineer and the technical draughtsman are asked to carefully characterise **the same** recent variant development project within this questionnaire.

2. The engineer and the technical draughtsman / product designer are asked to enter the exact name of the project to be described in the questionnaire. Afterwards they are requested to complete the questionnaire by themselves.

3. The participating engineer and the participating technical draughtsman / product designer are requested to return the questionnaire in a timely manner to Christoph Staita (mail: christoph.staita@kathrein.de).